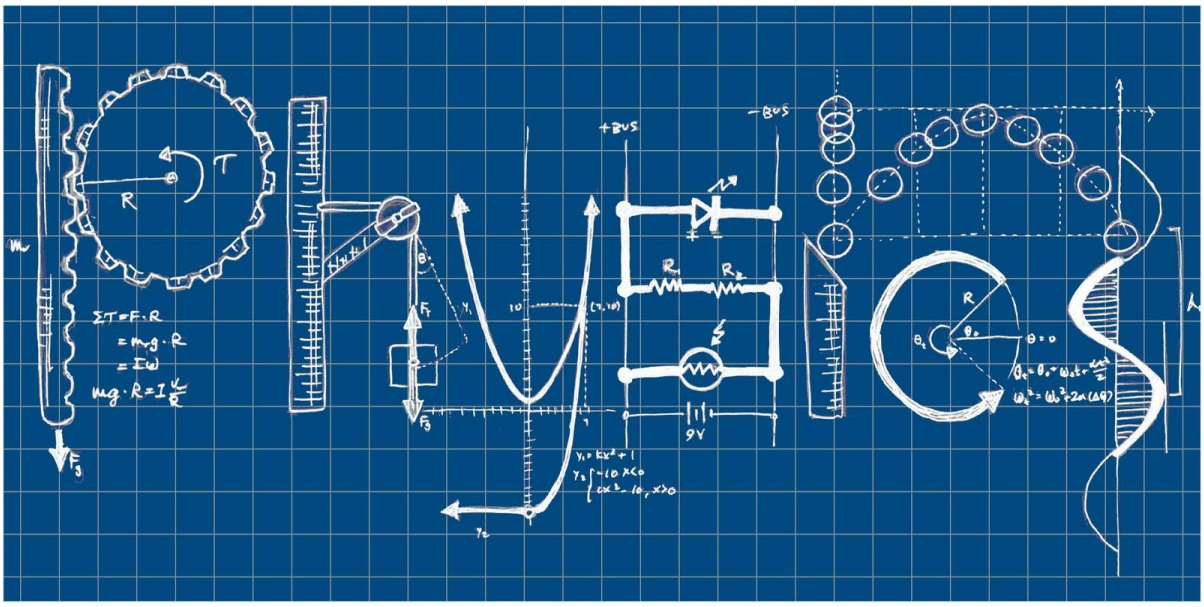


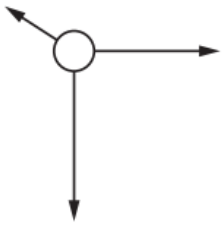
Topical Questions

1. SI UNITS, MEASUREMENTS AND UNCERTAINTY

S16/11:

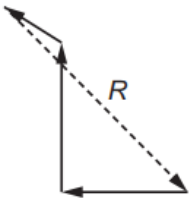
1.

Three wires each exert a horizontal force on a vertical pole, as shown.

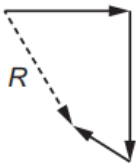


Which vector diagram shows the resultant force *R* acting on the pole?

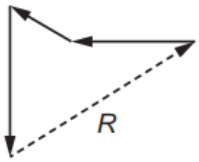
A



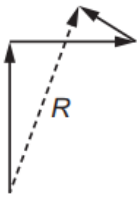
B



C



D



2.

Which pair of quantities do **not** have the same SI base units?

A electromotive force and electric potential difference

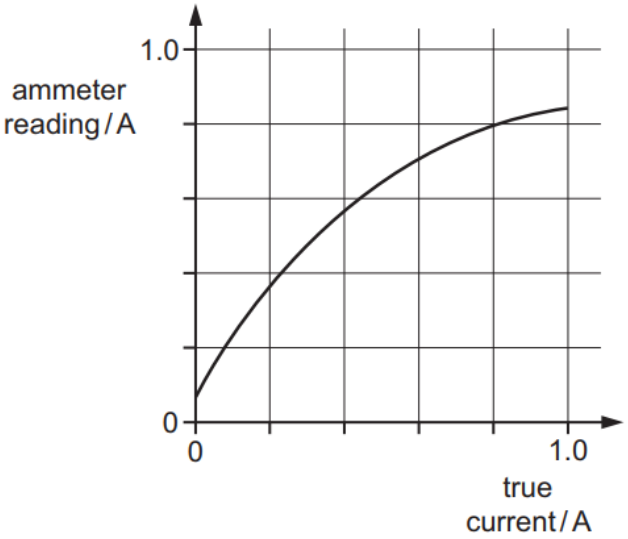
B pressure and stress

C spring constant and moment of a force

D torque and work

3.

A calibration graph is produced for a faulty ammeter.



Which ammeter reading will be nearest to the true current?

A 0.2 A **B** 0.4 A **C** 0.6 A **D** 0.8 A

S16/12

4.

Which quantity with its unit is correct?

A acceleration of a bicycle = 1.4 m s^{-1}

B electric current in a lamp = 0.25 A s^{-1}

C electric potential difference across a battery = 8.0 J C^{-1}

D kinetic energy of a car = 4500 N m^{-1}

5.

The luminosity L of a star is given by

$$L = 4\pi r^2 \sigma T^4$$

where

r is the radius of the star,

T is the temperature of the star,

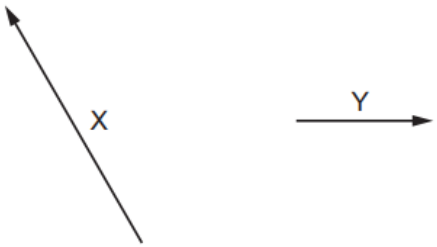
σ is a constant with units $W m^{-2} K^{-4}$.

What are the SI base units of L?

A $kg\,m^2\,s^{-1}$ **B** $kg\,m^2\,s^{-2}$ **C** $kg\,m^2\,s^{-3}$ **D** $kg\,m^2\,s^{-4}$

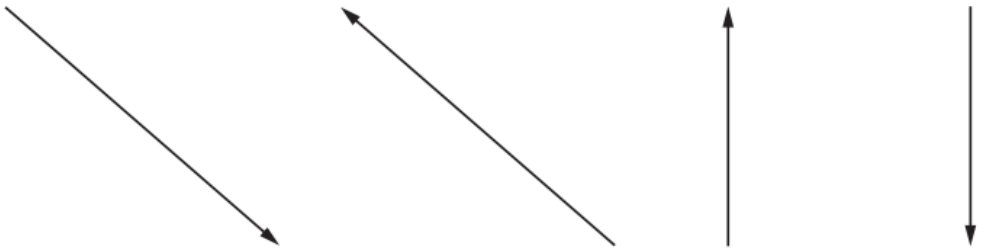
6.

The diagram shows two vectors X and Y, drawn to scale.



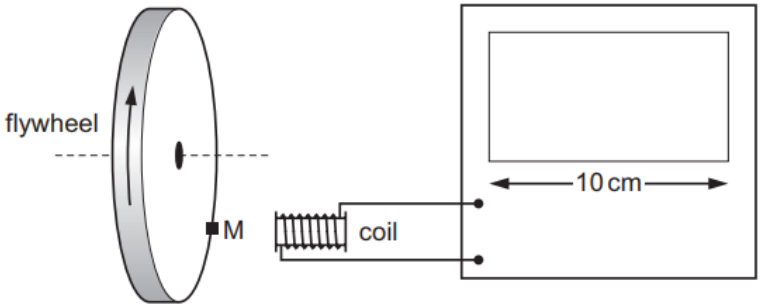
If X = Y – Z, which diagram best represents the vector Z?

A **B** **C** **D**



7.

The diagram shows a cathode-ray oscilloscope (c.r.o.) being used to measure the rate of rotation of a flywheel.



The flywheel has a small magnet M mounted on it. Each time the magnet passes the coil, a voltage pulse is generated, which is passed to the c.r.o. The display of the c.r.o. is 10 cm wide. The flywheel is rotating at 3000 revolutions per minute.

Which time-base setting will display clearly separate pulses on the screen?

A $1\,\text{s cm}^{-1}$ **B** $10\,\text{ms cm}^{-1}$ **C** $100\,\mu\text{s cm}^{-1}$ **D** $1\,\mu\text{s cm}^{-1}$

S16/13

8.

Which list contains only SI base units?

A ampere, kelvin, joule, gram

B kilogram, newton, metre, ampere

C metre, coulomb, second, kelvin

D second, kelvin, ampere, kilogram

9.

The stress σ needed to fracture a particular solid is given by the equation

$$\sigma = k\sqrt{\frac{\gamma E}{d}}$$

where E is the Young modulus, d is the distance between planes of atoms, and k is a constant with no units.

What are the SI base units of γ?

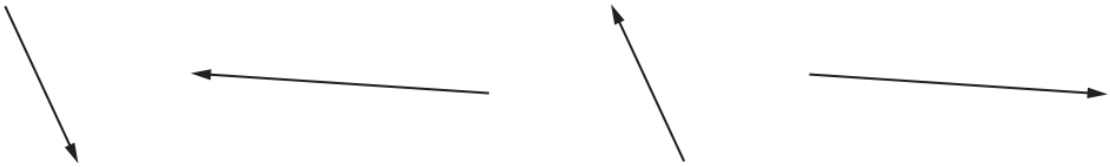
A kg m s^{-2} **B** kg s^{-2} **C** kg m s^{-1} **D** kg s^{-1}

10.

Vectors P and Q are drawn to scale.

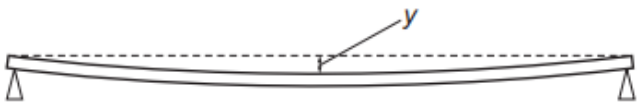
Which diagram represents the vector (P – Q)?

A **B** **C** **D**



11.

A metre rule is supported horizontally by two pivots as shown.



The vertical displacement y at the centre of the rule is given by the equation

$$y = \frac{kML^3}{wt^3}$$

where

k is a constant,

L is the distance between the pivots,

M is the mass of the rule,

t is the thickness of the rule and

w is the width of the rule.

In an experiment, the following results are obtained:

$L = (80.0 \pm 0.2)\,\text{cm}$

$M = (60 \pm 1)\,\text{g}$

$t = (6.0 \pm 0.1)\,\text{mm}$

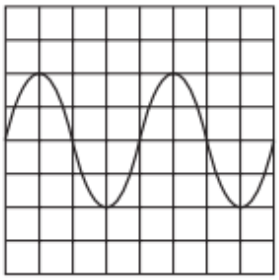
$w = (23.0 \pm 0.5)\,\text{mm}$.

Which measurement contributes most to the uncertainty in the calculated value of y?

A L **B** M **C** t **D** w

12.

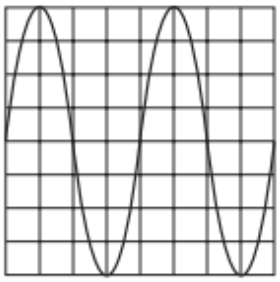
The following trace is seen on the screen of a cathode-ray oscilloscope.



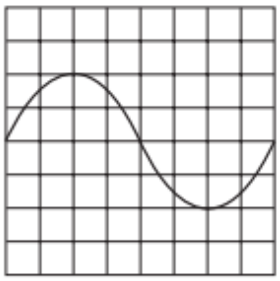
The setting of the time-base is then changed from $10\,ms\,cm^{-1}$ to $20\,ms\,cm^{-1}$ and the Y-plate sensitivity remains constant.

Which trace is now seen on the screen?

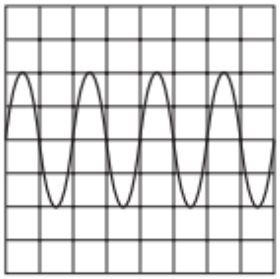
A



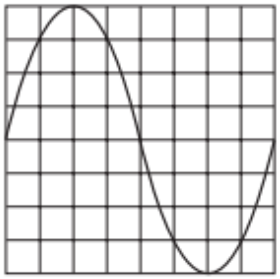
B



C



D



W15/11

13.

What is the unit of weight in terms of SI base unit(s)?

A $kg\,m\,s^{-1}$ **B** $kg\,m\,s^{-2}$ **C** N **D** $J\,m^{-1}$

14.

At temperatures close to 0 K, the specific heat capacity c of a particular solid is given by $c = bT^3$, where T is the thermodynamic temperature and b is a constant characteristic of the solid.
The SI unit of specific heat capacity is $J\,kg^{-1}\,K^{-1}$.

What is the unit of constant b, expressed in SI base units?

A $m^2\,s^{-2}\,K^{-3}$

B $m^2\,s^{-2}\,K^{-4}$

C $kg\,m^2\,s^{-2}\,K^{-3}$

D $kg\,m^2\,s^{-2}\,K^{-4}$

15.

In making reasonable estimates of physical quantities, which statement is **not** correct?

A The frequency of sound can be of the order of GHz.

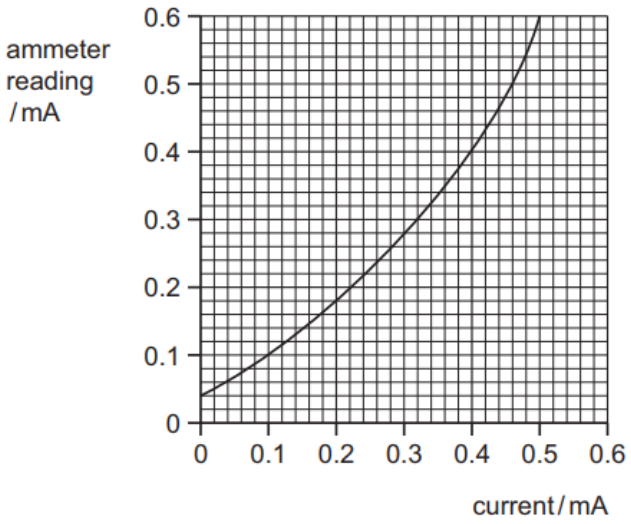
B The wavelength of light can be of the order of 600 nm.

C The Young modulus of a metal can be of the order of 10^{11} Pa.

D Beta particles are associated with one unit of negative charge.

16.

A calibration graph is shown for an ammeter whose scale is inaccurate.



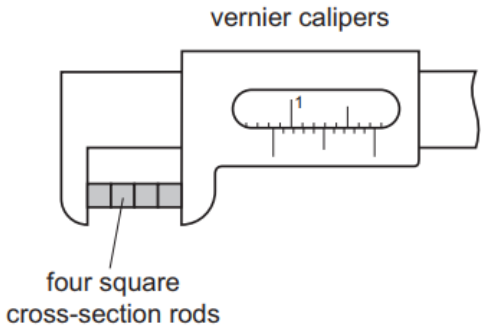
Two readings taken on the meter at different times during an experiment are 0.13 mA and 0.47 mA.

By how much did the current really increase between taking the two readings?

A 0.30 mA **B** 0.35 mA **C** 0.40 mA **D** 0.44 mA

17.

Four identical rods have a square cross-section. The rods are placed side by side and their total width is measured with vernier calipers, as shown.



The measurement is (8.4 ± 0.1) mm and the zero reading on the calipers is (0.0 ± 0.1) mm.

What is the width of one rod?

A (2.10 ± 0.025) mm

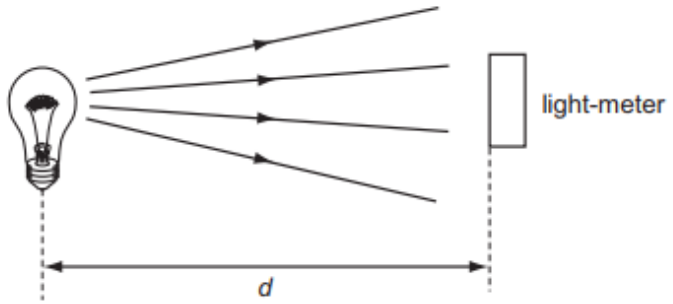
B (2.10 ± 0.05) mm

C (2.1 ± 0.1) mm

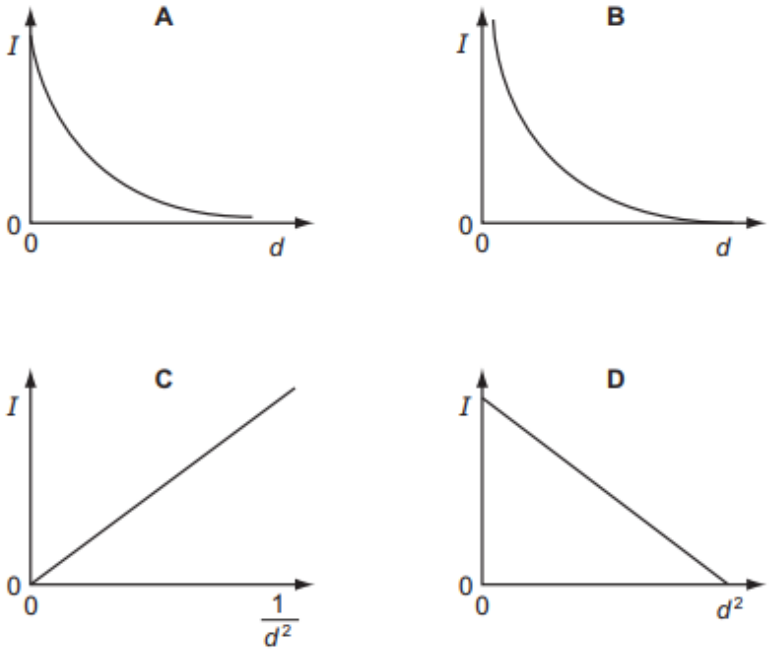
D (2.1 ± 0.2) mm

18.

A light-meter measures the intensity I of the light incident on it. Theory suggests that I varies inversely as the square of the distance d.



Which graph of the results supports this theory?



W15/12

19.

Which list shows increasing lengths from beginning to end?

A	1 cm	1 nm	1 mm	1 μm
B	1 μm	1 mm	1 nm	1 cm
C	1 nm	1 μm	1 mm	1 cm
D	1 mm	1 cm	1 μm	1 nm

20.

Which equation contains only scalar quantities?

A $\text{acceleration} = \dfrac{\text{force}}{\text{mass}}$

B $\text{power} = \dfrac{\text{work}}{\text{time}}$

C $\text{pressure} = \dfrac{\text{force}}{\text{area}}$

D $\text{velocity} = \dfrac{\text{displacement}}{\text{time}}$

21.

The time T taken for a satellite to orbit the Earth on a circular path is given by the equation

$$T^2 = \frac{kr^3}{M}$$

where r is the radius of the orbit, M is the mass of the Earth and k is a constant.

What are the SI base units of k?

A $\text{kg}^{-1}\,\text{m}^{-3}\,\text{s}^2$ **B** $\text{kg}^{-1}\,\text{m}^3\,\text{s}^2$ **C** $\text{kg}\,\text{m}^{-3}\,\text{s}^2$ **D** $\text{kg}\,\text{m}^3\,\text{s}^2$

22.

Which row gives reasonable estimates for the mass and the speed of an adult running?

	mass / kg	speed / m s^{-1}
A	6×10^0	5×10^1
B	6×10^1	5×10^0
C	6×10^1	5×10^1
D	6×10^2	5×10^0

23.

A student measures the time T for one complete oscillation of a pendulum of length l.

Her results are shown in the table.

l/m	T/s
0.420 ± 0.001	1.3 ± 0.1

She uses the formula

$$T = 2\pi\sqrt{\frac{l}{g}}$$

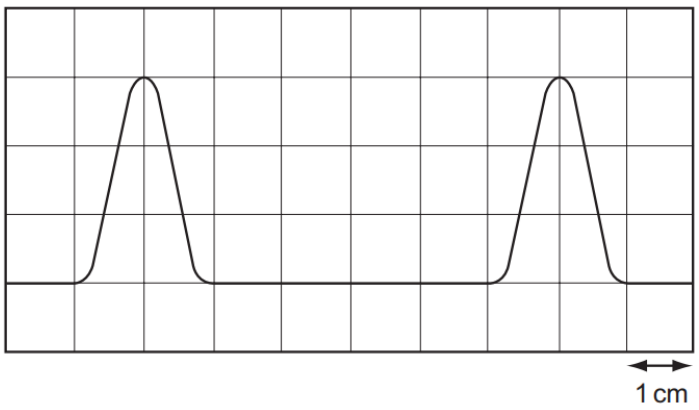
to calculate the acceleration of free fall g.

What is the best estimate of the percentage uncertainty in the value of g?

A 0.02% **B** 4% **C** 8% **D** 16%

24.

The diagram shows two complete pulses on the screen of a cathode-ray oscilloscope. A grid of 1 cm squares covers the screen. The time-base setting is 1 μs cm^{-1}.



How long does each pulse last?

A 2 μs **B** 3 μs **C** 4 μs **D** 6 μs

W15/13

25.

What is the unit of the Young modulus when expressed in SI base units?

A kg m^{-1} s^{-2}

B kg m^{3} s^{-2}

C kg m^{-2}

D kg m^{-1} s^{-1}

26.

The Reynolds number R is a constant used in the study of liquids flowing through pipes. R is a pure number with no unit.

$$R = \frac{\rho v D}{\mu}$$

where ρ is the density of the liquid, v is the speed of the liquid and D is the diameter of the pipe through which the liquid flows.

What are the SI base units of μ?

A $\mathrm{kg\,m\,s}$ **B** $\mathrm{kg\,m^{-1}\,s}$ **C** $\mathrm{kg\,m\,s^{-1}}$ **D** $\mathrm{kg\,m^{-1}\,s^{-1}}$

27.

When a force F moves its point of application through a displacement s in the direction of the force, the work W done by the force is given by

$$W = Fs.$$

How many vector quantities and scalar quantities does this equation contain?

A one scalar quantity and two vector quantities

B one vector quantity and two scalar quantities

C three scalar quantities

D three vector quantities

28.

Measurements are subject to systematic error and random error.

Which measurements have high accuracy and low precision?

A high random error and high systematic error

B high random error and low systematic error

C low random error and high systematic error

D low random error and low systematic error

29.

The density of the material of a coil of thin wire is to be found.

Which set of instruments could be used to do this most accurately?

A metre rule, protractor, spring balance

B micrometer, metre rule, top-pan balance

C stopwatch, newton-meter, vernier calipers

D tape measure, vernier calipers, lever balance

30.

A cylindrical tube rolling down a slope of inclination θ moves a distance L in time T. The equation relating these quantities is

$$L\left(3+\frac{a^2}{P}\right) = QT^2 \sin\theta$$

where a is the internal radius of the tube and P and Q are constants.

Which row gives the correct units for P and for Q?

	P	Q
A	m^2	$m^2 s^{-2}$
B	m^2	$m s^{-2}$
C	m^2	$m^3 s^{-2}$
D	m^3	$m s^{-2}$

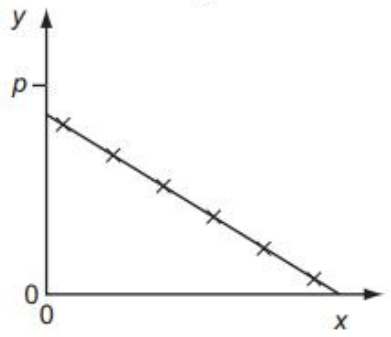
31.

Variables x and y are related by the equation $y = p - qx$ where p and q are constants.

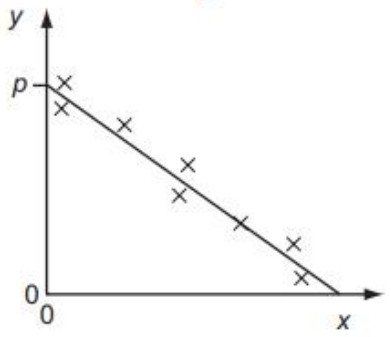
Values of x and y are measured experimentally. The results contain a systematic error.

Which graph best represents these results?

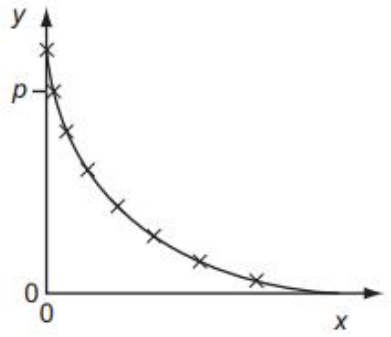
A



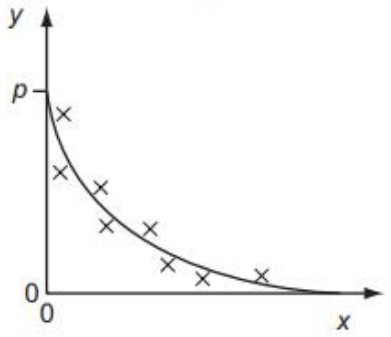
B



C

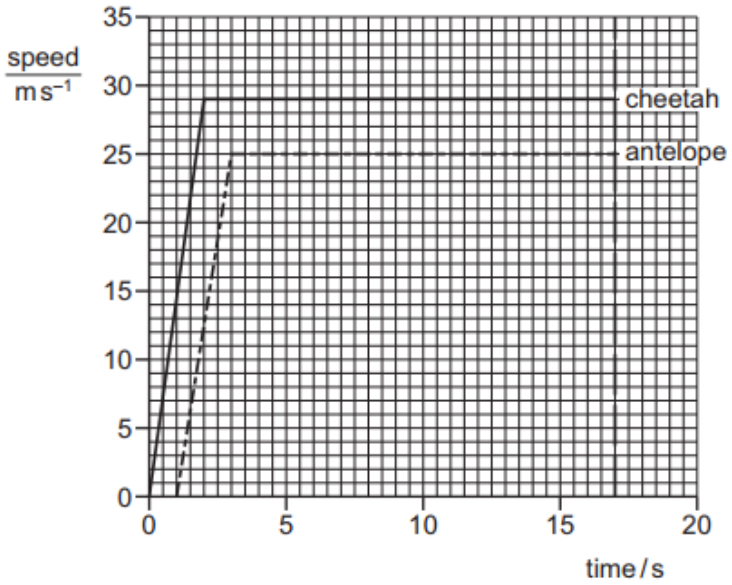


D



32.

A cheetah and an antelope are 100 m apart. The cheetah spots the antelope and runs towards it. The antelope reacts to the cheetah after one second and runs directly away from the cheetah. Both animals take 2 seconds to reach their top speeds. The graph shows how the speeds of the two animals vary with time.



How far apart are the animals, 17 seconds after the cheetah began running?

A 4 m **B** 11 m **C** 54 m **D** 89 m

S15/11

32.

Which is an SI base unit?

A current

B gram

C kelvin

D volt

33.

Which pair contains one vector and one scalar quantity?

A	displacement	acceleration
B	force	kinetic energy
C	momentum	velocity
D	power	speed

34.

When a constant braking force is applied to a vehicle moving at speed v, the distance d moved by the vehicle in coming to rest is given by the expression

$$d = kv^2$$

where k is a constant.

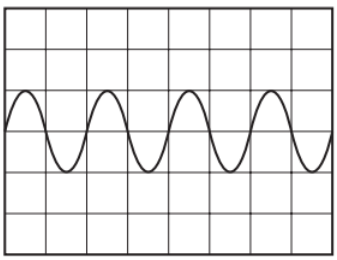
When d is measured in metres and v is measured in metres per second, the constant has a value of k_1.

What is the value of the constant when the distance is measured in metres, and the speed is measured in kilometres per hour?

A $0.0772\,k_1$ **B** $0.278\,k_1$ **C** $3.60\,k_1$ **D** $13.0\,k_1$

35.

A whale produces sound waves of frequency 5 Hz. The waves are detected by a microphone and displayed on an oscilloscope.

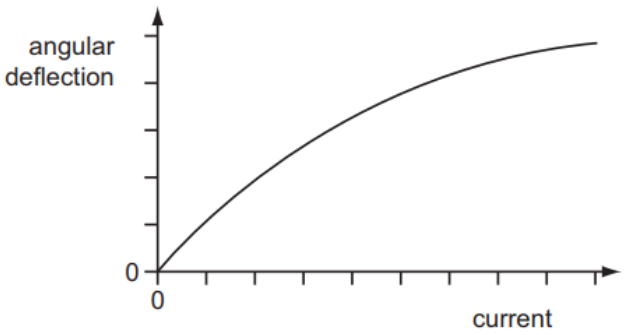


What is the time-base setting on the oscilloscope?

A $0.1\,\text{ms div}^{-1}$ **B** $1\,\text{ms div}^{-1}$ **C** $10\,\text{ms div}^{-1}$ **D** $100\,\text{ms div}^{-1}$

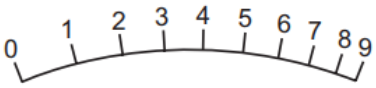
36.

The angular deflection of the needle of an ammeter varies with the current in the ammeter as shown in the graph.

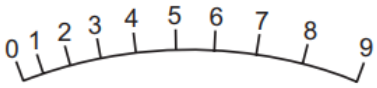


Which diagram could represent the appearance of the scale on this meter?

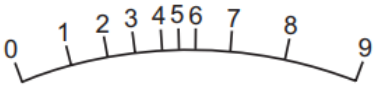
A



B



C



D

37.

6 The strain energy W of a spring is determined from its spring constant k and extension x. The spring obeys Hooke's law and the value of W is calculated using the equation shown.

$$W = \tfrac{1}{2}kx^2$$

The spring constant is $100 \pm 2\,\text{N m}^{-1}$ and the extension is $0.050 \pm 0.002\,\text{m}$.

What is the percentage uncertainty in the calculated value of W?

A 6% **B** 10% **C** 16% **D** 32%

S15/12

38.

Which definition is correct and uses only quantities rather than units?

A Density is mass per cubic metre.

B Potential difference is energy per unit current.

C Pressure is force per unit area.

D Speed is distance travelled per second.

39.

The average kinetic energy E of a gas molecule is given by the equation

$$E = \frac{3}{2}kT$$

where T is the absolute (kelvin) temperature.

What are the SI base units of k?

A $kg^{-1}\,m^{-1}\,s^{2}\,K$

B $kg^{-1}\,m^{-2}\,s^{2}\,K$

C $kg\,m\,s^{-2}\,K^{-1}$

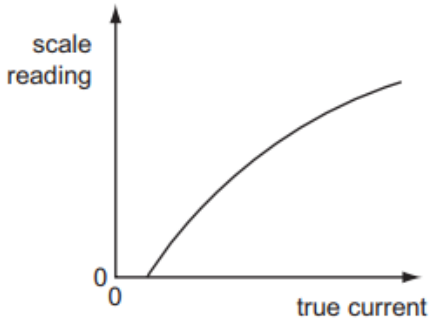
D $kg\,m^{2}\,s^{-2}\,K^{-1}$

40.

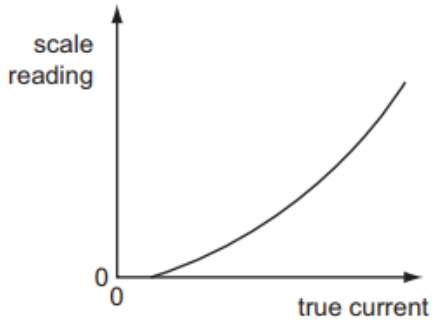
An analogue ammeter has a pointer which moves over a scale. Following prolonged use, the pointer does not return fully to zero when the current is turned off and the meter has become less sensitive at higher currents than it is at lower currents.

Which diagram best represents the calibration graph needed to obtain an accurate current reading?

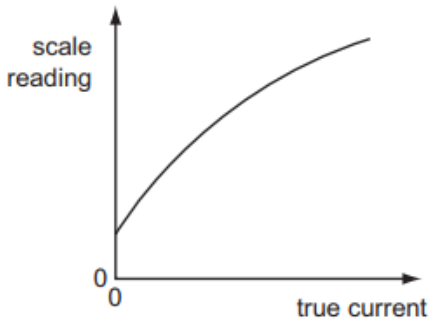
A



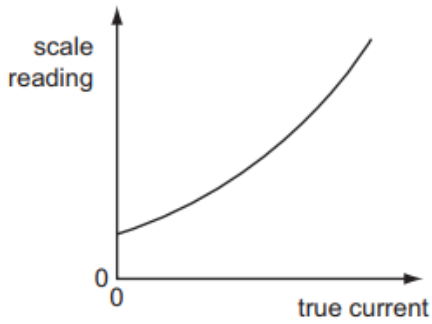
B



C



D



41.

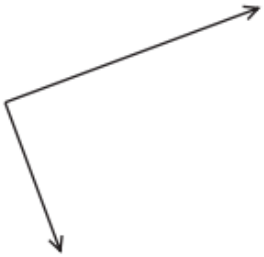
The arrow represents the vector R.

Which diagram does **not** represent R as two perpendicular components?

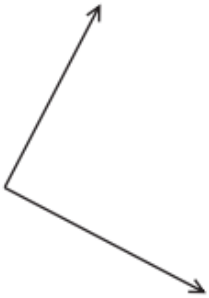
A

B

C

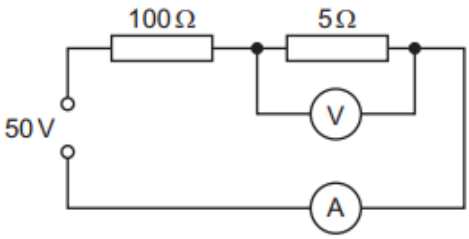


D



42.

A power supply of electromotive force (e.m.f.) 50 V and negligible internal resistance is connected in series with resistors of resistance 100 Ω and 5 Ω, as shown.



A voltmeter measures the potential difference (p.d.) across the 5 Ω resistor and an ammeter measures the current in the circuit.

What are suitable ranges for the ammeter and for the voltmeter?

	ammeter range / A	voltmeter range / V
A	0 – 0.1	0 – 1
B	0 – 0.1	0 – 3
C	0 – 1.0	0 – 1
D	0 – 1.0	0 – 3

S15/13

43.

Which statement includes a correct unit?

A energy = 7.8 N s

B force = 3.8 N s

C momentum = 6.2 N s

D torque = 4.7 N s

44.

What is the joule (J) in SI base units?

A $kg\,m\,s^{-1}$ **B** $kg\,m^2\,s^{-1}$ **C** $kg\,m\,s^{-2}$ **D** $kg\,m^2\,s^{-2}$

45.

The speed of an aeroplane in still air is 200 $km\,h^{-1}$. The wind blows from the west at a speed of 85.0 $km\,h^{-1}$.

In which direction must the pilot steer the aeroplane in order to fly due north?

A 23.0° east of north

B 23.0° west of north

C 25.2° east of north

D 25.2° west of north

46.

A student is given a reel of wire of diameter less than 0.2 mm and is asked to find the density of the metal.

Which pair of instruments would be most suitable for finding the **volume** of the wire?

A balance and micrometer

B metre rule and micrometer

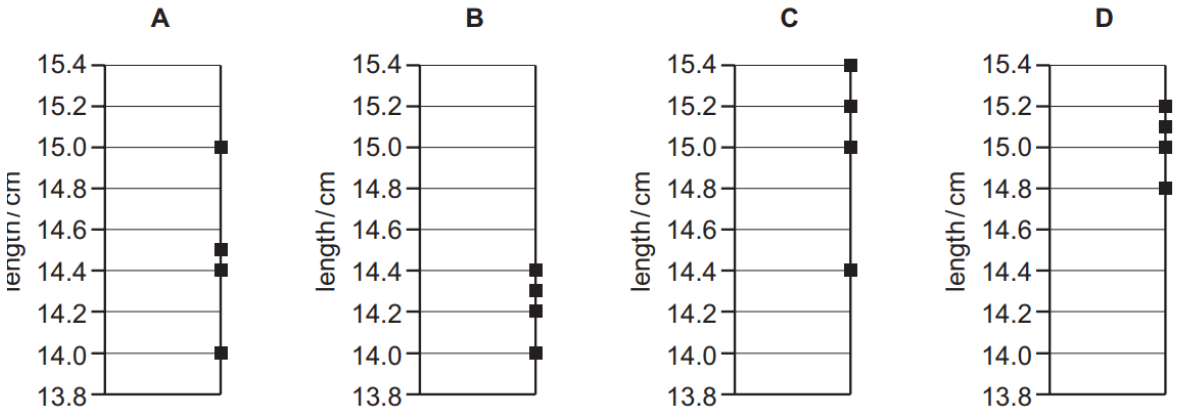
C metre rule and vernier calipers

D micrometer and vernier calipers

47.

Four different students use a ruler to measure the length of a 15.0 cm pencil. Their measurements are recorded on four different charts.

Which chart shows measurements that are precise but **not** accurate?



48.

In a simple electrical circuit, the current in a resistor is measured as (2.50 ± 0.05) mA. The resistor is marked as having a value of 4.7 Ω ± 2%.

If these values were used to calculate the power dissipated in the resistor, what would be the percentage uncertainty in the value obtained?

A 2% **B** 4% **C** 6% **D** 8%

W14/11

49.

A 0.10 kg mass is taken to Mars and then weighed on a spring balance and on a lever balance. The acceleration due to gravity on Mars is 38% of its value on Earth.

What are the readings on the two balances on Mars? (Assume that on Earth $g = 10\,m\,s^{-2}$.)

	spring balance / N	lever balance / kg
A	0.38	0.038
B	0.38	0.10
C	1.0	0.038
D	1.0	0.10

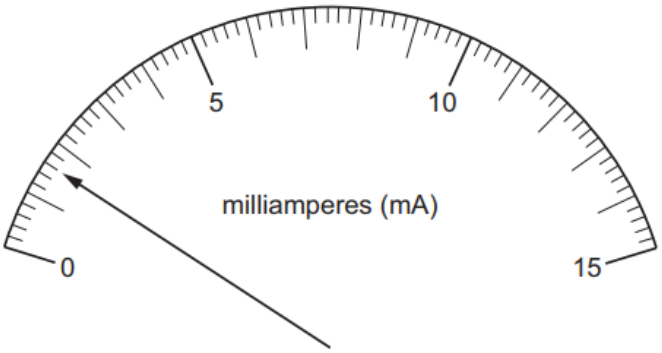
50.

What is equivalent to the unit of electric field strength?

A $J\,C\,m^{-1}$ **B** $N\,s\,A^{-1}$ **C** $kg\,m\,s^{-3}\,A^{-1}$ **D** $kg\,m^3\,s^{-3}\,A^{-1}$

51.

The diagram shows the reading on an analogue ammeter.



Which digital ammeter reading is the same as the reading on the analogue ammeter?

	display units	display reading
A	μA	1600
B	μA	160
C	mA	16.0
D	A	1.60

52.

A steel wire is stretched in an experiment to determine the Young modulus for steel.

The uncertainties in the measurements are given below.

measurement	uncertainty
load on wire	±2%
length of wire	±0.2%
diameter of wire	±1.5%
extension	±1%

What is the percentage uncertainty in the Young modulus?

A 1.3% **B** 1.8% **C** 4.7% **D** 6.2%

5W14/13

53.

When the brakes are applied on a vehicle moving at speed v, the distance d moved by the vehicle in coming to rest is given by the expression

$$d = kv^2$$

where k is a constant.

What is the unit of k expressed in SI base units?

A $m^{-1}s^2$ **B** ms^{-2} **C** m^2s^{-2} **D** $m^{-1}s$

54.

Which list contains one vector quantity and two scalar quantities?

A displacement, weight, velocity

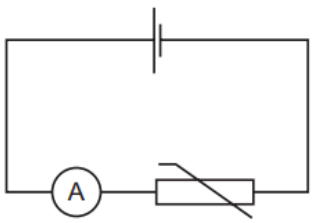
B force, acceleration, time

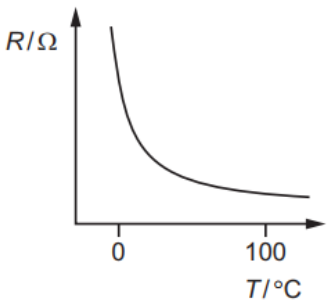
C momentum, mass, speed

D work, density, energy

55.

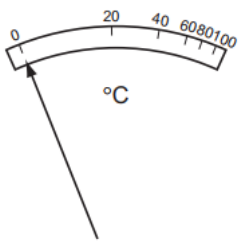
In the circuit shown, an analogue ammeter is to be recalibrated as a thermometer. The graph shows how the resistance R of the thermistor changes with temperature T.



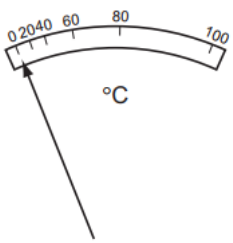


Which diagram could represent the temperature scale on the ammeter?

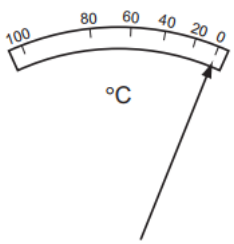
A



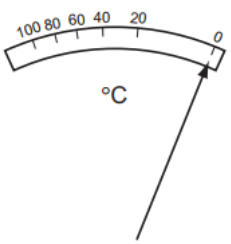
B



C

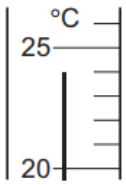


D



56.

The diagram shows part of a thermometer.



What is the correct reading on the thermometer and the uncertainty in this reading?

	reading / °C	uncertainty in reading / °C
A	24	±1
B	24	±0.5
C	24	±0.2
D	24.0	±0.5

57.

The resistance R of a resistor is to be determined. The current I in the resistor and the potential difference V across it are measured.

The results, with their uncertainties, are

$$I = (2.0 \pm 0.2)\,\text{A} \qquad V = (15.0 \pm 0.5)\,\text{V}.$$

The value of R is calculated to be 7.5 Ω.

What is the uncertainty in this value for R?

A ±0.3 Ω **B** ±0.5 Ω **C** ±0.7 Ω **D** ±1 Ω

S14/11

58.

Which pair of units contains one derived unit and one SI base unit?

A ampere coulomb

B kilogram kelvin

C metre second

D newton pascal

59.

What is equivalent to 2000 microvolts?

A $2\,\mu\text{J C}^{-1}$ **B** 2 mV **C** 2 pV **D** 2000 mV

60.

The speed v of a liquid leaving a tube depends on the change in pressure ΔP and the density ρ of the liquid. The speed is given by the equation

$$v = k\left(\frac{\Delta P}{\rho}\right)^n$$

where k is a constant that has no units.

What is the value of n?

A $\frac{1}{2}$ **B** 1 **C** $\frac{3}{2}$ **D** 2

61.

An experiment is carried out to measure the resistance of a wire.

The current in the wire is (1.0 ± 0.2) A and the potential difference across the wire is (8.0 ± 0.4) V.

What is the resistance of the wire and its uncertainty?

A $(8.0 \pm 0.2)\Omega$

B $(8.0 \pm 0.6)\Omega$

C $(8 \pm 1)\Omega$

D $(8 \pm 2)\Omega$

62.

The Young modulus of the material of a wire is to be found. The Young modulus E is given by the equation below.

$$E = \frac{4Fl}{\pi d^2 x}$$

The wire is extended by a known force and the following measurements are made.

Which measurement has the largest effect on the uncertainty in the value of the calculated Young modulus?

	measurement	symbol	value
A	length of wire before force applied	l	2.043 ± 0.002 m
B	diameter of wire	d	0.54 ± 0.02 mm
C	force applied	F	19.62 ± 0.01 N
D	extension of wire with force applied	x	5.2 ± 0.2 mm

S14/12

63.

The maximum theoretical power P of a wind turbine is given by the equation

$$P = k\rho A v^n$$

where ρ is the density of air, A is the area swept by the turbine blades, v is the speed of the air and k is a constant with no units.

What is the value of n?

A 1 **B** 2 **C** 3 **D** 4

64.

What is the unit of resistance when expressed in SI base units?

A $kg\,m^2\,s^{-2}\,A^{-1}$

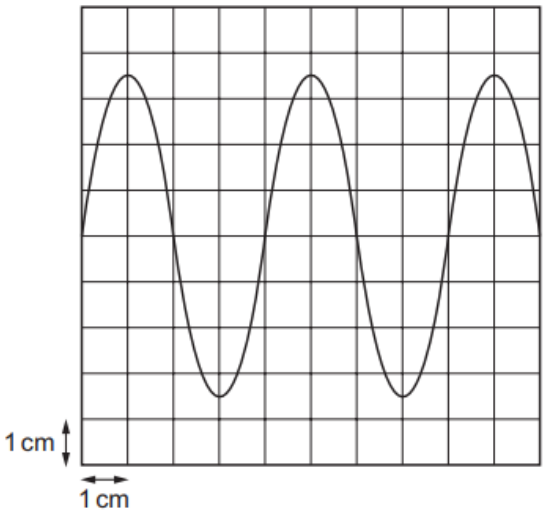
B $kg\,m^2\,s^{-3}\,A^{-2}$

C $kg\,m\,s^{-2}\,A^{-1}$

D $kg\,m\,s^{-3}\,A^{-1}$

65.

A cathode-ray oscilloscope (c.r.o.) is connected to an alternating voltage. The following trace is produced on the screen.



The oscilloscope time-base setting is $0.5\,ms\,cm^{-1}$ and the Y-plate sensitivity is $2\,V\,cm^{-1}$.

Which statement about the alternating voltage is correct?

A The amplitude is 3.5 cm.

B The frequency is 0.5 kHz.

C The period is 1 ms.

D The wavelength is 4 cm.

66.

A quantity y is to be determined from the equation shown.

$$y = \frac{px}{q^2}$$

The percentage uncertainties in p, x and q are shown.

	percentage uncertainty
p	6%
x	2%
q	4%

What is the percentage uncertainty in y?

A 0.5% **B** 1% **C** 16% **D** 192%

67.

A thermometer can be read to an accuracy of ±0.5 °C. This thermometer is used to measure a temperature rise from 40 °C to 100 °C.

What is the percentage uncertainty in the measurement of the temperature rise?

A 0.5% **B** 0.8% **C** 1.3% **D** 1.7%

S14/13

68.

Which quantity can be measured in electronvolts (eV)?

A electric charge

B electric potential

C energy

D power

69.

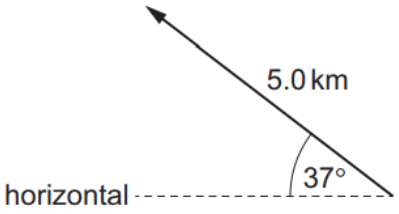
The unit of specific heat capacity is $J\,kg^{-1}\,K^{-1}$.

What is its equivalent in terms of SI base units?

A $kg^{-1}\,m^2\,K^{-1}$ **B** $m\,s^{-1}\,K^{-1}$ **C** $m\,s^{-2}\,K^{-1}$ **D** $m^2\,s^{-2}\,K^{-1}$

70.

What is the vertical component of this displacement vector?



A 3.0 km **B** 3.8 km **C** 4.0 km **D** 5.0 km

71.

The resistance of a lamp is calculated from the value of the potential difference (p.d.) across it and the value of the current passing through it.

Which statement correctly describes how to combine the uncertainties in the p.d. and in the current?

A Add together the actual uncertainty in the p.d. and the actual uncertainty in the current.

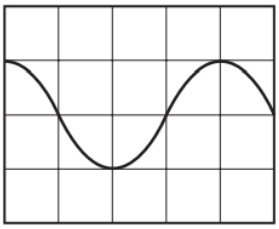
B Add together the percentage uncertainty in the p.d. and the percentage uncertainty in the current.

C Subtract the actual uncertainty in the current from the actual uncertainty in the p.d.

D Subtract the percentage uncertainty in the current from the percentage uncertainty in the p.d.

72.

The display on a cathode-ray oscilloscope shows the signal produced by an electronic circuit. The time-base is set at 5.0 ns per division and the Y-gain at 10 V per division.



What is the frequency of the signal?

A 2.0×10^{-8} Hz

B 2.5×10^{-2} Hz

C 5.0×10^{7} Hz

D 3.1×10^{8} Hz

W13/11

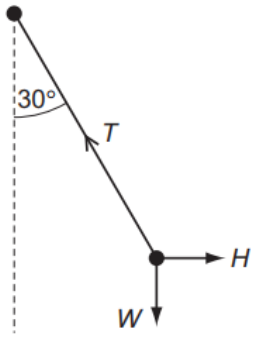
73.

Which row shows an SI base quantity with its correct unit?

	SI base quantity	unit
A	charge	coulomb
B	current	ampere
C	potential difference	volt
D	temperature	degree Celsius

74.

A pendulum bob is held stationary by a horizontal force *H*. The three forces acting on the bob are shown in the diagram.



The tension in the string of the pendulum is *T*. The weight of the pendulum bob is *W*.

Which statement is correct?

A $H = T\cos 30°$

B $T = H\sin 30°$

C $W = T\cos 30°$

D $W = T\sin 30°$

75.

The drag coefficient C_d is a number with no units. It is used to compare the drag on different cars at different speeds. It is given by the equation

$$C_d = \frac{2F}{\rho v^n A}$$

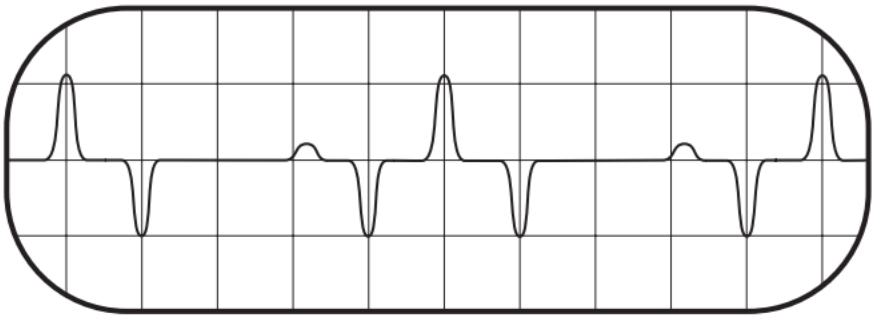
where *F* is the drag force on the car, ρ is the density of the air, *A* is the cross-sectional area of the car and *v* is the speed of the car.

What is the value of *n*?

A 1 **B** 2 **C** 3 **D** 4

76.

A signal that repeats periodically is displayed on the screen of a cathode-ray oscilloscope.



The screen has 1 cm squares and the time base is set at 2.00 ms cm^{-1}.

What is the frequency of this periodic signal?

A 50 Hz **B** 100 Hz **C** 125 Hz **D** 200 Hz

77.

A micrometer screw gauge is used to measure the diameter of a small uniform steel sphere. The micrometer reading is 5.00 mm ± 0.01 mm.

What will be the percentage uncertainty in a calculation of the volume of the sphere, using these values?

A 0.2% **B** 0.4% **C** 0.6% **D** 1.2%

W13/13

78.

Which estimate is realistic?

A The kinetic energy of a bus travelling on an expressway is 30 000 J.

B The power of a domestic light is 300 W.

C The temperature of a hot oven is 300 K.

D The volume of air in a car tyre is 0.03 m^3.

79.

Which unit is equivalent to the coulomb?

A ampere per second

B joule per volt

C watt per ampere

D watt per volt

80.

Two forces of equal magnitude are represented by two coplanar vectors. One is directed eastwards and the other is directed northwards.

What is the direction of a single force that will balance these two forces?

A towards the north-east

B towards the north-west

C towards the south-east

D towards the south-west

81.

The spring constant k of a coiled wire spring is given by the equation

$$k = \frac{Gr^4}{4nR^3}$$

where r is the radius of the wire, n is the number of turns of wire and R is the radius of each of the turns of wire. The quantity G depends on the material from which the wire is made.

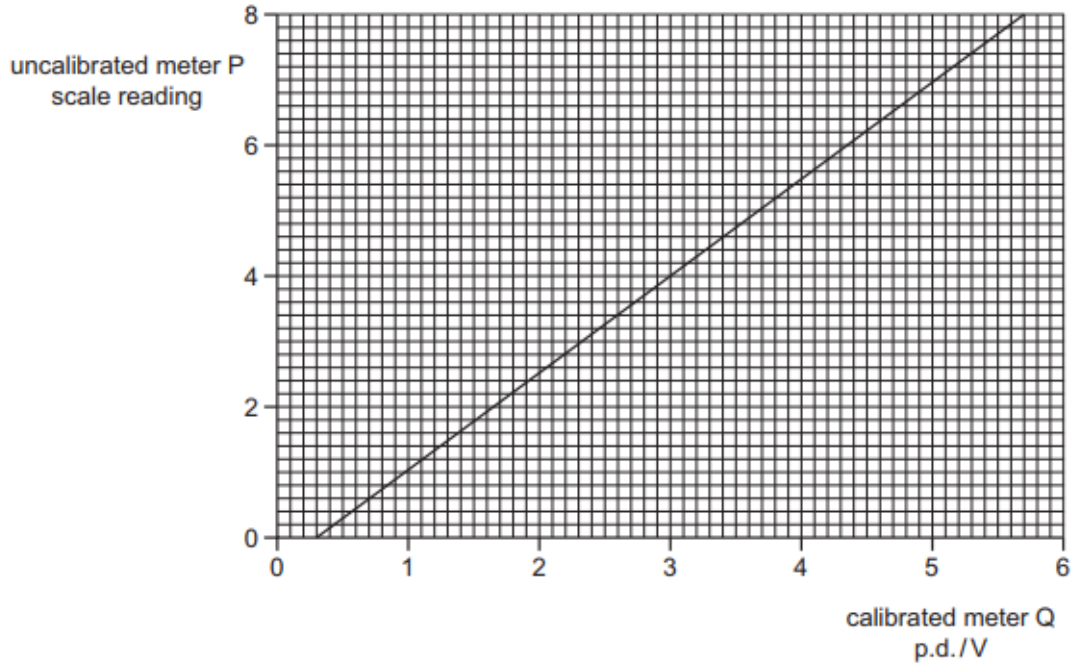
What is a suitable unit for G?

A $\mathrm{N\,m^{-2}}$ **B** $\mathrm{N\,m^{-1}}$ **C** $\mathrm{N\,m}$ **D** $\mathrm{N\,m^{2}}$

82.

An uncalibrated analogue voltmeter P is connected in parallel with another voltmeter Q which is known to be accurately calibrated. For a range of values of potential difference (p.d.), readings are taken from the two meters.

The diagram shows the calibration graph obtained.



The graph shows that meter P has a zero error. This meter is now adjusted to remove this zero error. When the meter is recalibrated, the gradient of the calibration graph is found to be unchanged.

What is the new scale reading on meter P when it is used to measure a p.d. of 5.0 V?

A 6.6 **B** 6.7 **C** 7.2 **D** 7.4

S13/11

83.

Which pair of quantities contains one vector and one scalar quantity?

A displacement; force

B kinetic energy; power

C acceleration; momentum

D velocity; distance

84.

One property Q of a material is used to describe the behaviour of sound waves in the material. Q is defined as the pressure P of the sound wave divided by the speed v of the wave and the surface area A of the material through which the wave travels:

$$Q = \frac{P}{vA}.$$

What are the SI base units of Q?

A $\mathrm{kg\,m^2\,s^{-3}}$ **B** $\mathrm{kg\,m^{-3}\,s^{-1}}$ **C** $\mathrm{kg\,m^{-4}\,s^{-1}}$ **D** $\mathrm{kg\,m^{-2}\,s^{-2}}$

85.

A wave has a frequency of 5 GHz.

What is the period of the wave?

A 20 000 µs

B 20 ns

C 2 ns

D 200 ps

86.

In an experiment to determine the acceleration of free fall g, the period of oscillation T and length l of a simple pendulum were measured. The uncertainty in the measurement of l is estimated to be 4%, and the uncertainty in the measurement of T is estimated to be 1%.

The value of g is determined using the formula

$$g = \frac{4\pi^2 l}{T^2}.$$

What is the uncertainty in the calculated value for g?

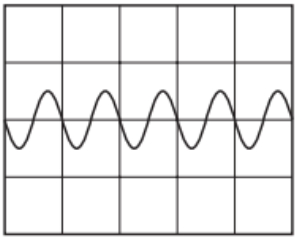
A 2% **B** 3% **C** 5% **D** 6%

87.

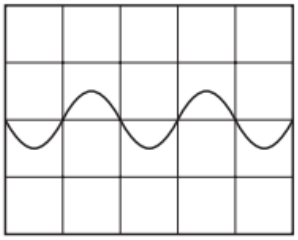
The Y-input terminals of a cathode-ray oscilloscope (c.r.o.) are connected to a supply of amplitude 5.0 V and frequency 50 Hz. The time-base is set at 10 ms per division and the Y-gain at 5.0 V per division.

Which trace is obtained?

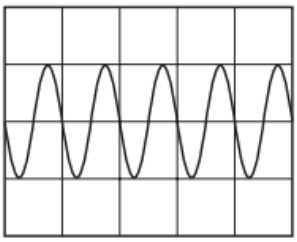
A



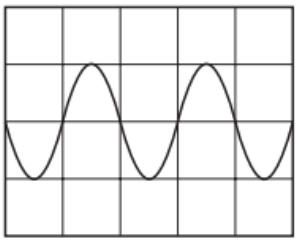
B



C



D



S13/12

88.

Which pair includes a vector quantity and a scalar quantity?

A displacement; acceleration

B force; kinetic energy

C power; speed

D work; potential energy

89.

The unit of resistivity, expressed in terms of base units, is given by

$$\text{kg}\,x^3 y^{-2} z^{-3}.$$

Which base units are x, y and z?

	x	y	z
A	ampere	metre	second
B	metre	ampere	second
C	metre	second	ampere
D	second	ampere	metre

90.

A student carried out an experiment in which an electric current was known to decrease with time. The readings he found, from first to last, were 3.62 mA, 2.81 mA, 1.13 mA, 1.76 mA and 0.90 mA.

Which statement could **not** explain the anomalous 1.13 mA reading?

A He has reversed the third and fourth readings in the results table.

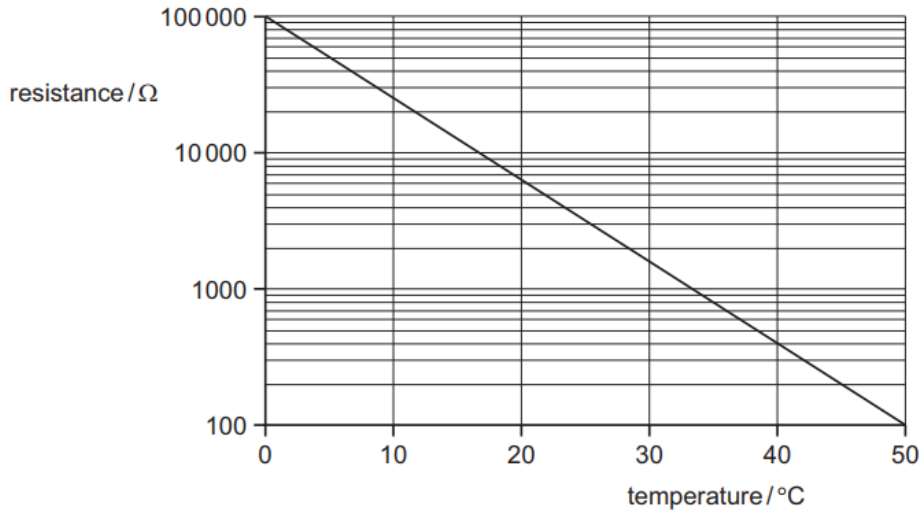
B He read the ammeter incorrectly; the reading should have been 2.13 mA.

C He took the current reading at the wrong time.

D There was a systematic error in the readings from the ammeter.

91.

The diagram shows a calibration curve for a thermistor, drawn with an unusual scale on the vertical axis.



What is the thermistor resistance corresponding to a temperature of 40 °C?

A 130 Ω **B** 150 Ω **C** 400 Ω **D** 940 Ω

S13/13

92.

The diagram shows a displacement vector.

What is the vertical component of this displacement vector?

A 3.0 km **B** 4.0 km **C** 5.0 km **D** 6.6 km

93.

What is the unit of power, expressed in SI base units?

A $kg\,m^2\,s^{-3}$ **B** $kg\,m\,s^{-3}$ **C** $kg\,m\,s^{-2}$ **D** $kg\,m^2\,s^{-1}$

94.

Which statement is **incorrect** by a factor of 100 or more?

A Atmospheric pressure is about 1×10^5 Pa.

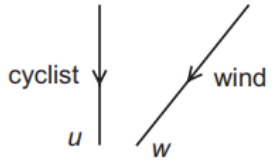
B Light takes 5×10^2 s to reach us from the Sun.

C The frequency of ultra-violet light is 3×10^{12} Hz.

D The life-span of a man is about 2×10^9 s.

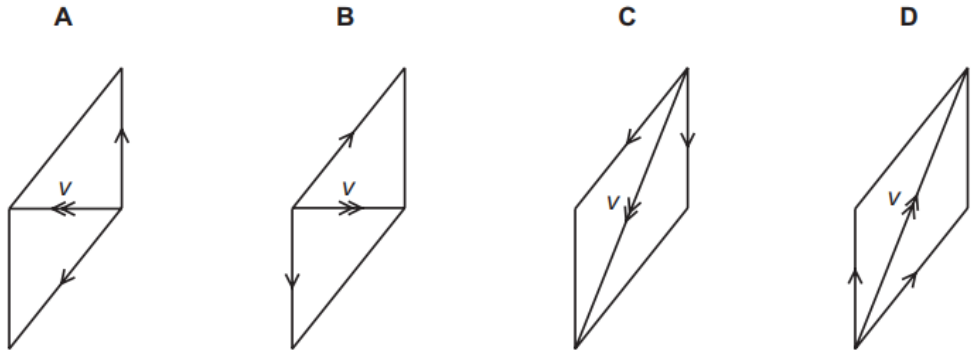
95.

A cyclist is travelling due south with velocity u. The wind is blowing from the north-east with velocity w.



The wind has a velocity v relative to the cyclist, where $v = w - u$.

Which vector diagram shows the magnitude and direction of velocity v?



96.

A student takes measurements of the current in a resistor of constant resistance and the potential difference (p.d.) across it. The readings are then used to plot a graph of current against p.d.

There is a systematic error in the current readings.

How could this be identified from the graph?

A At least one anomalous data point can be identified.

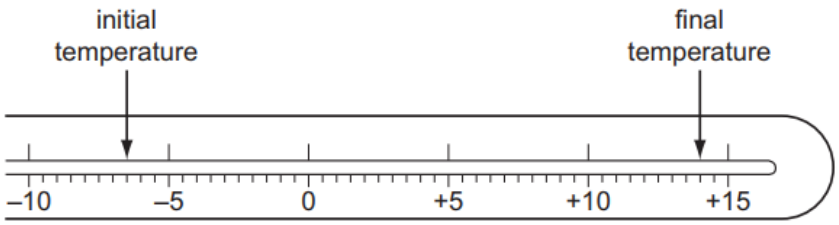
B The data points are scattered about the straight line of best fit.

C The graph is a curve, not a straight line.

D The straight line graph does not pass through the origin.

97.

The diagram shows the stem of a Celsius thermometer, marked to show initial and final temperature values.



What is the temperature change expressed to an appropriate number of significant figures?

A 14 °C **B** 20.5 °C **C** 21 °C **D** 22.0 °C

W12/11

98.

What is the unit of weight in terms of SI base unit(s)?

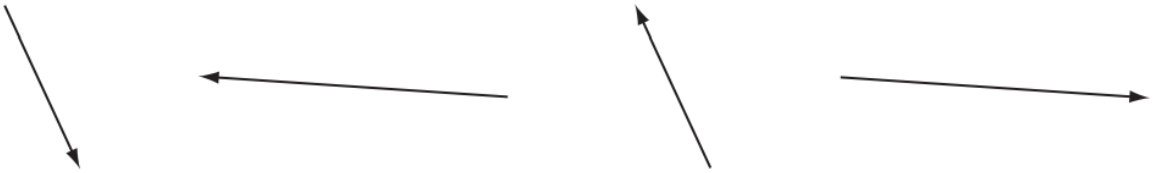
A $kg\,m\,s^{-1}$ **B** $kg\,m\,s^{-2}$ **C** N **D** $J\,m^{-1}$

99.

Vectors P and Q are drawn to scale.

Which diagram represents the vector (P – Q)?

A **B** **C** **D**



100.

What is the approximate temperature of a red-hot ring on an electric cooker?

A 100 °C **B** 200 °C **C** 400 °C **D** 800 °C

101.

Which list contains only scalar quantities?

A area, length, displacement

B kinetic energy, speed, power

C potential energy, momentum, time

D velocity, distance, temperature

102.

The density of the material of a coil of thin wire is to be found.

Which set of instruments could be used to do this most accurately?

A metre rule, protractor, spring balance

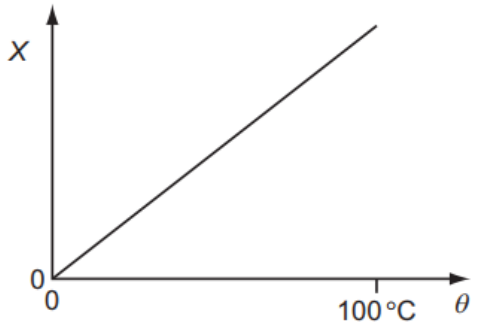
B micrometer, metre rule, top-pan balance

C stopwatch, newton-meter, vernier calipers

D tape measure, vernier calipers, lever balance

103.

A quantity X varies with temperature θ as shown.



θ is determined from the corresponding values of X by using this graph.
X is measured with a percentage uncertainty of ±1 % of its value at all temperatures.

Which statement about the uncertainty in θ is correct?

A The percentage uncertainty in θ is least near 0 °C.

B The percentage uncertainty in θ is least near 100 °C.

C The actual uncertainty in θ is least near 0 °C.

D The actual uncertainty in θ is least near 100 °C.

104.

The measurement of a physical quantity may be subject to random errors and to systematic errors.

Which statement is correct?

A Random errors can be reduced by taking the average of several measurements.

B Random errors are always caused by the person taking the measurement.

C A systematic error cannot be reduced by adjusting the apparatus.

D A systematic error results in a different reading each time the measurement is taken.

W12/12

105.

Which quantity has the same base units as momentum?

A density × energy

B density × volume × velocity

C pressure × area

D weight ÷ area

106.

Vectors P and Q are drawn to scale.

Which diagram represents the vector (P + Q)?

A

B

C

D

107.

What is the approximate kinetic energy of an Olympic athlete when running at maximum speed during a 100 m race?

A 400 J **B** 4000 J **C** 40 000 J **D** 400 000 J

108.

Physical quantities can be classed as vectors or as scalars.

Which pair of quantities are both vectors?

A kinetic energy and elastic force

B momentum and time

C velocity and electric field strength

D weight and temperature

109.

A student is given a reel of wire of diameter less than 0.2 mm and is asked to find the density of the metal.

Which pair of instruments would be most suitable for finding the **volume** of the wire?

A balance and micrometer

B metre rule and micrometer

C metre rule and vernier calipers

D micrometer and vernier calipers

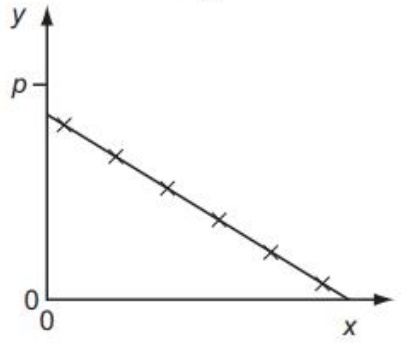
110.

Variables x and y are related by the equation $y = p - qx$ where p and q are constants.

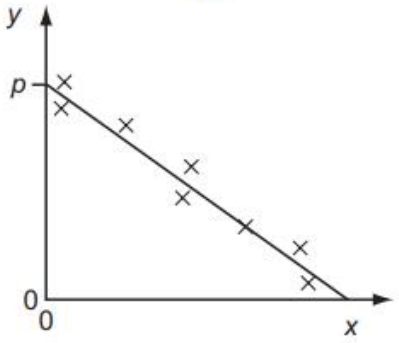
Values of x and y are measured experimentally. The results contain a systematic error.

Which graph best represents these results?

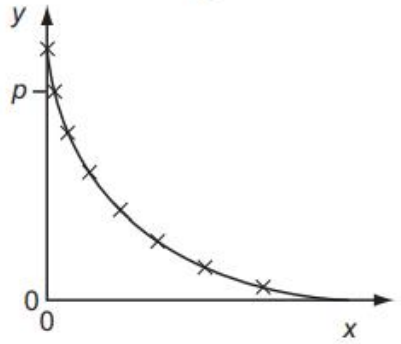
A



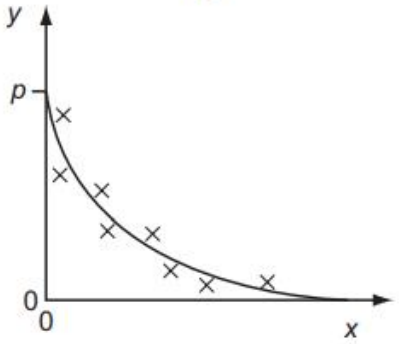
B



C



D



111.

The speed of a car is calculated from measurements of the distance travelled and the time taken.

The distance is measured as 200 m, with an uncertainty of ± 2 m.

The time is measured as 10.0 s, with an uncertainty of ± 0.2 s.

What is the percentage uncertainty in the calculated speed?

A ± 0.5 % **B** ± 1 % **C** ± 2 % **D** ± 3 %

W12/13

112.

The units of all physical quantities can be expressed in terms of SI base units.

Which pair contains quantities with the same base units?

A force and momentum

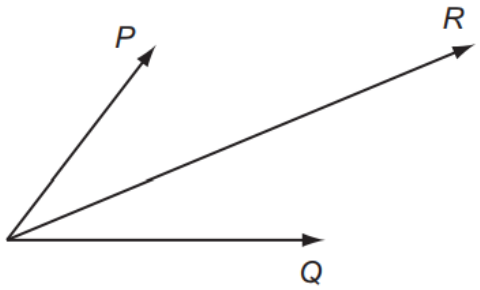
B pressure and Young modulus

C power and kinetic energy

D mass and weight

113.

Two physical quantities *P* and *Q* are added. The sum of *P* and *Q* is *R*, as shown.



Which quantity could be represented by *P* and by *Q*?

A kinetic energy

B power

C speed

D velocity

114.

A 1.5 V cell supplies 0.20 A to a lamp for seven hours before the lamp goes out.

What is a sensible estimate for the initial chemical energy content of the cell?

A 1×10^2 J **B** 1×10^4 J **C** 1×10^6 J **D** 1×10^8 J

115.

Three of these quantities have the same unit.

Which quantity has a different unit?

A $\frac{\text{energy}}{\text{distance}}$

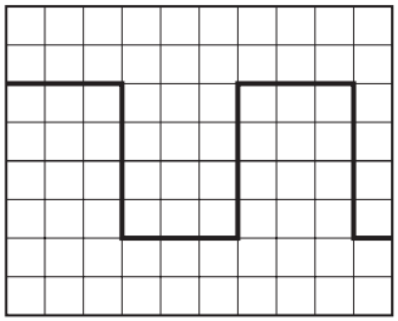
B force

C power × time

D rate of change of momentum

116.

A cathode-ray oscilloscope displays a square wave, as shown in the diagram.



The time-base setting is 0.20 ms per division.

What is the frequency of the square wave?

A 8.3 Hz **B** 830 Hz **C** 1300 Hz **D** 1700 Hz

117.

What will reduce the systematic errors when taking a measurement?

A adjusting the needle on a voltmeter so that it reads zero when there is no potential difference across it

B measuring the diameter of a wire at different points and taking the average

C reducing the parallax effects by using a marker and a mirror when measuring the amplitude of oscillation of a pendulum

D timing 20 oscillations, rather than a single oscillation, when finding the period of a pendulum

118.

In an experiment to determine the acceleration of free fall g, the time t taken for a ball to fall through distance s was measured. The uncertainty in the measurement of s is estimated to be 2%. The uncertainty in the measurement of t is estimated to be 3%.

The value of g is determined using the equation

$$g = \frac{2s}{t^2}.$$

What is the uncertainty in the calculated value of g?

A 1% **B** 5% **C** 8% **D** 11%

S12/11

119.

When a force F moves its point of application through a displacement s in the direction of the force, the work W done by the force is given by

$$W = Fs.$$

How many vector quantities and scalar quantities does this equation contain?

A one scalar quantity and two vector quantities

B one vector quantity and two scalar quantities

C three scalar quantities

D three vector quantities

120.

What is a possible unit for the product VI, where V is the potential difference across a resistor and I is the current through the same resistor?

A newton per second ($\mathrm{N\,s^{-1}}$)

B newton second (N s)

C newton metre (N m)

D newton metre per second ($\mathrm{N\,m\,s^{-1}}$)

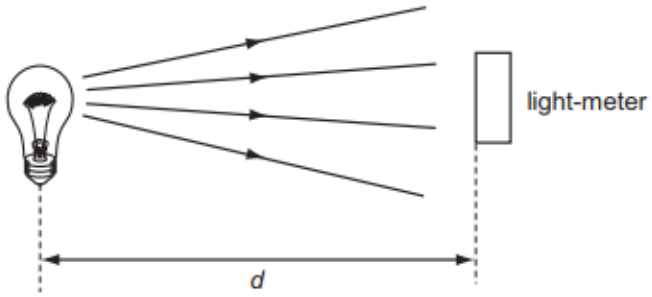
121.

What is a reasonable estimate of the average kinetic energy of an athlete during a 100 m race that takes 10 s?

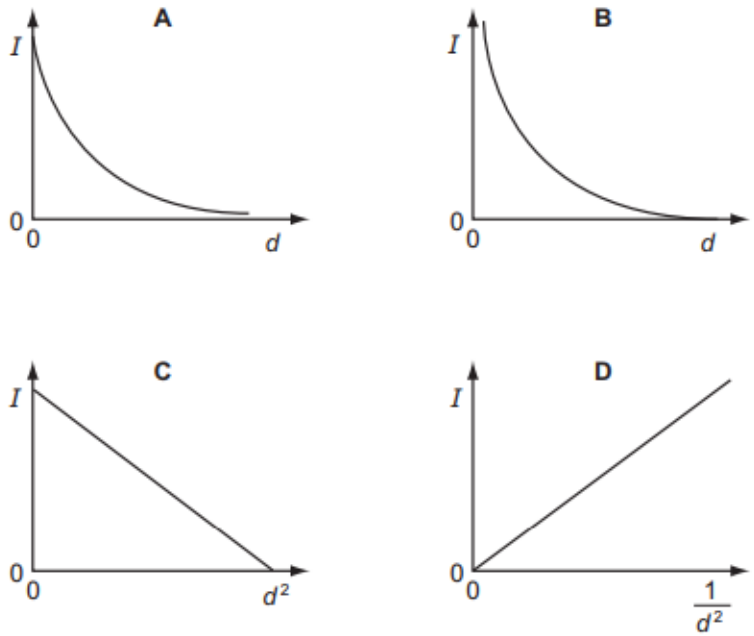
A 40 J **B** 400 J **C** 4000 J **D** 40 000 J

122.

A light-meter measures the intensity I of the light falling on it. Theory suggests that I varies inversely as the square of the distance d.



Which graph of the results supports this theory?



123.

In an experiment, a radio-controlled car takes 2.50 ± 0.05 s to travel 40.0 ± 0.1 m.

What is the car's average speed and the uncertainty in this value?

A $16 \pm 1\,m\,s^{-1}$

B $16.0 \pm 0.2\,m\,s^{-1}$

C $16.0 \pm 0.4\,m\,s^{-1}$

D $16.00 \pm 0.36\,m\,s^{-1}$

124.

In an experiment to determine the acceleration of free fall using a falling body, what would lead to a value that is too large?

A air resistance

B dimensions of the body are too large

C measured distance longer than true distance

D measured time longer than true time

S12/12

125.

What is the unit watt in terms of SI base units?

A $J\,s^{-1}$ **B** $m^2\,kg\,s^{-1}$ **C** $m^2\,kg\,s^{-3}$ **D** $N\,m\,s^{-1}$

126.

For which quantity is the magnitude a reasonable estimate?

A frequency of a radio wave 500 pHz

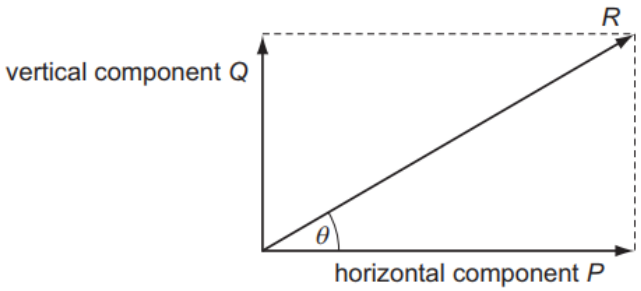
B mass of an atom 500 μg

C the Young modulus of a metal 500 kPa

D wavelength of green light 500 nm

127.

A vector has magnitude *R* and perpendicular components *P* and *Q*, as shown in the diagram.



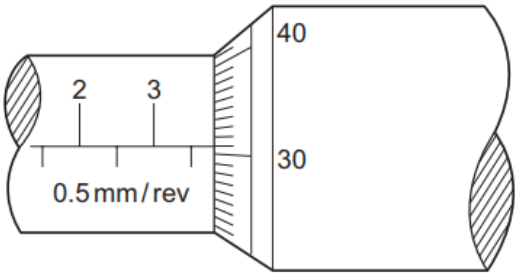
Which row correctly describes the perpendicular components?

	vertical component	horizontal component
A	Q	$R\sin\theta$
B	$R\cos\theta$	P
C	$R\cos\theta$	$R\sin\theta$
D	$R\sin\theta$	$R\cos\theta$

128.

The diameter of a cylindrical metal rod is measured using a micrometer screw gauge.

The diagram below shows an enlargement of the scale on the micrometer screw gauge when taking the measurement.



What is the cross-sectional area of the rod?

A $3.81\,mm^2$ **B** $11.4\,mm^2$ **C** $22.8\,mm^2$ **D** $45.6\,mm^2$

129.

A mass is dropped from rest, and falls through a distance of 2.0 m in a vacuum. An observer records the time taken for the mass to fall through this distance using a manually operated stopwatch and repeats the measurements a further two times. The average result of these measured times, displayed in the table below, was used to determine a value for the acceleration of free fall. This was calculated to be $9.8\,m\,s^{-2}$.

	first measurement	second measurement	third measurement	average
time / s	0.6	0.73	0.59	0.64

Which statement best relates to the experiment?

A The measurements are precise and accurate with no evidence of random errors.

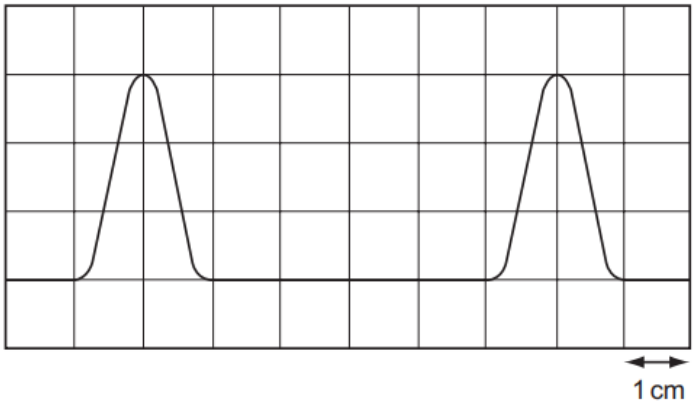
B The measurements are not accurate and not always recorded to the degree of precision of the measuring device but the calculated experimental result is accurate.

C The measurements are not always recorded to the degree of precision of the measuring device but are accurate. Systematic errors may be present.

D The range of results shows that there were random errors made but the calculated value is correct so the experiment was successful.

130.

The diagram shows two complete pulses on the screen of a cathode-ray oscilloscope. A grid of 1 cm squares covers the screen. The time-base setting is 1 $\mu s\,cm^{-1}$.



How long does each pulse last?

A 2 μs **B** 3 μs **C** 4 μs **D** 6 μs

W11/11

131.

Which statement using prefixes of the base unit metre (m) is **not** correct?

A 1 pm = 10^{-12} m

B 1 nm = 10^{-9} m

C 1 Mm = 10^{6} m

D 1 Gm = 10^{12} m

132.

An Olympic athlete of mass 80 kg competes in a 100 m race.

What is the best estimate of his mean kinetic energy during the race?

A 4×10^{2} J **B** 4×10^{3} J **C** 4×10^{4} J **D** 4×10^{5} J

133.

Which group of quantities contains only vectors?

A acceleration, displacement, speed

B acceleration, work, electric field strength

C displacement, force, velocity

D power, electric field strength, force

134.

A cylindrical tube rolling down a slope of inclination θ moves a distance L in time T. The equation relating these quantities is

$$L\left(3+\frac{a^2}{P}\right) = QT^2 \sin\theta$$

Where a is the internal radius of the tube and P and Q are constants.

Which line gives the correct units for P and Q?

	P	Q
A	m^2	$m^2 s^{-2}$
B	m^2	$m s^{-2}$
C	m^2	$m^3 s^{-2}$
D	m^3	$m s^{-2}$

135.

The Young modulus of the material of a wire is to be found. The Young modulus E is given by the equation below.

$$E = \frac{4Fl}{\pi d^2 x}$$

The wire is extended by a known force and the following measurements are made.

Which measurement has the largest effect on the uncertainty in the value of the calculated Young modulus?

	measurement	symbol	value
A	length of wire before force applied	l	2.043 ± 0.002 m
B	diameter of wire	d	0.54 ± 0.02 mm
C	force applied	F	19.62 ± 0.01 N
D	extension of wire with force applied	x	5.2 ± 0.2 mm

W11/12

136.

Which quantity can be measured in electronvolts (eV)?

A electric charge

B electric potential

C energy

D power

137.

What is the ratio $\frac{10^{-3}\ \text{THz}}{10^{3}\ \text{kHz}}$?

A 10^{-9} **B** 10^{-6} **C** 10^{0} **D** 10^{3}

138.

The following physical quantities can be either positive or negative.

s : displacement of a particle along a straight line

θ : temperature on the Celsius scale

q : electric charge

V : readings on a digital voltmeter

Which of these quantities are vectors?

A s, θ, q, V **B** s, q, V only **C** θ, V only **D** s only

139.

A micrometer is used to measure the diameters of two cylinders.

diameter of first cylinder = 12.78 ± 0.02 mm

diameter of second cylinder = 16.24 ± 0.03 mm

The difference in the diameters is calculated.

What is the uncertainty in this difference?

A ± 0.01 mm **B** ± 0.02 mm **C** ± 0.03 mm **D** ± 0.05 mm

140.

The speedometer in a car consists of a pointer which rotates. The pointer is situated several millimetres from a calibrated scale.

What could cause a random error in the driver's measurement of the car's speed?

A The car's speed is affected by the wind direction.

B The driver's eye is not always in the same position in relation to the pointer.

C The speedometer does not read zero when the car is at rest.

D The speedometer reads 10 % higher than the car's actual speed.

S11/11

141.

Decimal sub-multiples and multiples of units are indicated using a prefix to the unit. For example, the prefix milli (m) represents 10^{-3}.

Which row gives the sub-multiples or multiples represented by pico (p) and giga (G)?

	pico (p)	giga (G)
A	10^{-9}	10^{9}
B	10^{-9}	10^{12}
C	10^{-12}	10^{9}
D	10^{-12}	10^{12}

142.

Which definition is correct and uses only quantities rather than units?

A Density is mass per cubic metre.

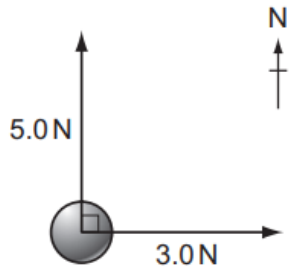
B Potential difference is energy per unit current.

C Pressure is force per unit area.

D Speed is distance travelled per second.

143.

A force of 5.0 N pushes a ball due north and another force of 3.0 N pushes it due east.



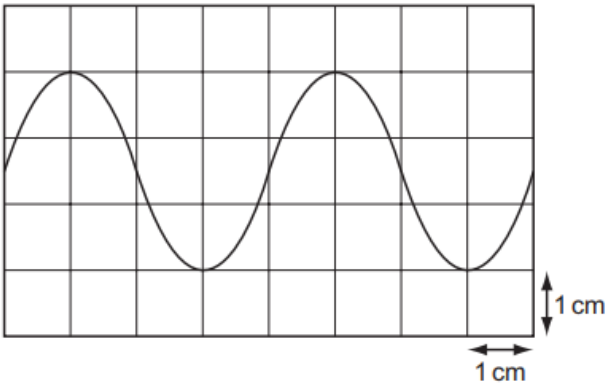
What is the magnitude of the net force acting on the ball?

A 2.8 N **B** 4.0 N **C** 5.8 N **D** 8.0 N

144.

The diagram shows a trace of a wave on a cathode-ray oscilloscope.

The vertical and horizontal gridlines have a spacing of 1.0 cm. The voltage scaling is 4 V cm^{-1} and the time scaling is 5 ms cm^{-1}.

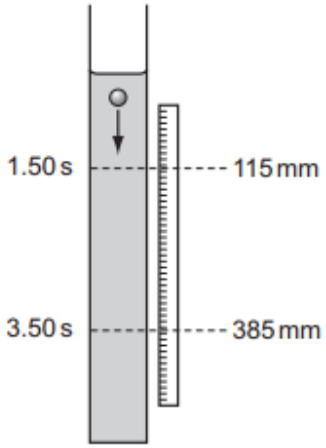


What are the amplitude and period of the wave?

	amplitude / V	period / ms
A	1.5	4
B	5.0	10
C	6.0	20
D	12.0	20

145.

The diagram shows an experiment to measure the speed of a small ball falling at constant speed through a clear liquid in a glass tube.



There are two marks on the tube. The top mark is positioned at 115 ± 1 mm on the adjacent rule and the lower mark at 385 ± 1 mm. The ball passes the top mark at 1.50 ± 0.02 s and passes the lower mark at 3.50 ± 0.02 s.

The constant speed of the ball is calculated by $\frac{385-115}{3.50-1.50} = \frac{270}{2.00} = 135\,\text{mm s}^{-1}$.

Which expression calculates the fractional uncertainty in the value of this speed?

A $\frac{2}{270} + \frac{0.04}{2.00}$

B $\frac{2}{270} - \frac{0.04}{2.00}$

C $\frac{1}{270} \times \frac{0.02}{2.00}$

D $\frac{1}{270} \div \frac{0.02}{2.00}$

S11/12

146.

Stress has the same SI base units as

A $\frac{\text{force}}{\text{mass}}$.

B $\frac{\text{force}}{\text{length}}$.

C $\frac{\text{force}}{\text{area}}$.

D energy.

147.

To check calculations, the units are put into the following equations together with the numbers.

Which equation must be **incorrect**?

A force = 300 J / 6 m

B power = 6000 J × 20 s

C time = 6 m / 30 m s^{-1}

D velocity = 4 m s^{-2} × 30 s

148.

In making reasonable estimates of physical quantities, which statement is **not** correct?

A The frequency of sound can be of the order of GHz.

B The wavelength of light can be of the order of 600 nm.

C The Young modulus can be of the order of 10^{11} Pa.

D Beta radiation is associated with one unit of negative charge.

149.

The uncertainty in the value of the momentum of a trolley passing between two points X and Y varies with the choice of measuring devices.

Measurements for the same trolley made by different instruments were recorded.

1 distance between X and Y using a metre rule with cm divisions = 0.55 m

2 distance between X and Y using a metre rule with mm divisions = 0.547 m

3 timings using a wristwatch measuring to the nearest 0.5 s at X = 0.0 s and at Y = 4.5 s

4 timings using light gates measuring to the nearest 0.1 s at X = 0.0 s and at Y = 4.3 s

5 mass of trolley using a balance measuring to the nearest g = 6.4 × 10^{-2} kg

6 mass of trolley using a balance measuring to the nearest 10 g = 6 × 10^{-2} kg

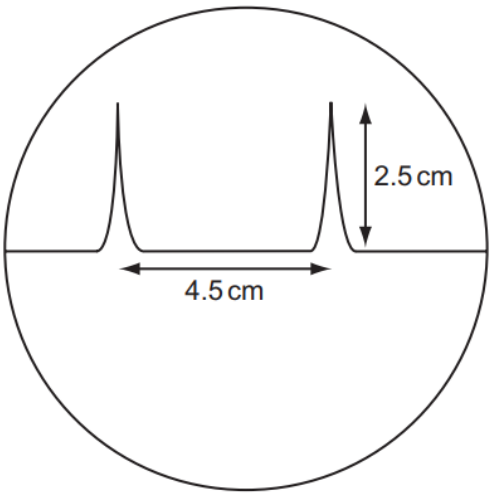
Which measurements, one for each quantity measured, lead to the least uncertainty in the value of the momentum of the trolley?

A 1, 3 and 6 **B** 1, 4 and 6 **C** 2, 3 and 6 **D** 2, 4 and 5

150.

The time-base on a cathode-ray oscilloscope is set at 6 ms / cm.

A trace consisting of two pulses is recorded as shown in the diagram.



What is the time interval between the two pulses?

A 0.42 ms **B** 0.75 ms **C** 1.33 ms **D** 27 ms

W10/11

151.

A signal has a frequency of 2.0 MHz.

What is the period of the signal?

A 2 μs **B** 5 μs **C** 200 ns **D** 500 ns

152.

A metal sphere of radius r is dropped into a tank of water. As it sinks at speed v, it experiences a drag force F given by $F = krv$, where k is a constant.

What are the SI base units of k?

A $kg\,m^2\,s^{-1}$ **B** $kg\,m^{-2}\,s^{-2}$ **C** $kg\,m^{-1}\,s^{-1}$ **D** $kg\,m\,s^{-2}$

153.

Which physical quantity would result from a calculation in which a potential difference is multiplied by an electric charge?

A electric current

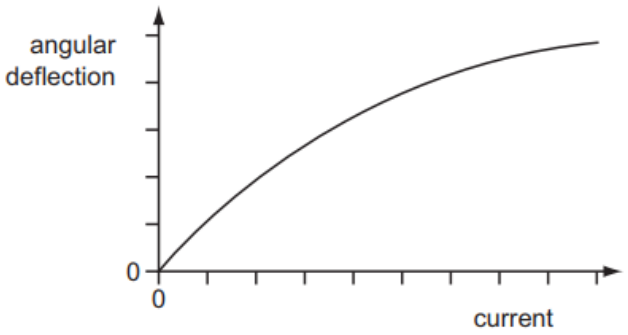
B electric energy

C electric field strength

D electric power

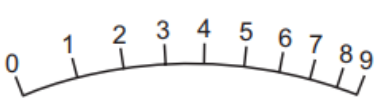
154.

The angular deflection of the needle of an ammeter varies with the current passing through the ammeter as shown in the graph.

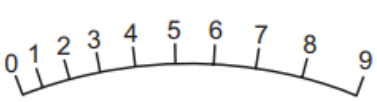


Which diagram could represent the appearance of the scale on this meter?

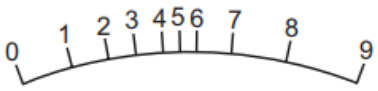
A



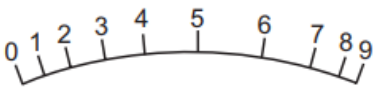
B



C

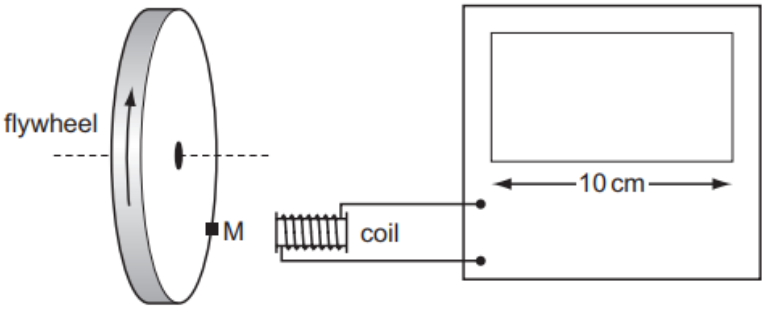


D



155.

The diagram shows a cathode-ray oscilloscope (c.r.o.) being used to measure the rate of rotation of a flywheel.



The flywheel has a small magnet M mounted on it. Each time the magnet passes the coil, a voltage pulse is generated, which is passed to the c.r.o. The display of the c.r.o. is 10 cm wide. The flywheel is rotating at a rate of about 3000 revolutions per minute.

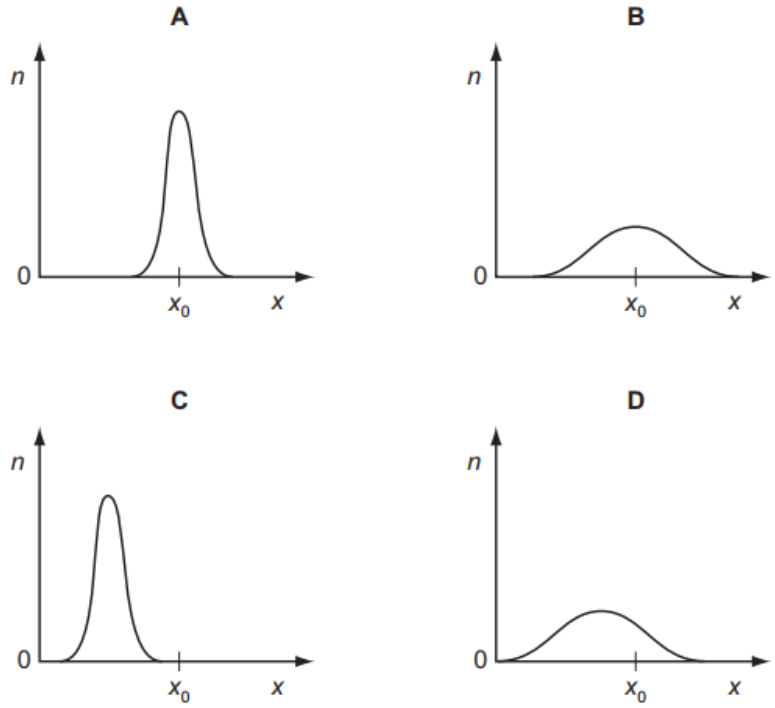
Which time-base setting will display clearly separate pulses on the screen?

A $1\,s\,cm^{-1}$ **B** $10\,ms\,cm^{-1}$ **C** $100\,\mu s\,cm^{-1}$ **D** $1\,\mu s\,cm^{-1}$

156.

A fixed quantity x_0 is measured many times in an experiment that has experimental uncertainty. A graph is plotted to show the number n of times that a particular value x is obtained.

Which graph could be obtained if the measurement of x_0 has a large systematic error but a small random error?



W10/12

157.

Which row shows a base quantity with its correct SI unit?

	quantity	unit
A	current	A
B	mass	g
C	temperature	°C
D	weight	N

158.

The frictional force F on a sphere falling through a fluid is given by the formula

$$F = 6\pi a \eta v$$

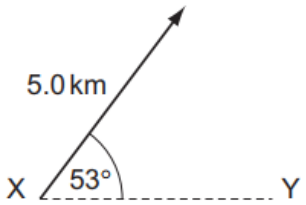
where a is the radius of the sphere, η is a constant relating to the fluid and v is the velocity of the sphere.

What are the units of η?

A $kg\,m\,s^{-1}$ **B** $kg\,m^{-1}\,s^{-1}$ **C** $kg\,m\,s^{-3}$ **D** $kg\,m^{3}\,s^{-3}$

159.

What is the component of this displacement vector in the direction XY?



A 3.0 km **B** 4.0 km **C** 5.0 km **D** 6.6 km

160.

A metre rule is used to measure the length of a piece of wire. It is found to be 70 cm long to the nearest millimetre.

How should this result be recorded in a table of results?

A 0.7 m **B** 0.70 m **C** 0.700 m **D** 0.7000 m

161.

A quantity x is to be determined from the equation

$$x = P - Q.$$

P is measured as 1.27 ± 0.02 m.

Q is measured as 0.83 ± 0.01 m.

What is the percentage uncertainty in x to one significant figure?

A 0.4 % **B** 2 % **C** 3 % **D** 7 %

S10/11

162.

The SI unit for potential difference (the volt) is given, in base units, by

A $\text{kg m A}^{-1}\text{s}^{-3}$.

B $\text{m}^2\text{A}^{-1}\text{s}^{-2}$.

C $\text{kg m}^2\text{s}^{-2}$.

D $\text{kg m}^2\text{A}^{-1}\text{s}^{-3}$.

163.

The product of pressure and volume has the same SI base units as

A energy.

B force.

C $\frac{\text{force}}{\text{area}}$.

D $\frac{\text{force}}{\text{length}}$.

164.

An ion is accelerated by a series of electrodes in a vacuum. A graph of the power supplied to the ion is plotted against time.

What is represented by the area under the graph between two times?

A the change in kinetic energy of the ion

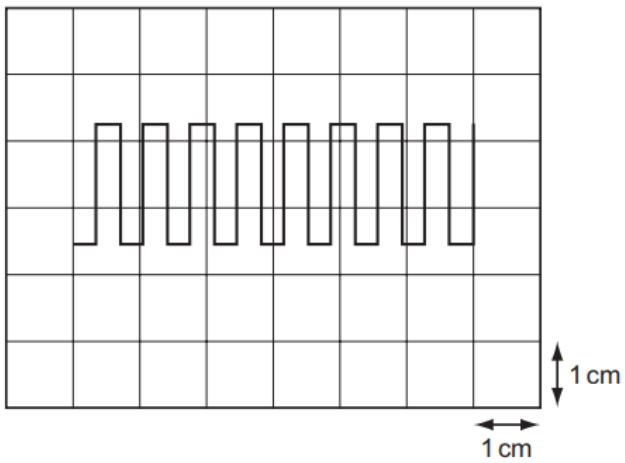
B the average force on the ion

C the change in momentum of the ion

D the change in velocity of the ion

165.

The diagram shows a square-wave trace on the screen of a cathode-ray oscilloscope. A grid of 1 cm squares covers the screen. The time-base setting is 10 ms cm^{-1}.

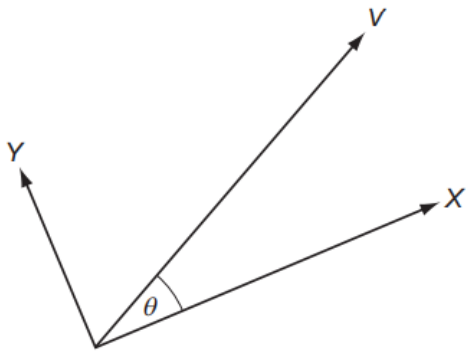


What is the approximate frequency of the square wave?

A 70 Hz **B** 140 Hz **C** 280 Hz **D** 1400 Hz

166.

A vector quantity V is resolved into two perpendicular components X and Y. The angle between V and component X is θ.



The angle between component X and the vector V is increased from 0° to 90°.

How do the magnitudes of X and Y change as the angle θ is increased in this way?

	X	Y
A	increase	increase
B	increase	decrease
C	decrease	increase
D	decrease	decrease

167.

A student finds the density of a liquid by measuring its mass and its volume. The following is a summary of his measurements.

mass of empty beaker = (20 ± 1) g

mass of beaker + liquid = (70 ± 1) g

volume of liquid = (10.0 ± 0.6) cm^3

He correctly calculates the density of the liquid as 5.0 g cm^{-3}.

What is the uncertainty in this value?

A 0.3 g cm^{-3} **B** 0.5 g cm^{-3} **C** 0.6 g cm^{-3} **D** 2.6 g cm^{-3}

168.

A micrometer screw gauge is used to measure the diameter of a copper wire.

The reading with the wire in position is shown in diagram 1. The wire is removed and the jaws of the micrometer are closed. The new reading is shown in diagram 2.

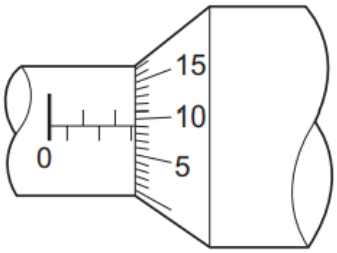


diagram 1

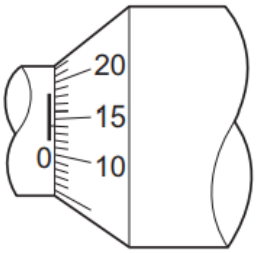


diagram 2

What is the diameter of the wire?

A 1.90 mm **B** 2.45 mm **C** 2.59 mm **D** 2.73 mm

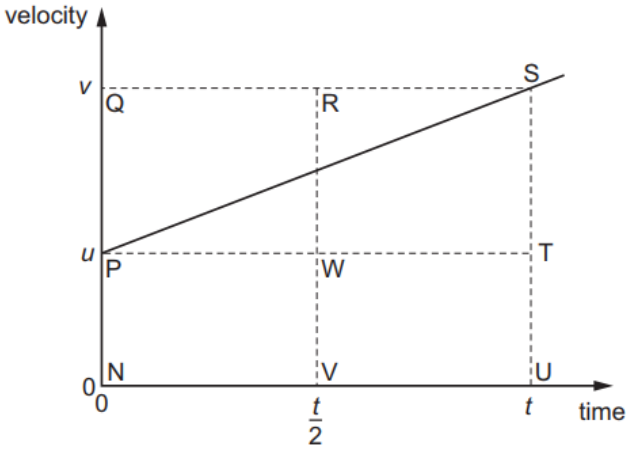
New Topic 2:

2. Kinematics

S16/11

1.

6 A car accelerates uniformly from velocity u to velocity v in time t.



On the graph, which area equals the distance travelled by the car in time t?

A NPTU + PQST

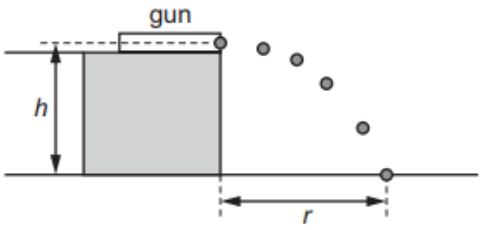
B NPWV + VRSU

C NPWV + WRST

D PST + PQS

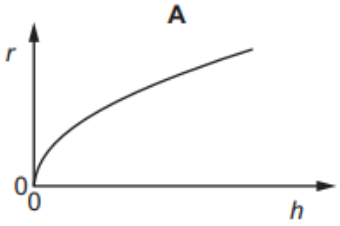
2.

7 A student uses a spring gun to launch a steel ball with a constant horizontal velocity. He varies the height *h* of the gun and measures the horizontal displacement *r* of the ball when it hits the ground.

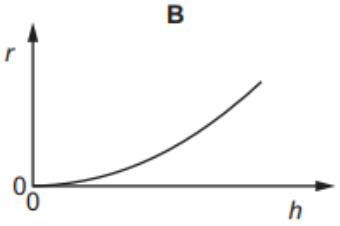


Which graph shows the variation with height *h* of the horizontal displacement *r*?

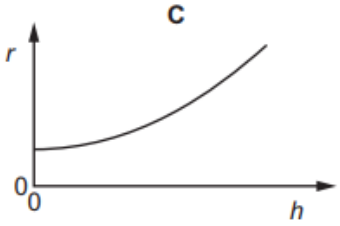
A



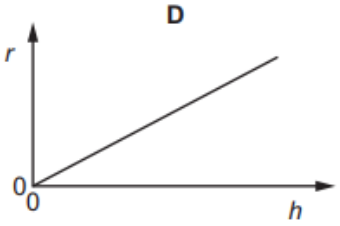
B



C



D

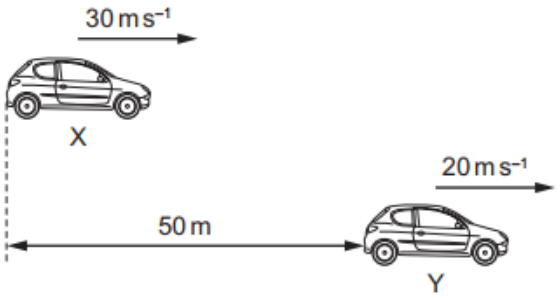


3.

Two cars X and Y are positioned as shown at time $t = 0$.

They are travelling in the same direction.

X is 50 m behind Y and has a constant velocity of 30 m s^{-1}. Y has a constant velocity of 20 m s^{-1}.



What is the value of *t* when X is level with Y?

A 1.0 s **B** 1.7 s **C** 2.5 s **D** 5.0 s

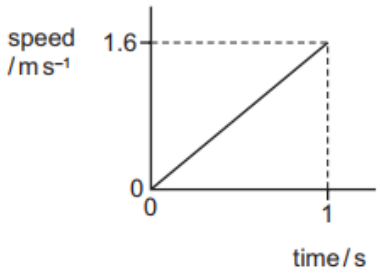
S16/12

4.

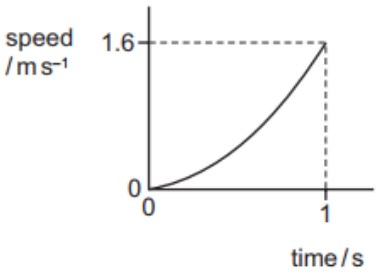
6 The acceleration of free fall on the Moon is $1.6\,m\,s^{-2}$. The Moon has no atmosphere. An astronaut standing on the surface of the Moon drops a feather.

Which graph shows the variation with time of the speed of the feather during the first second of its fall?

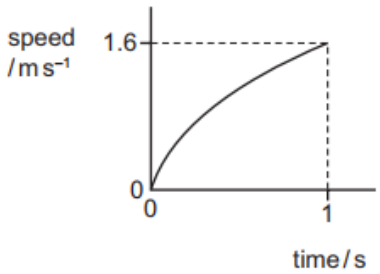
A



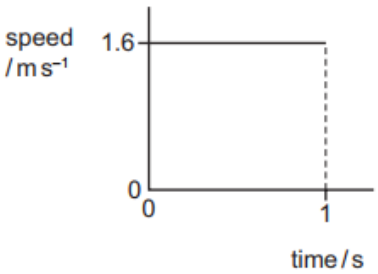
B



C



D

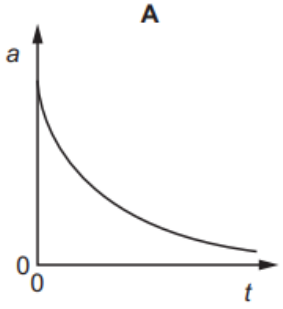


5.

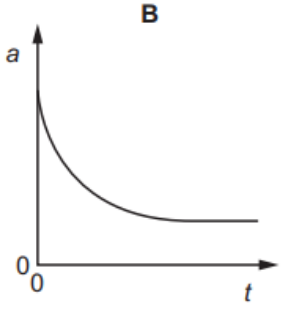
7 A tennis ball is released from rest at the top of a tall building.

Which graph best represents the variation with time *t* of the acceleration *a* of the ball as it falls, assuming that the effect of air resistance is **not** negligible?

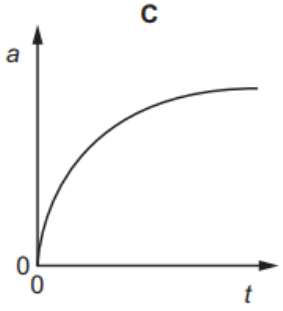
A



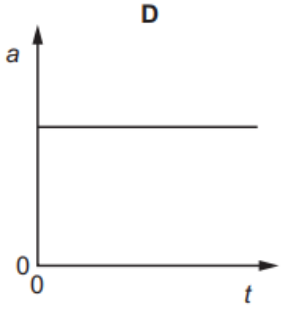
B



C

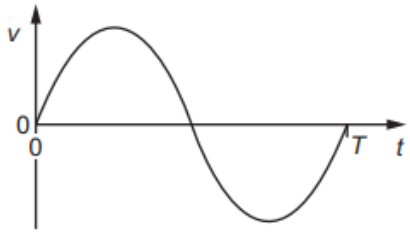


D



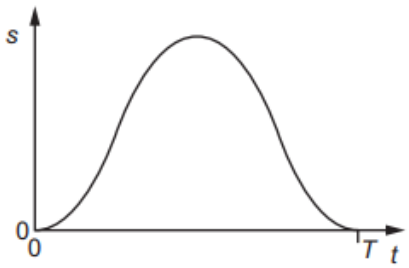
6.

8 The graph shows how the velocity v of an object moving in a straight line varies with time t from $t = 0$ to $t = T$.

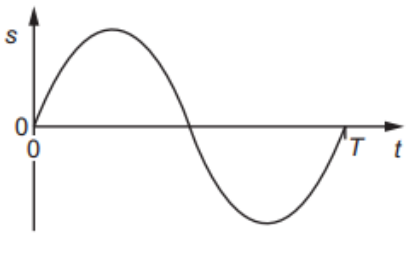


Which graph represents the displacement s of the object in the time $t = 0$ to $t = T$?

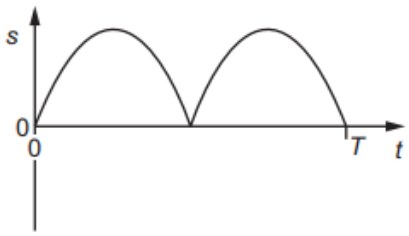
A



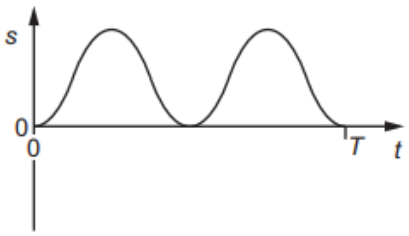
B



C



D

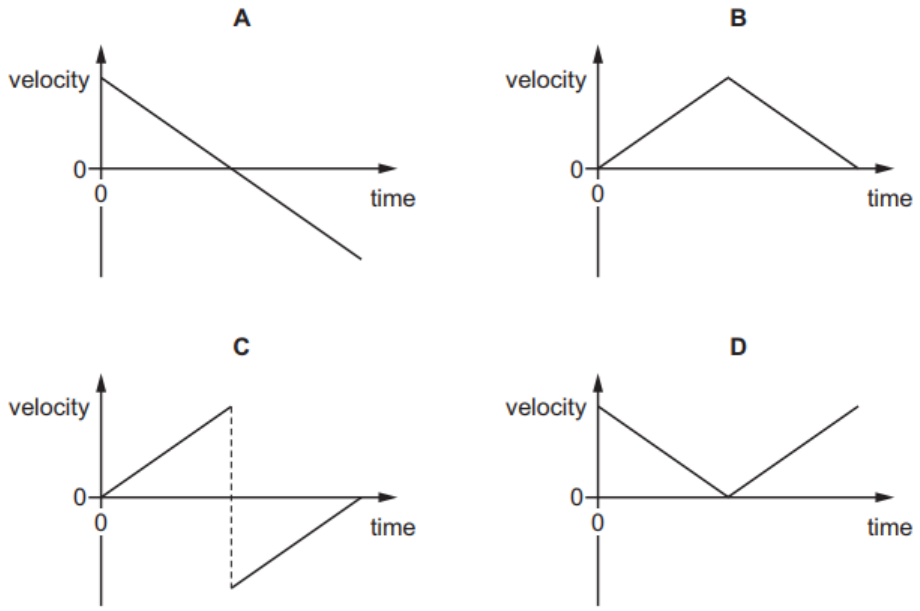


S16/13

7.

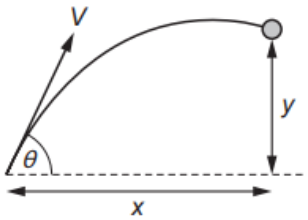
6 A ball rolls in a straight line up a ramp and then back down the ramp along its original path.

Which graph shows the variation with time of the ball's velocity?



8.

7 A ball is thrown with velocity V at an angle θ to the horizontal.



The acceleration of free fall is g. Assume that air resistance is negligible.

What are the horizontal displacement x and the vertical displacement y after time t?

	x	y
A	$Vt\cos\theta$	$Vt\sin\theta + \frac{1}{2}gt^2$
B	$Vt\cos\theta$	$Vt\sin\theta - \frac{1}{2}gt^2$
C	$Vt\sin\theta$	$Vt\cos\theta + \frac{1}{2}gt^2$
D	$Vt\sin\theta$	$Vt\cos\theta - \frac{1}{2}gt^2$

9.

8 A ball travels from point X to point Y around a semi-circular track of radius 1.0 m as shown.

What is the displacement of the ball from X to Y?

A 2.0 m

B 2.0 m due south

C 3.1 m

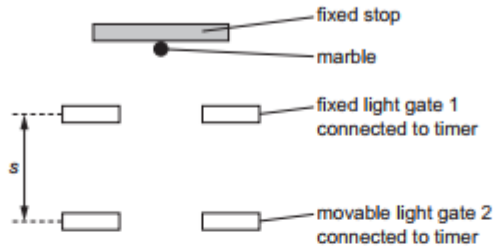
D 3.1 m due south

W15/11

10. 7 One of the equations of uniformly accelerated motion is shown.

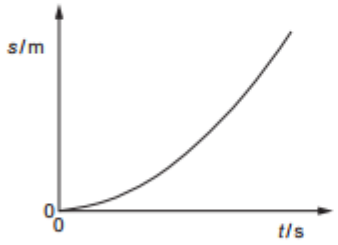
$$s = ut + \tfrac{1}{2}at^2$$

Apparatus is arranged to record the time t taken for a marble to fall between two light gates connected to timers. The marble touches the stop before it is released. The vertical distance s between the light gates is measured.

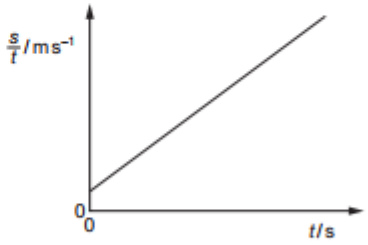


Which graph does **not** show a correct relationship when light gate 2 moves up to light gate 1 which is fixed?

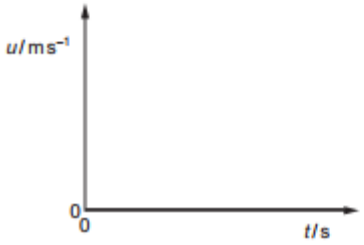
A



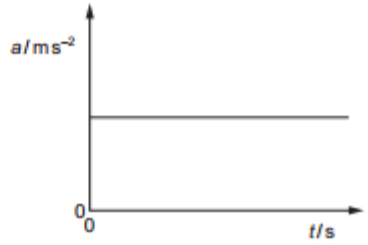
B



C

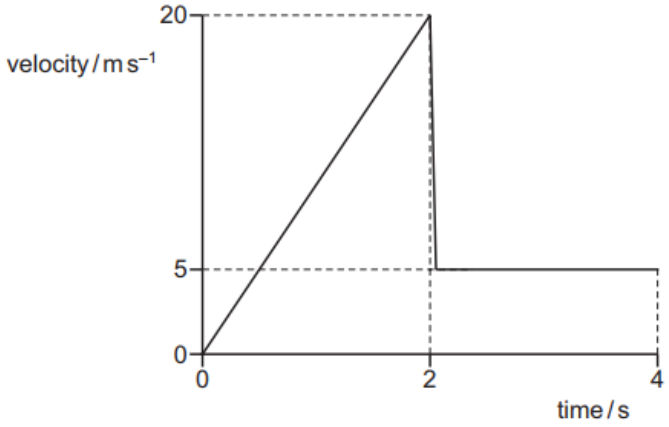


D



11.

8 A stone is dropped from a height of 20 m above water. The graph shows the variation with time of the velocity of the stone.



Which statement describes the approximate position of the stone four seconds after it is dropped?

A It is at a distance of 10 m above the surface of the water.

B It is at a distance of 10 m below the surface of the water.

C It is at a distance of 20 m below the surface of the water.

D It is at a distance of 30 m below the surface of the water.

12.

9 The water surface in a deep well is 78.0 m below the top of the well. A person at the top of the well drops a heavy stone down the well.

Air resistance is negligible. The speed of sound in the air is 330 m s^{-1}.

What is the time interval between the person dropping the stone and hearing it hitting the water?

A 3.75 s **B** 3.99 s **C** 4.19 s **D** 4.22 s

W15/12

13.

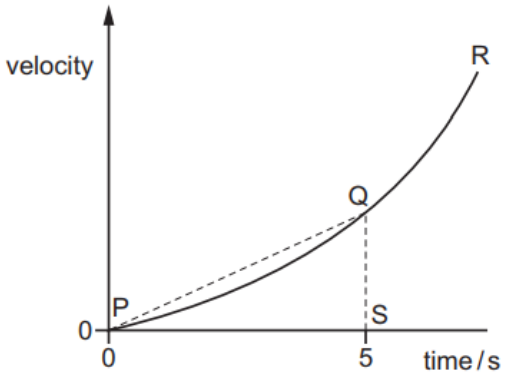
7 A boy throws a ball vertically upwards. It rises to a maximum height, where it is momentarily at rest, and then falls back to his hands.

Which row gives the acceleration of the ball at various stages in its motion? (Take vertically upwards as positive. Ignore air resistance.)

	rising	at maximum height	falling
A	–9.81 m s^{-2}	0	+9.81 m s^{-2}
B	–9.81 m s^{-2}	–9.81 m s^{-2}	–9.81 m s^{-2}
C	+9.81 m s^{-2}	+9.81 m s^{-2}	+9.81 m s^{-2}
D	+9.81 m s^{-2}	0	–9.81 m s^{-2}

14.

8 The curved line PQR is the velocity-time graph for a car starting from rest.



What is the average acceleration of the car over the first 5 s?

A the area below the curve PQ

B the area of the triangle PQS

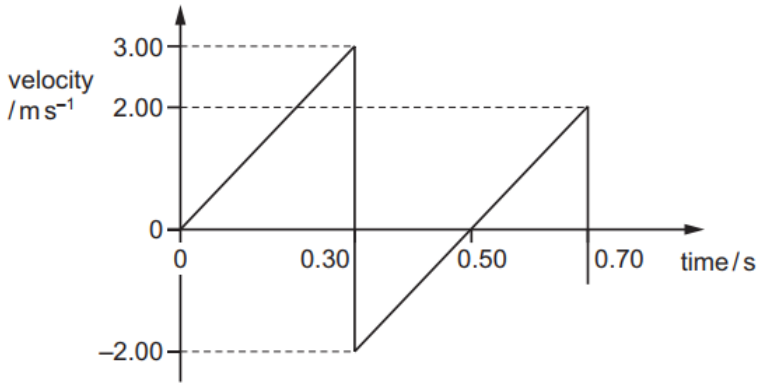
C the gradient of the straight line PQ

D the gradient of the tangent at Q

15.

9 A ball is released from rest above a horizontal surface. It strikes the surface and bounces several times.

The velocity-time graph for the first two bounces is shown.

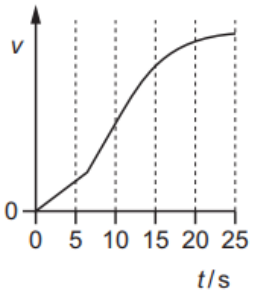


What is the maximum height of the ball after the first bounce?

A 0.20 m **B** 0.25 m **C** 0.45 m **D** 0.65 m

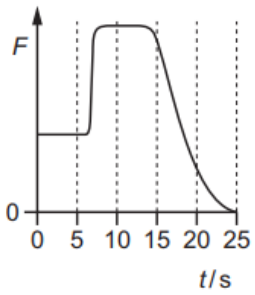
16.

10 A bus takes a time of 25 s to reach a constant speed while travelling in a straight line. A graph of speed *v* against time *t* is shown.

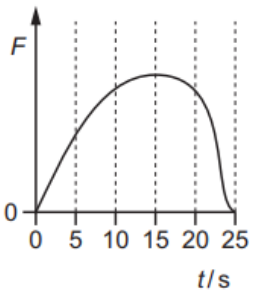


Which graph shows the variation with *t* of the resultant force *F* on the bus?

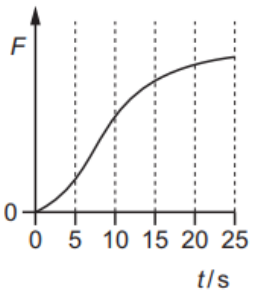
A



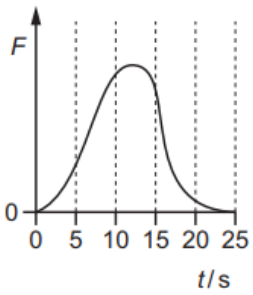
B



C



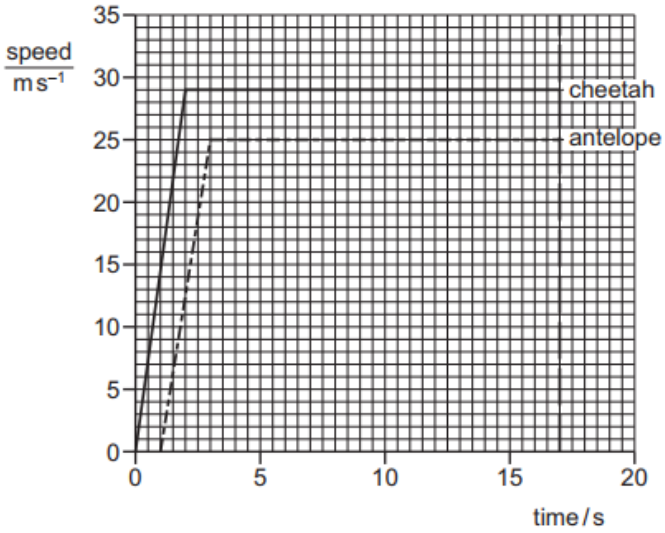
D



W15/13

17.

8 A cheetah and an antelope are 100 m apart. The cheetah spots the antelope and runs towards it. The antelope reacts to the cheetah after one second and runs directly away from the cheetah. Both animals take 2 seconds to reach their top speeds. The graph shows how the speeds of the two animals vary with time.

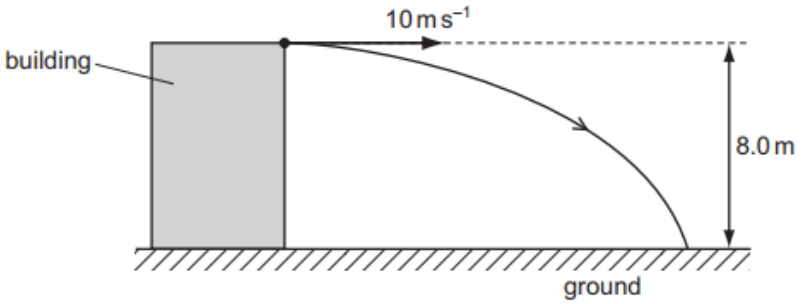


How far apart are the animals, 17 seconds after the cheetah began running?

A 4 m **B** 11 m **C** 54 m **D** 89 m

18.

9 A boy throws a stone with a horizontal velocity of $10\,m\,s^{-1}$ from the top of a building. The height of the building is 8.0 m. The stone travels along a curved path until it hits the ground, as shown in the diagram.

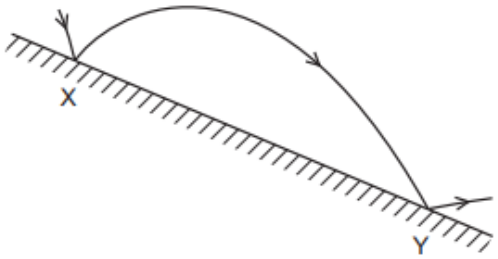


How long does it take the stone to reach the ground? (Air resistance can be neglected.)

A 0.61 s **B** 0.80 s **C** 1.3 s **D** 1.6 s

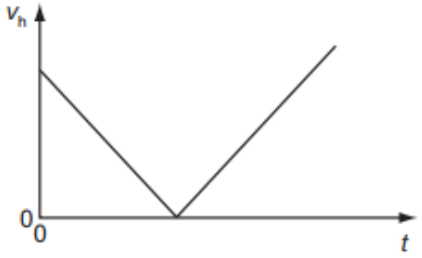
19.

10 A football is released above a plane, sloping surface and bounces several times. The diagram shows its path between its bounces at X and at Y. Assume that there is no air resistance.

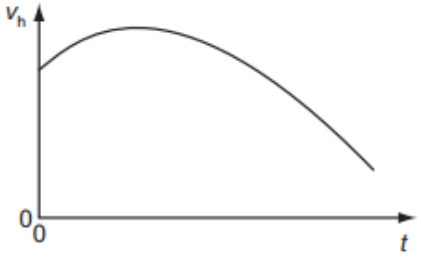


Which graph correctly shows the variation with time t of the horizontal component of its velocity v_h between X and Y?

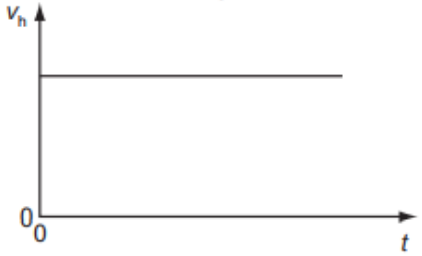
A



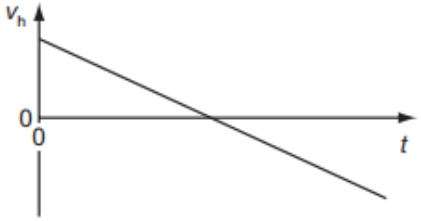
B



C



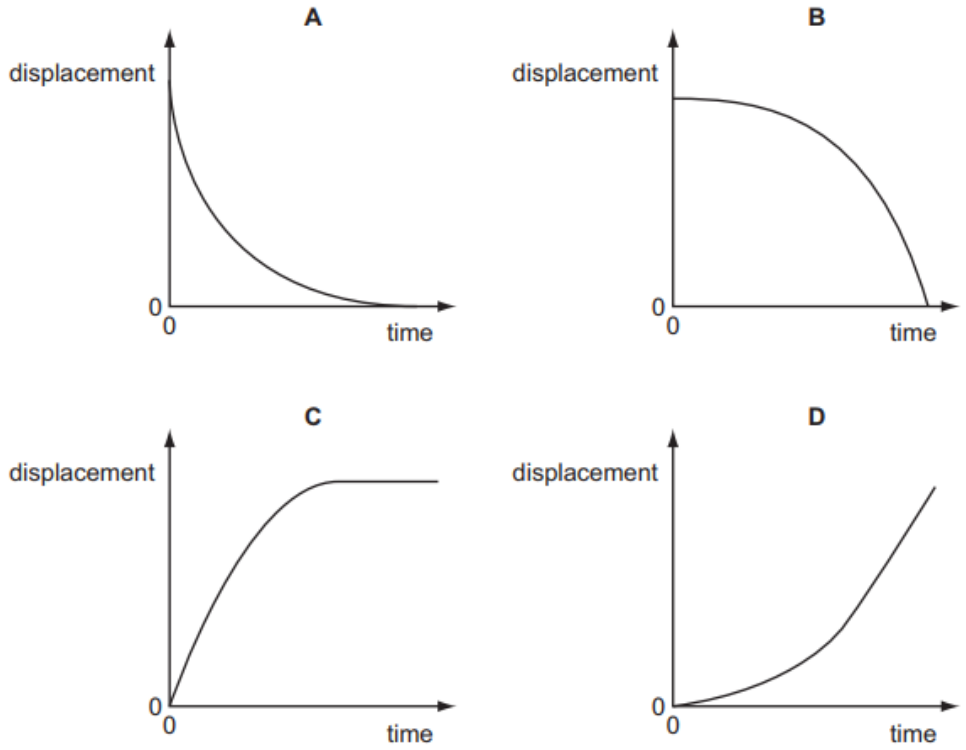
D



S15/11

20.

7 A sphere is released and falls. Its initial acceleration reduces until it eventually begins to travel at constant terminal velocity. Which displacement-time graph best represents the motion of the sphere?



21.

8 An insect jumps with an initial vertical velocity of $1.0\,m\,s^{-1}$, reaching a maximum height of $3.5 \times 10^{-2}\,m$. Assume the deceleration is uniform.

What is the magnitude of the deceleration?

A $3.6\,m\,s^{-2}$ **B** $9.8\,m\,s^{-2}$ **C** $14\,m\,s^{-2}$ **D** $29\,m\,s^{-2}$

22.

9 A body having uniform acceleration a increases its velocity from u to v in time t.

Which expression would **not** give a correct value for the body's displacement during time t?

A $ut + \frac{1}{2}at^2$

B $vt - \frac{1}{2}at^2$

C $\frac{(v+u)(v-u)}{2a}$

D $\frac{(v-u)t}{2}$

S15/12

23.

7 In an experiment to determine the acceleration of free fall g, a ball bearing is held by an electromagnet. When the current to the electromagnet is switched off, a clock starts and the ball bearing falls. After falling a distance h, the ball bearing strikes a switch to stop the clock which measures the time t of the fall.

If systematic errors cause t and h to be measured incorrectly, which error **must** cause g to appear greater than $9.81\,m\,s^{-2}$?

A h measured as being **smaller** than it actually is and t is measured correctly

B h measured as being **smaller** than it actually is and t measured as being **larger** than it actually is

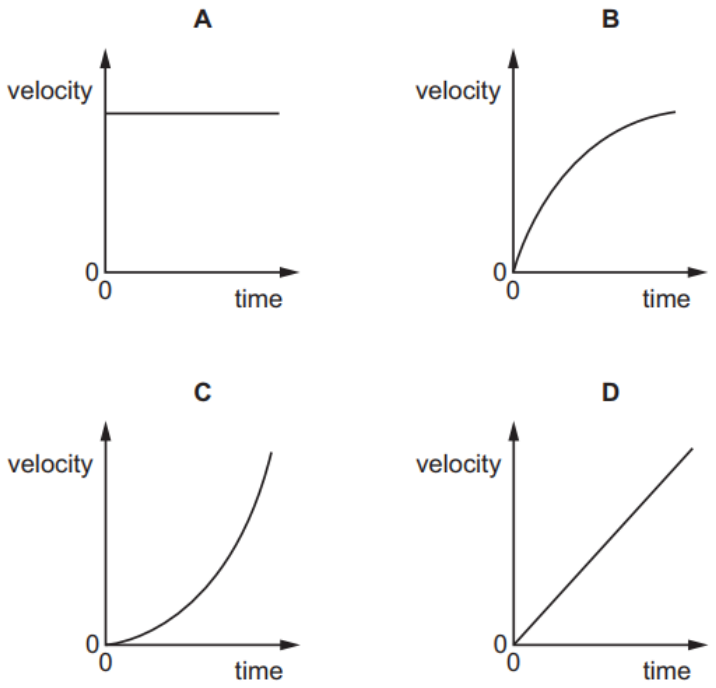
C h measured as being **larger** than it actually is and t measured as being **larger** than it actually is

D h is measured correctly and t measured as being **smaller** than it actually is

24.

8 A stone is thrown horizontally from the top of a cliff. Air resistance is negligible.

Which graph shows the variation with time of the vertical component of the stone's velocity?



25.

9 A sprinter runs a 100 m race in a straight line. He accelerates from the starting block at a constant acceleration of $2.5\,m\,s^{-2}$ to reach his maximum speed of $10\,m\,s^{-1}$. He maintains this speed until he crosses the finish line.

Which time does it take the sprinter to run the race?

A 4 s **B** 10 s **C** 12 s **D** 20 s

26.

10 A firework rocket is fired vertically upwards. The fuel burns and produces a constant upwards force on the rocket. After 5 seconds there is no fuel left. Air resistance is negligible.

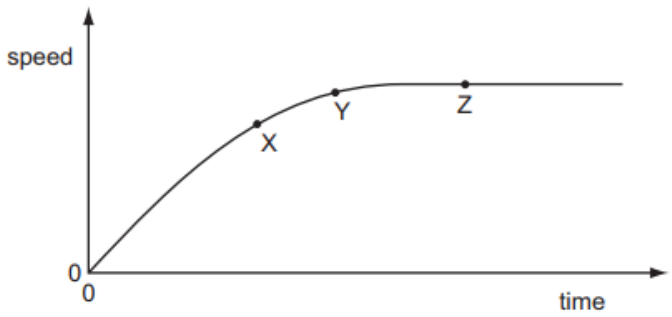
What is the acceleration before and after 5 seconds?

	before 5 seconds	after 5 seconds
A	constant	constant
B	constant	zero
C	increasing	constant
D	increasing	zero

S15/13

27.

7 A raindrop falls vertically from rest in air. The variation with time of the speed of the raindrop is shown in the graph.



Which statement about the raindrop is correct?

A At point X, the raindrop has an acceleration of $9.81\,m\,s^{-2}$.

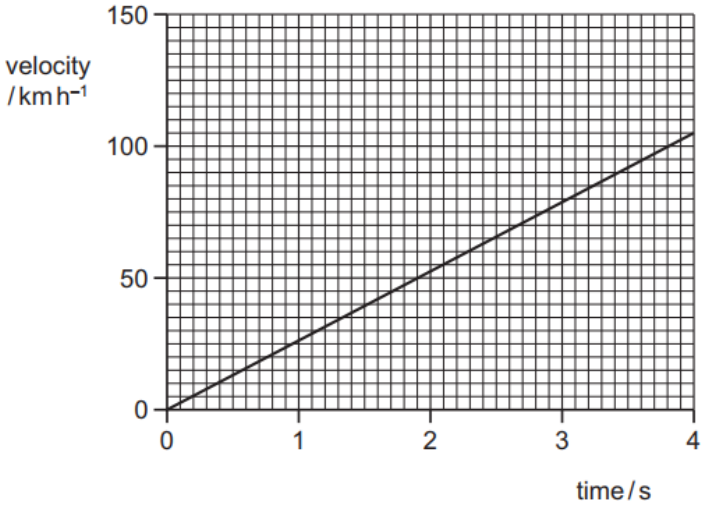
B At point Z, the force on the raindrop due to air resistance has reached its maximum value and so the acceleration of the raindrop has also reached its maximum value.

C At point Z, the force due to air resistance is equal and opposite to the weight of the raindrop and so the speed of the raindrop is zero.

D The resultant force on the raindrop at point Y is less than the resultant force on the raindrop at point X.

28.

8 The velocity of an electric car changes as shown.



What is the acceleration of the car?

A $210\,m\,s^{-2}$ **B** $58\,m\,s^{-2}$ **C** $26\,m\,s^{-2}$ **D** $7.3\,m\,s^{-2}$

29.

9 A body falling in a uniform gravitational field encounters air resistance. The air resistance increases until terminal velocity is reached.

Which factor does **not** affect its terminal velocity?

A the density of the air

B the height from which the body falls

C the mass of the body

D the shape of the body

W14/11

30.

5 The acceleration of free fall on the Moon is one-sixth of that on Earth.

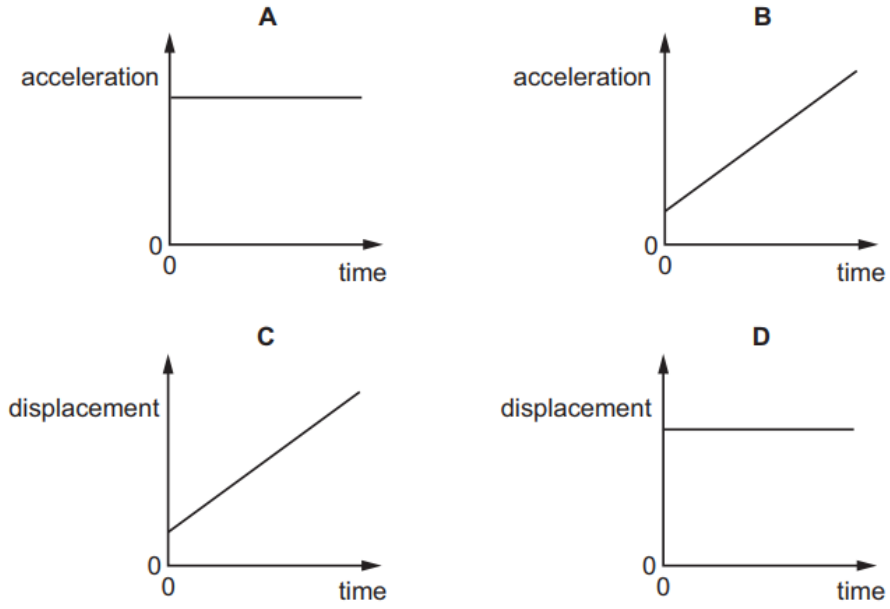
On Earth it takes time t for a stone to fall from rest a distance of 2 m.

What is the time taken for a stone to fall from rest a distance of 2 m on the Moon?

A $6t$ **B** $\frac{t}{6}$ **C** $t\sqrt{6}$ **D** $\frac{t}{\sqrt{6}}$

31.

6 Which graph represents the motion of a car that is travelling along a straight road with a speed that increases uniformly with time?



S14/11

32.

6 A tennis ball is thrown horizontally in air from the top of a tall building.

If the effect of air resistance is **not** negligible, what happens to the horizontal and vertical components of the ball's velocity?

	horizontal component of velocity	vertical component of velocity
A	constant	constant
B	constant	increases at a constant rate
C	decreases to zero	increases at a constant rate
D	decreases to zero	increases to a maximum value

33.

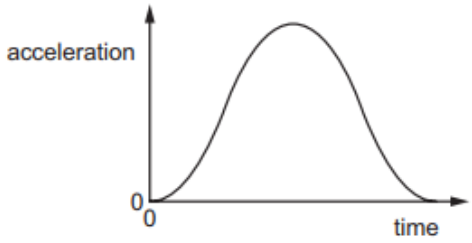
7 An object is thrown with velocity $5.2\,m\,s^{-1}$ vertically upwards on the Moon. The acceleration due to gravity on the Moon is $1.62\,m\,s^{-2}$.

What is the time taken for the object to return to its starting point?

A 2.5 s **B** 3.2 s **C** 4.5 s **D** 6.4 s

34.

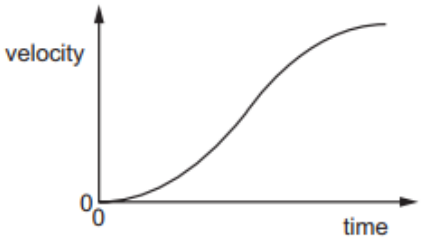
8 The graph shows how the acceleration of an object moving in a straight line varies with time.



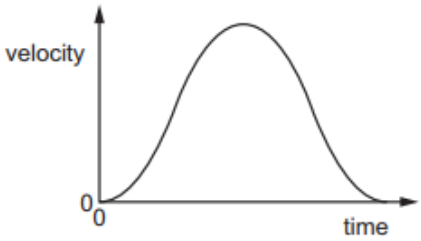
The object starts from rest.

Which graph shows the variation with time of the velocity of the object over the same time interval?

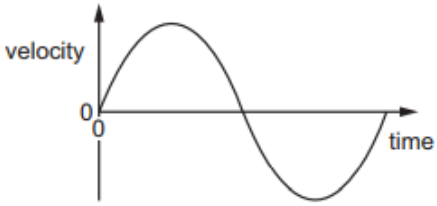
A



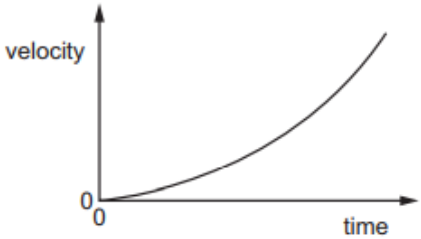
B



C



D

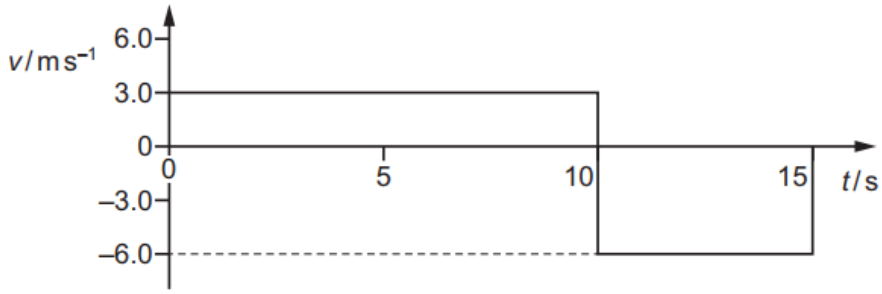


S14/12

35.

6 A radio-controlled toy car travels along a straight line for a time of 15 s.

The variation with time t of the velocity v of the car is shown below.



What is the average velocity of the toy car for the journey shown by the graph?

A $-1.5\,m\,s^{-1}$ **B** $0.0\,m\,s^{-1}$ **C** $4.0\,m\,s^{-1}$ **D** $4.5\,m\,s^{-1}$

S14/13

36.

7 An experiment is performed to measure the acceleration of free fall g. A body falls between two fixed points. The four measurements shown below are taken.

Which measurement is **not** required for the calculation of g?

A the distance fallen by the body

B the initial velocity of the body

C the mass of the body

D the time taken for the body to fall

37.

8 In a cathode-ray tube, an electron is accelerated uniformly in a straight line from a speed of $4 \times 10^3\,m\,s^{-1}$ to $2 \times 10^7\,m\,s^{-1}$ over a distance of 10 mm.

What is the acceleration of the electron?

A $2 \times 10^3\,m\,s^{-2}$

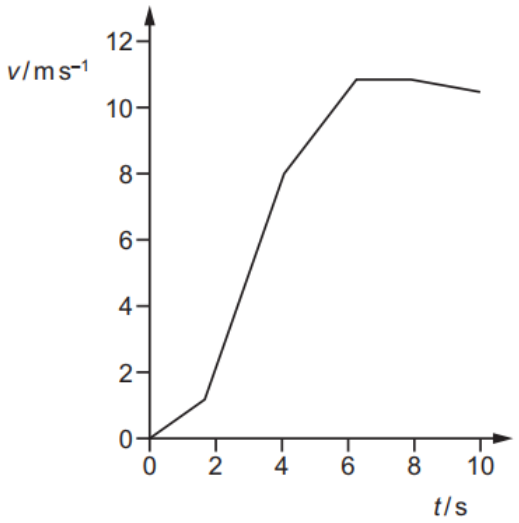
B $2 \times 10^6\,m\,s^{-2}$

C $2 \times 10^{13}\,m\,s^{-2}$

D $2 \times 10^{16}\,m\,s^{-2}$

38.

9 The graph shows how the speed v of a sprinter changes with time t during a 100 m race.



What is the best estimate of the maximum acceleration of the sprinter?

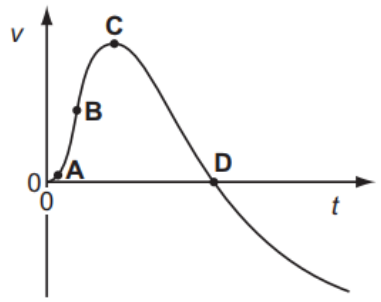
A $0.5\,m\,s^{-2}$ **B** $1\,m\,s^{-2}$ **C** $3\,m\,s^{-2}$ **D** $10\,m\,s^{-2}$

W13/13

39.

7 The graph shows how the velocity v of a firework rocket changes with time t.

At which point on the graph does the rocket have the greatest acceleration?



40.

8 On a particular railway, a train driver applies the brake of the train at a yellow signal, a distance of 1.0 km from a red signal, where the train stops.

The maximum deceleration of the train is 0.20 $m s^{-2}$.

Assuming uniform deceleration, what is the maximum safe speed of the train at the yellow signal?

A 14 $m s^{-1}$ **B** 20 $m s^{-1}$ **C** 40 $m s^{-1}$ **D** 400 $m s^{-1}$

41.

9 A person, travelling on a motorway a total distance of 200 km, travels the first 90 km at an average speed of 80 $km h^{-1}$.

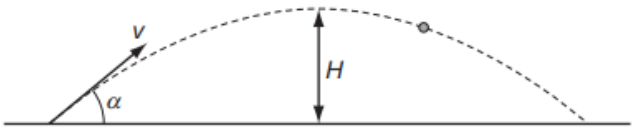
Which average speed must be obtained for the rest of the journey if the person is to reach the destination in a total time of 2 hours 0 minutes?

A 110 $km h^{-1}$ **B** 120 $km h^{-1}$ **C** 122 $km h^{-1}$ **D** 126 $km h^{-1}$

S13/11

42.

3 A cannon fires a cannonball with an initial speed v at an angle α to the horizontal.



Which equation is correct for the maximum height H reached?

A $H = \frac{v \sin\alpha}{2g}$ **B** $H = \frac{g \sin\alpha}{2v}$ **C** $H = \frac{(v \sin\alpha)^2}{2g}$ **D** $H = \frac{g^2 \sin\alpha}{2v}$

43.

7 A body is released from rest and falls vertically in air of constant density.

Which statement about the motion of the falling body is correct?

A As it accelerates, its weight decreases so that its acceleration decreases until it travels with constant velocity.

B It accelerates initially at $9.8\,m\,s^{-2}$ but the drag force increases so its acceleration decreases.

C Its velocity increases at a constant rate until its velocity becomes constant.

D The drag force of the air increases continually and eventually the velocity decreases.

44.

8 A goods train passes through a station at a steady speed of $10\,m\,s^{-1}$. An express train is at rest at the station. The express train leaves the station with a uniform acceleration of $0.5\,m\,s^{-2}$ just as the goods train goes past. Both trains move in the same direction on straight, parallel tracks.

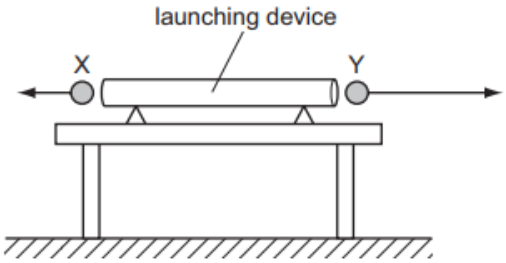
How much time passes before the express train overtakes the goods train?

A 6 s **B** 10 s **C** 20 s **D** 40 s

S13/13

45.

7 A double-ended launching device fires two identical steel balls X and Y at exactly the same time. The diagram shows the initial velocities of the balls. They are both launched horizontally, but Y has greater speed.



Which statement explains what an observer would see?

A Both X and Y reach the ground simultaneously, because air resistance will cause both to have the same final speed.

B Both X and Y reach the ground simultaneously, because gravitational acceleration is the same for both.

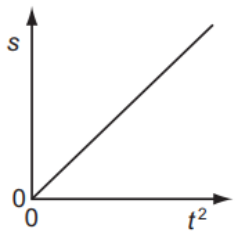
C X reaches the ground before Y, because X lands nearer to the launcher.

D Y reaches the ground before X, because Y has greater initial speed.

46.

8 At time $t = 0$, a body moves from rest with constant acceleration in a straight line. At time t, the body is distance s from its rest position.

A graph is drawn of s against t^2, as shown.



Which statement describes the acceleration of the body?

A It is equal to half the value of the gradient of the graph.

B It is equal to the value of the gradient of the graph.

C It is equal to twice the value of the gradient of the graph.

D It is equal to the reciprocal of the gradient of the graph.

S13/12

47.

7 The diagram shows an arrangement to stop trains that are travelling too fast.

Trains coming from the left travel at a speed of $50\,m\,s^{-1}$. At marker 1, the driver must apply the brakes so that the train decelerates uniformly in order to pass marker 2 at no more than $10\,m\,s^{-1}$.

The train carries a detector that notes the times when the train passes each marker and will apply an emergency brake if the time between passing marker 1 and marker 2 is less than 20 s.

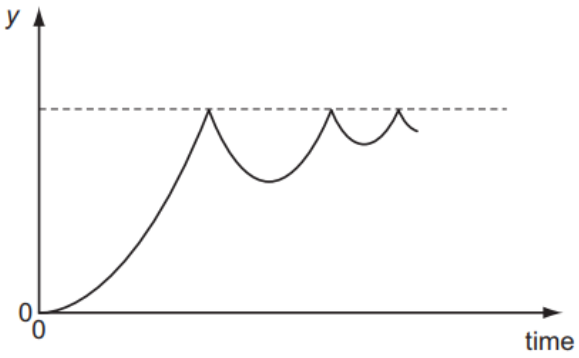
How far from marker 2 should marker 1 be placed?

A 200 m **B** 400 m **C** 500 m **D** 600 m

48.

8 A ball is released from rest above a horizontal surface and bounces several times.

The graph shows how, for this ball, a quantity *y* varies with time.



What is the quantity *y*?

A acceleration

B displacement

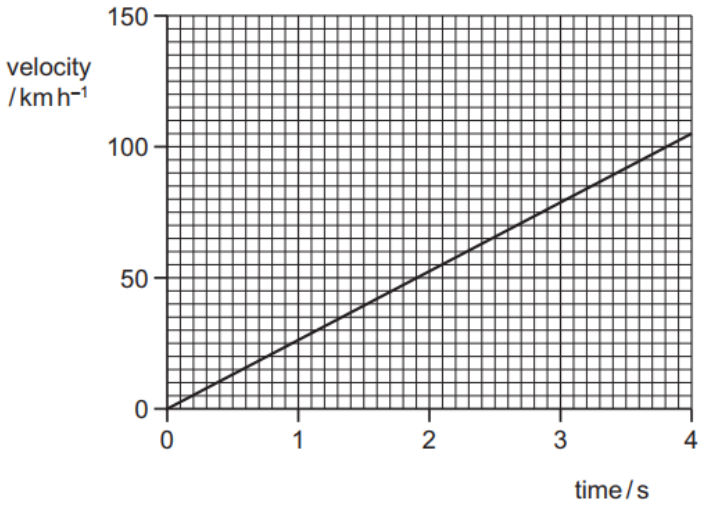
C kinetic energy

D velocity

W12/11

49.

8 The velocity of an electric car changes as shown.



What is the acceleration of the car?

A 190 m s^{-2} **B** 53 m s^{-2} **C** 26 m s^{-2} **D** 7.3 m s^{-2}

50.

9 A ball is thrown vertically in air.

Neglecting air resistance, which property of the ball can **never** be zero at any time during the flight?

A acceleration

B kinetic energy

C speed

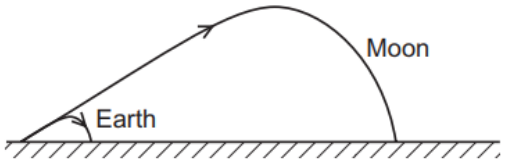
D velocity

51.

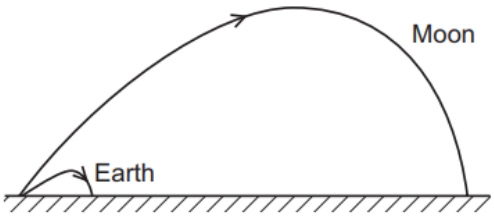
10 A golf ball is hit with the same force and direction on the Earth and on the Moon.

Which diagram best represents the shapes of the paths taken by the golf ball?

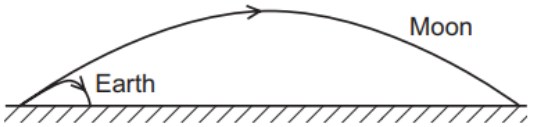
A



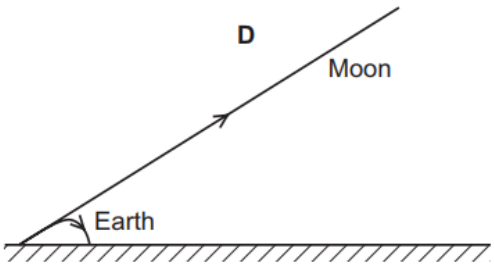
B



C



D



W12/12

52.

8 A science museum designs an experiment to show the fall of a feather in a vertical glass vacuum tube.

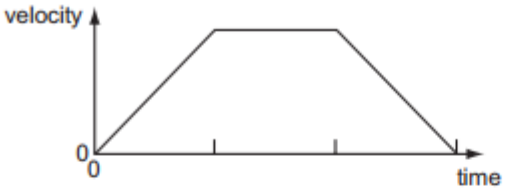
The time of fall from rest is to be close to 0.5 s.

What length of tube is required?

A 1.3 m **B** 2.5 m **C** 5.0 m **D** 10.0 m

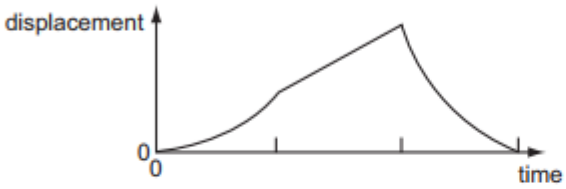
53.

9 The graph of velocity against time for an object moving in a straight line is shown.

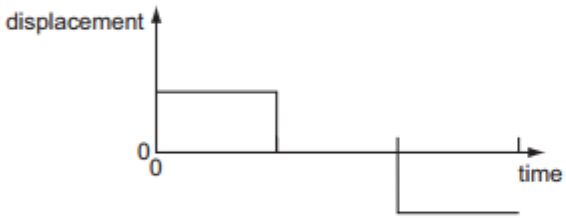


What is the corresponding graph of displacement against time?

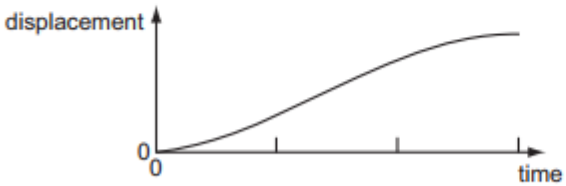
A



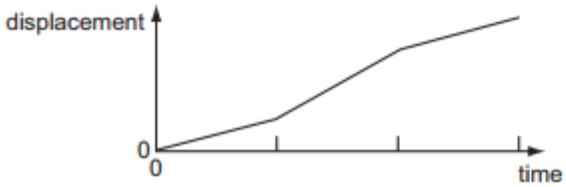
B



C

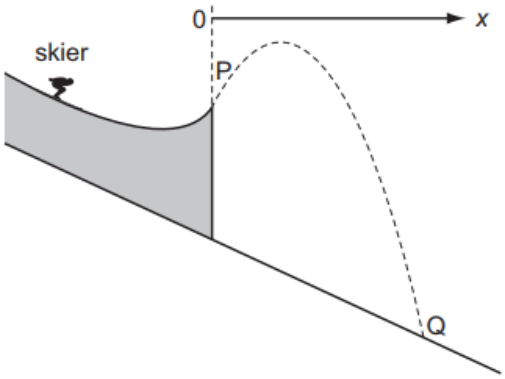


D

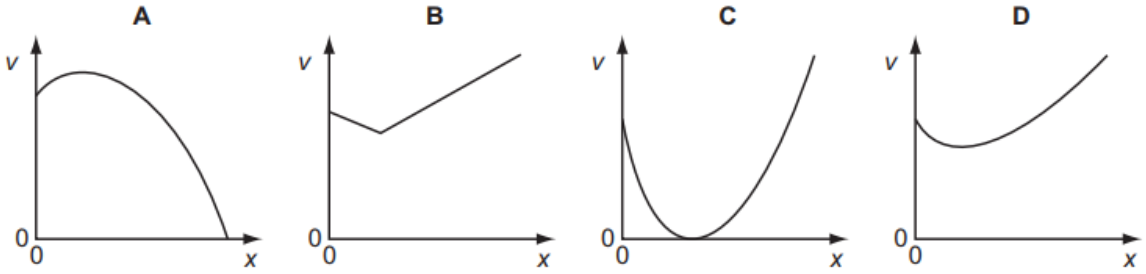


54. *

10 The dotted line shows the path of a competitor in a ski-jumping competition.

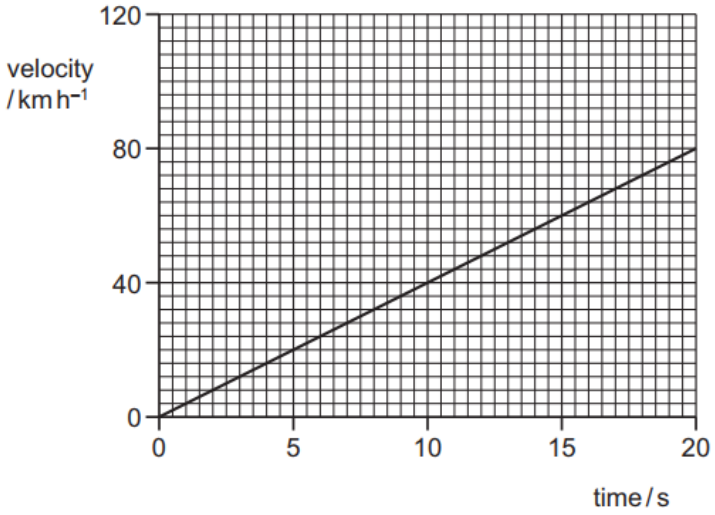


Ignoring air resistance, which graph best represents the variation of his speed *v* with the horizontal distance *x* covered from the start of his jump at P before landing at Q?



55.

11 The velocity of a car changes as shown.



What is the acceleration of the car?

A 1.1 m s^{-2} **B** 4.0 m s^{-2} **C** 224 m s^{-2} **D** 800 m s^{-2}

W12/13

56.

8 A bicycle brakes so that it undergoes uniform deceleration from a speed of $8\,m\,s^{-1}$ to $6\,m\,s^{-1}$ over a distance of 7 m.

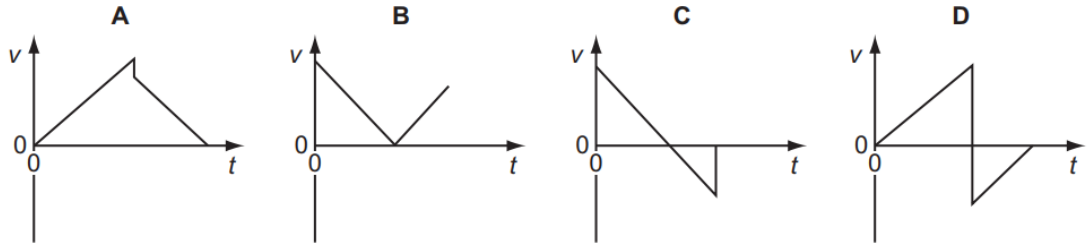
If the deceleration of the bicycle remains constant, what further distance will it travel before coming to rest?

A 7 m **B** 9 m **C** 16 m **D** 21 m

57.

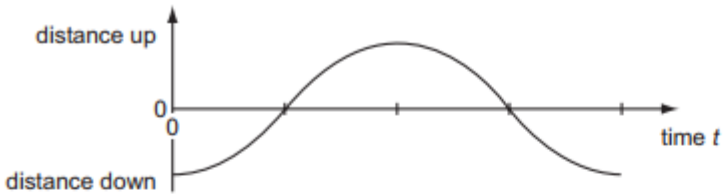
9 A ball is released from rest above a horizontal surface. It bounces once and is caught.

Which graph represents the variation with time *t* of the velocity *v* of the ball?



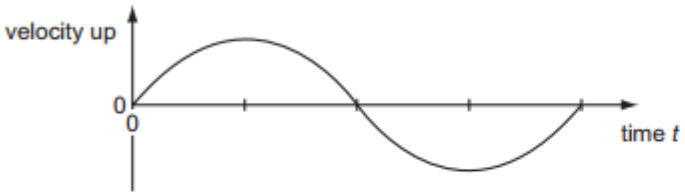
58.

10 A mass on the end of a spring bounces up and down as shown, after being released at time $t = 0$.

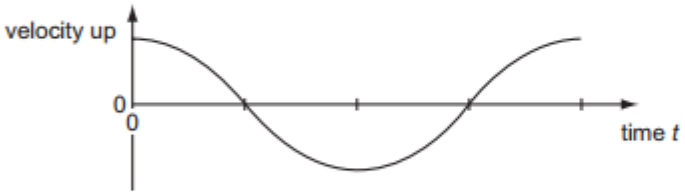


Which graph shows how the velocity varies with time?

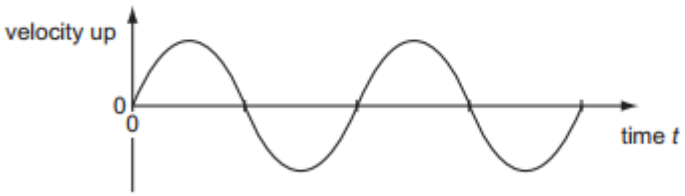
A



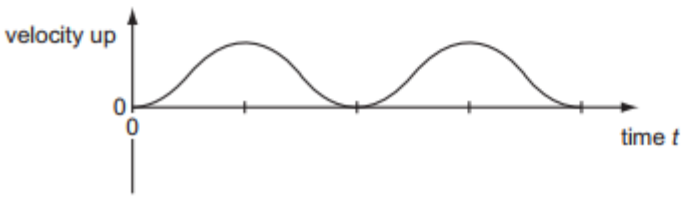
B



C



D



S12/11

59.

7 Which feature of a graph allows acceleration to be determined?

A the area under a displacement-time graph

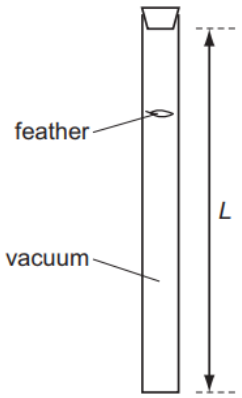
B the area under a velocity-time graph

C the slope of a displacement-time graph

D the slope of a velocity-time graph

60.

8 The diagram shows a laboratory experiment in which a feather falls from rest in a long evacuated vertical tube of length *L*.



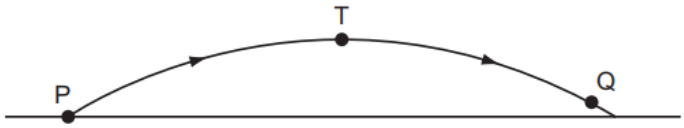
The feather takes time *T* to fall from the top to the bottom of the tube.

How far will the feather have fallen from the top of the tube in time 0.50 *T*?

A 0.13 *L* **B** 0.25 *L* **C** 0.38 *L* **D** 0.50 *L*

61.

9 In the absence of air resistance, a stone is thrown from P and follows a parabolic path in which the highest point reached is T. The stone reaches point Q just before landing.



The vertical component of acceleration of the stone is

A zero at T.

B larger at T than at Q.

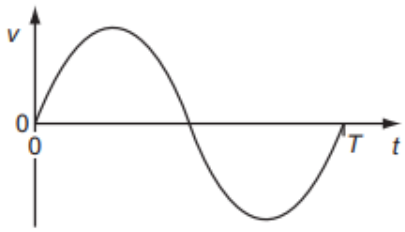
C larger at Q than at T.

D the same at Q as at T.

S12/12

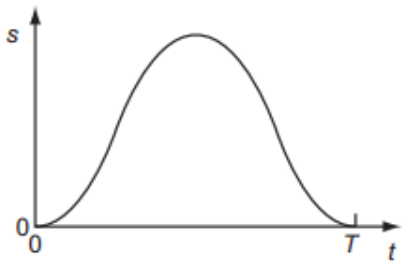
62.

7 The graph shows how the velocity v of an object moving in a straight line varies over time $t = 0$ to $t = T$.

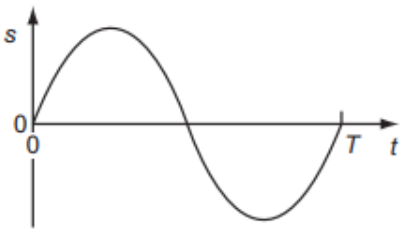


Which graph represents the displacement s of the object in the time $t = 0$ to $t = T$?

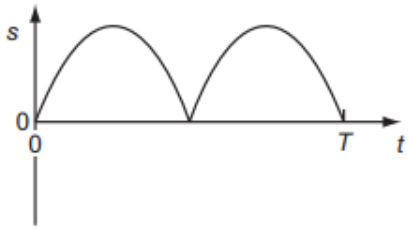
A



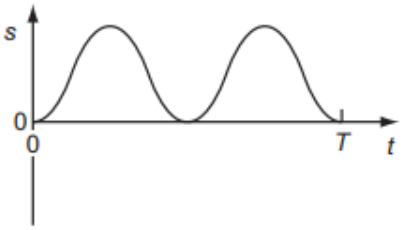
B



C

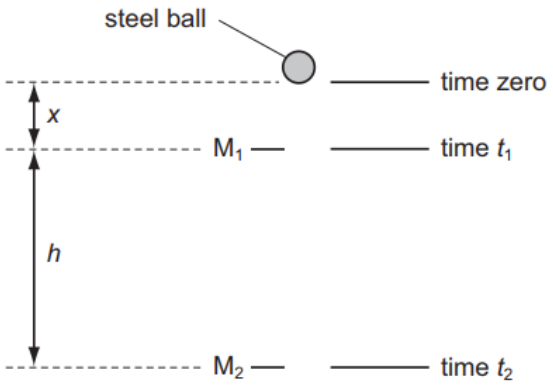


D



63.

8 Two markers M_1 and M_2 are set up a vertical distance h apart.



A steel ball is released at time zero from a point a distance x above M_1. The ball reaches M_1 at time t_1 and reaches M_2 at time t_2. The acceleration of the ball is constant.

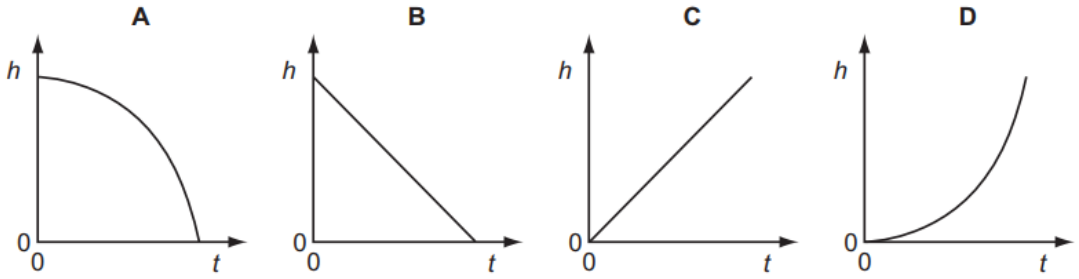
Which expression gives the acceleration of the ball?

A $\frac{2h}{t_2^{\,2}}$ **B** $\frac{2h}{(t_2+t_1)}$ **C** $\frac{2h}{(t_2-t_1)^2}$ **D** $\frac{2h}{(t_2^{\,2}-t_1^{\,2})}$

64.

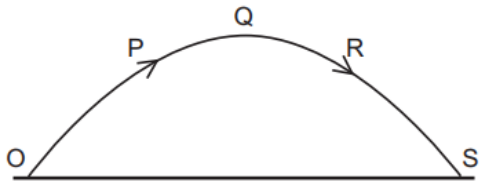
9 A brick is dislodged from a building and falls vertically under gravity.

Which graph best represents the variation of its height h above the ground with time t if air resistance is negligible?



65.

10 A projectile is launched at point O and follows the path OPQRS, as shown. Air resistance may be neglected.



Which statement is true for the projectile when it is at the highest point Q of its path?

A The horizontal component of the projectile's acceleration is zero.

B The horizontal component of the projectile's velocity is zero.

C The kinetic energy of the projectile is zero.

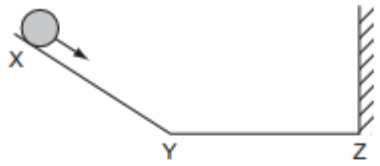
D The momentum of the projectile is zero.

W11/11

66.

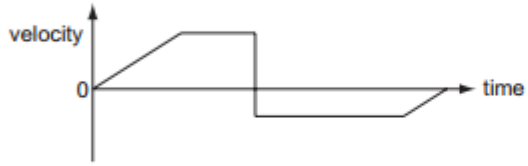
6 A ball is released from rest on a smooth slope XY.

It moves down the slope, along a smooth horizontal surface YZ and rebounds inelastically at Z. Then it moves back to Y and comes to rest momentarily somewhere on XY.

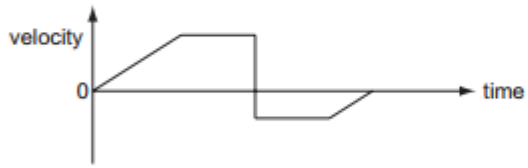


Which velocity-time graph represents the motion of the ball?

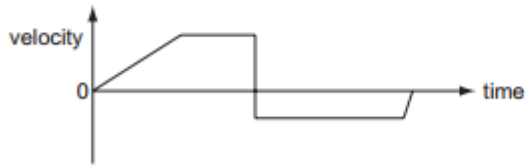
A



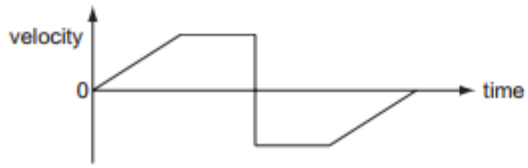
B



C



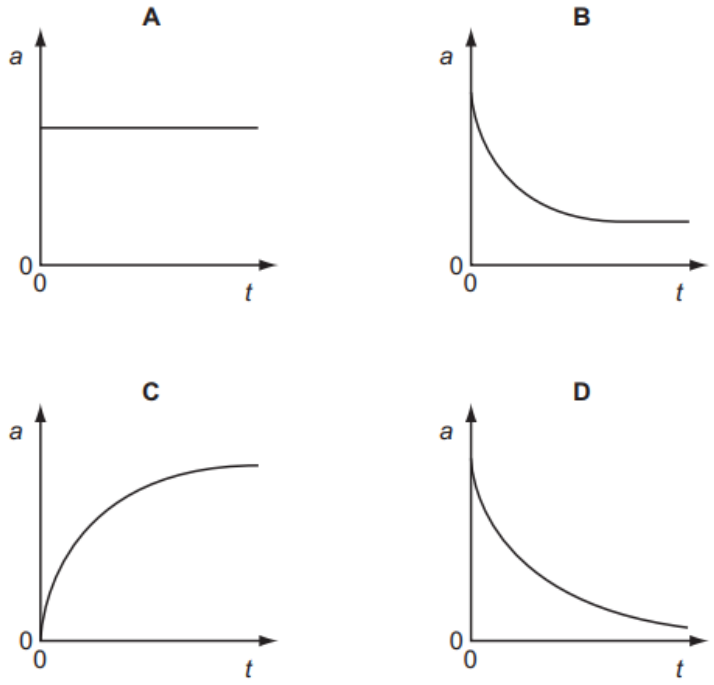
D



67. *

7 A tennis ball is released from rest at the top of a tall building.

Which graph best represents the variation with time t of the acceleration a of the ball as it falls, assuming that the effect of air resistance is **not** negligible?



68.

8 A boy throws a ball vertically upwards. It rises to a maximum height, where it is momentarily at rest, and then falls back to his hands.

Which row gives the acceleration of the ball at various stages in its motion? (Take vertically upwards as positive. Ignore air resistance.)

	rising	at maximum height	falling
A	$-9.81\,m\,s^{-2}$	0	$+9.81\,m\,s^{-2}$
B	$-9.81\,m\,s^{-2}$	$-9.81\,m\,s^{-2}$	$-9.81\,m\,s^{-2}$
C	$+9.81\,m\,s^{-2}$	$+9.81\,m\,s^{-2}$	$+9.81\,m\,s^{-2}$
D	$+9.81\,m\,s^{-2}$	0	$-9.81\,m\,s^{-2}$

69.

9 A body falling in a uniform gravitational field encounters air resistance. The air resistance increases until terminal velocity is reached.

Which factor does **not** affect its terminal velocity?

A the density of the air

B the height from which the body falls

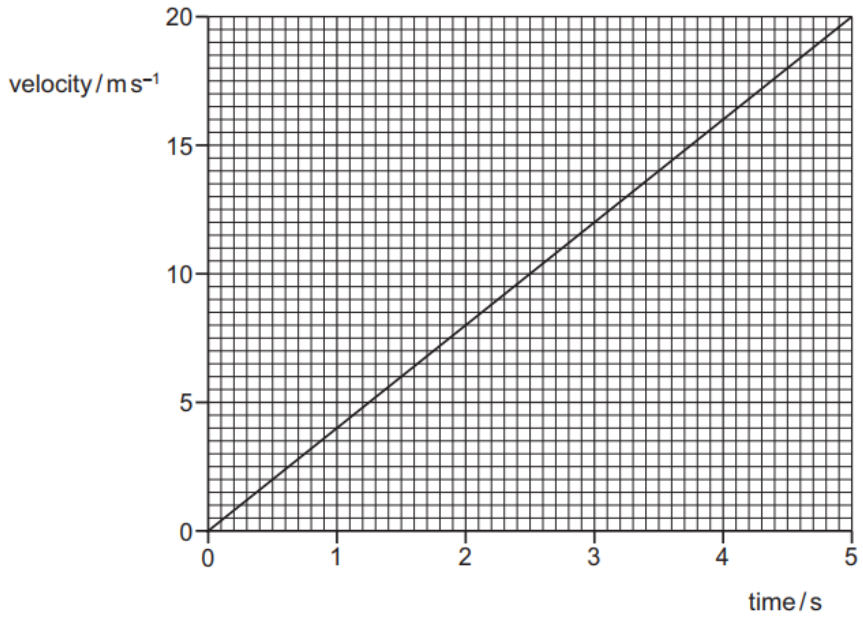
C the mass of the body

D the shape of the body

W11/12

70.

6 The velocity of an object during the first five seconds of its motion is shown on the graph.



What is the distance travelled by the object in this time?

A 4 m **B** 20 m **C** 50 m **D** 100 m

71.

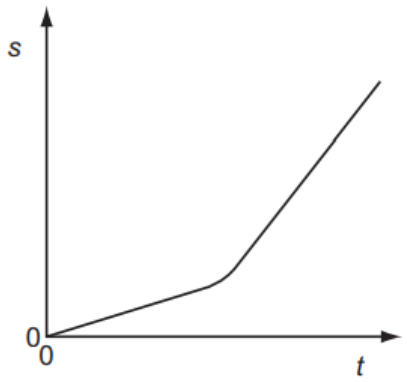
7 A stone of mass *m* is dropped from a tall building. There is significant air resistance. The acceleration of free fall is *g*.

When the stone reaches its terminal velocity, which information is correct?

	magnitude of the acceleration of the stone	magnitude of the force of gravity on the stone	magnitude of the force of air resistance on the stone
A	*g*	*mg*	*mg*
B	zero	*mg*	*mg*
C	zero	zero	*mg*
D	zero	zero	zero

72.

8 The variation with time t of the distance s moved by a body is shown below.



What can be deduced from the graph about the motion of the body?

A It accelerates continuously.

B It starts from rest.

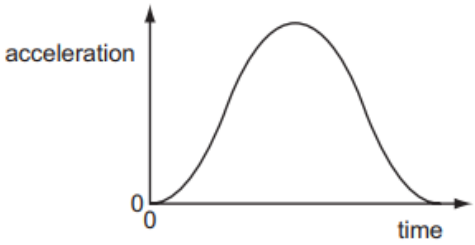
C The distance is proportional to time.

D The speed changes.

S11/11

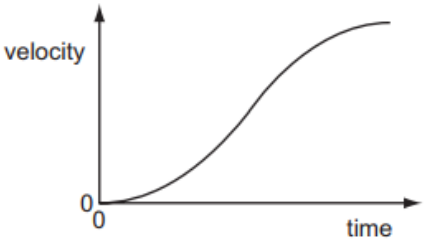
73.

6 The graph shows how the acceleration of an object moving in a straight line varies with time.

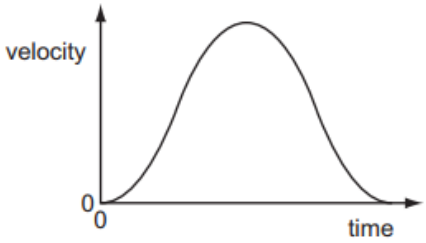


Which graph shows the variation with time of the velocity of the object?

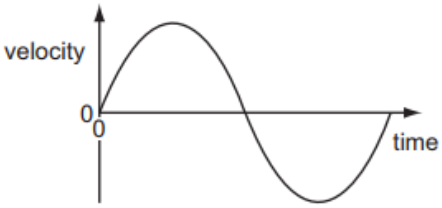
A



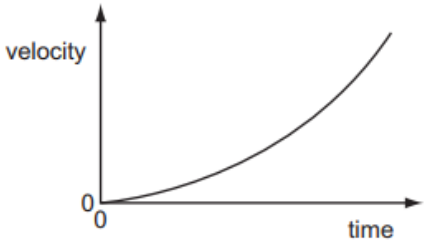
B



C

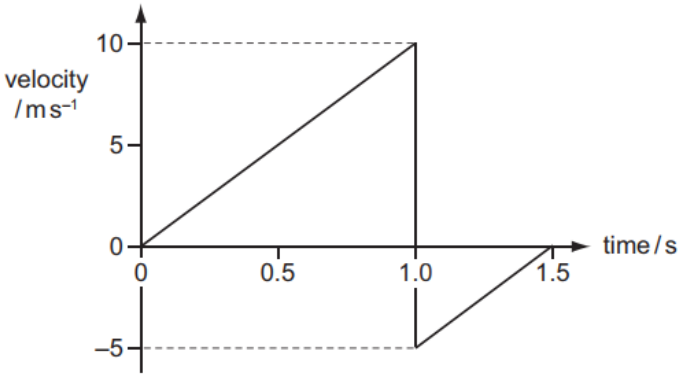


D



74.

7 A ball is released from rest at time zero. After 1.0 s it bounces inelastically from a horizontal surface and rebounds, reaching the top of its first bounce after 1.5 s.



What is the total displacement of the ball from its original position after 1.5 s?

A 1.25 m **B** 3.75 m **C** 5.00 m **D** 6.25 m

S11/12

75.

6 A bullet is fired horizontally with speed v from a rifle. For a short time t after leaving the rifle, the only force affecting its motion is gravity. The acceleration of free fall is g.

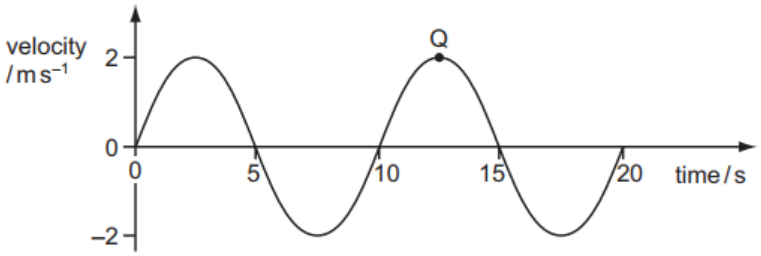
Which expression gives the value of $\frac{\text{the horizontal distance travelled in time } t}{\text{the vertical distance travelled in time } t}$?

A $\frac{vt}{g}$ **B** $\frac{v}{gt}$ **C** $\frac{2vt}{g}$ **D** $\frac{2v}{gt}$

76.

7 A particle moves in the manner shown by the velocity-time graph.

The displacement of the particle has been measured so that it is zero at $t = 0$. Point Q refers to a point in its motion.



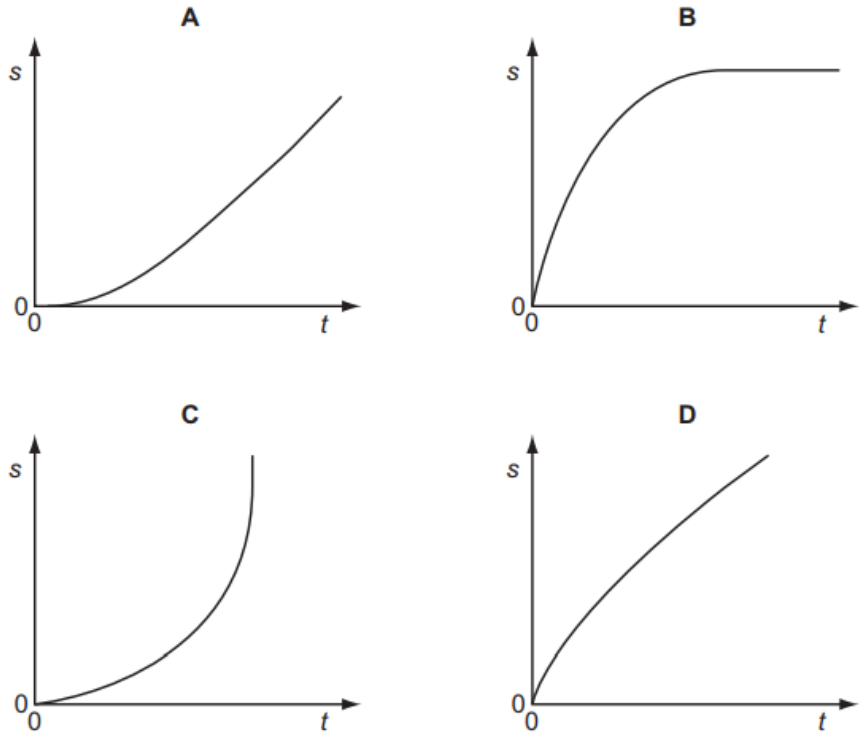
Which row of the table is correct?

	times for maximum displacement / s		acceleration at point Q / m s^{-2}
A	2.5	12.5	2
B	5	15	2
C	2.5	12.5	0
D	5	15	0

77.

8 A tennis ball falls freely, in air, from the top of a tall building.

Which graph best represents the variation of distance *s* fallen with time *t*?



W10/11

78.

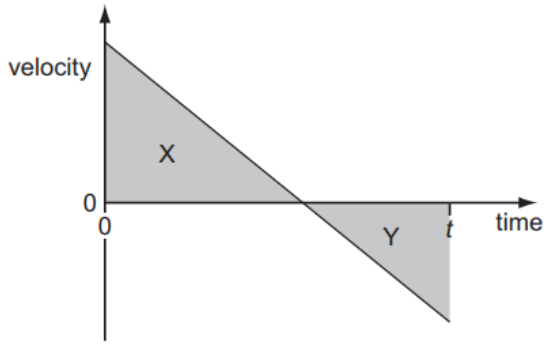
7 A ball is thrown horizontally in still air from the top of a very tall building. The ball is affected by air resistance.

What happens to the horizontal and to the vertical components of the ball's velocity?

	horizontal component of velocity	vertical component of velocity
A	decreases to zero	increases at a constant rate
B	decreases to zero	increases to a constant value
C	remains constant	increases at a constant rate
D	remains constant	increases to a constant value

79.

8 The velocity-time graph below is for a stone thrown vertically up into the air. Air resistance is negligible.



The stone is thrown up at time zero.

Area X represents a distance of 5 m. Area Y represents a distance of 3 m.

What is the displacement of the stone from its initial position at time *t*?

A 2 m **B** 3 m **C** 5 m **D** 8 m

80.

9 In order that a train can stop safely, it will always pass a signal showing a yellow light before it reaches a signal showing a red light. Drivers apply the brake at the yellow light and this results in a uniform deceleration to stop exactly at the red light.

The distance between the red and yellow lights is *x*.

What must be the minimum distance between the lights if the train speed is increased by 20 %, without changing the deceleration of the trains?

A 1.20 *x* **B** 1.25 *x* **C** 1.44 *x* **D** 1.56 *x*

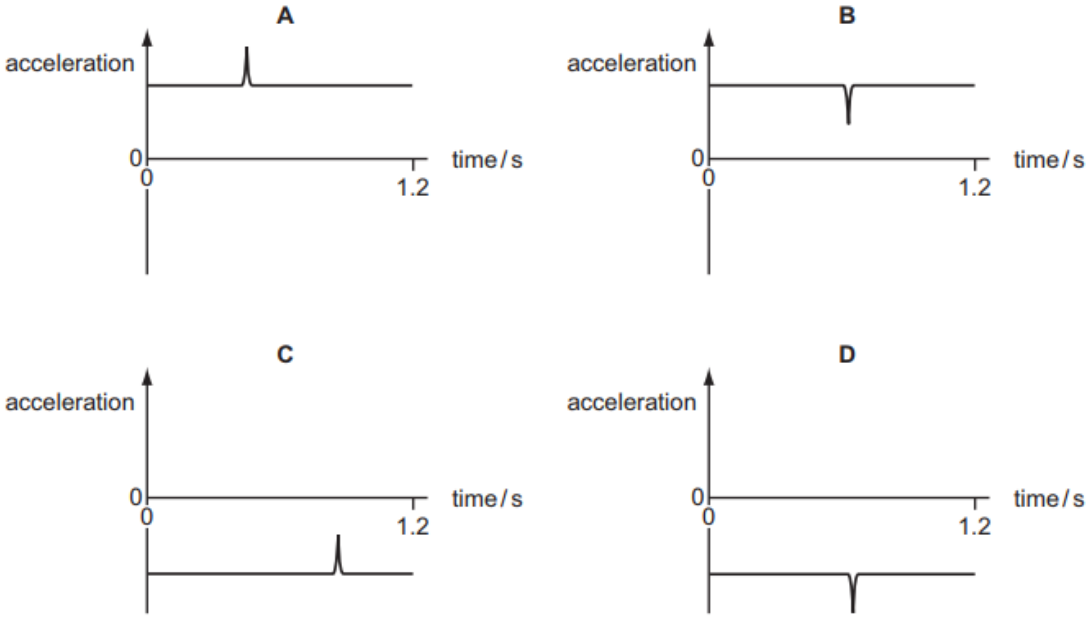
W10/12

81.

7 A student throws a ball in the positive direction vertically upwards.

The ball makes an elastic collision with the ceiling, rebounds and accelerates back to the student's hand in a time of 1.2 s.

Which graph best represents the acceleration of the ball from the moment it leaves the hand to the instant just before it returns to the hand?



82.

8 A moving body undergoes uniform acceleration while travelling in a straight line between points X, Y and Z. The distances XY and YZ are both 40 m. The time to travel from X to Y is 12 s and from Y to Z is 6.0 s.

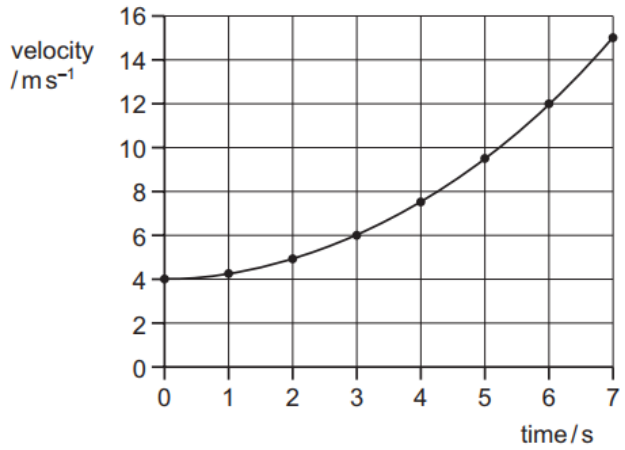
What is the acceleration of the body?

A $0.37\,m\,s^{-2}$ **B** $0.49\,m\,s^{-2}$ **C** $0.56\,m\,s^{-2}$ **D** $1.1\,m\,s^{-2}$

S10/11

83.

8 The diagram shows a velocity-time graph for a vehicle.



The vehicle, moving at 4.0 m s^{-1}, begins to accelerate at time = 0.

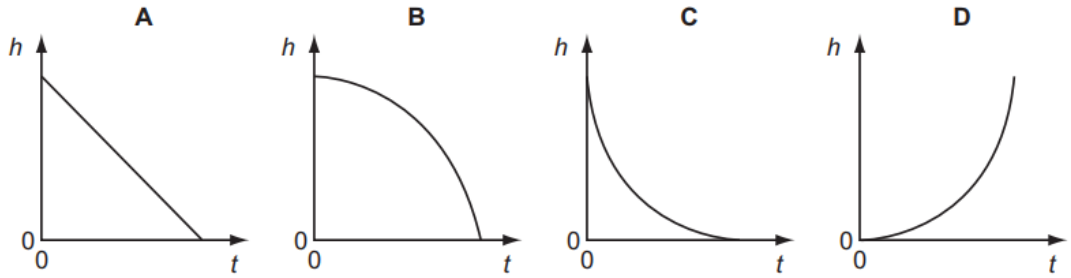
What is the vehicle's acceleration at time = 3.0 s?

A 0.67 m s^{-2} **B** 1.0 m s^{-2} **C** 1.3 m s^{-2} **D** 2.0 m s^{-2}

84.

9 A small steel ball falls freely under gravity after being released from rest.

Which graph best represents the variation of the height *h* of the ball with time *t*?



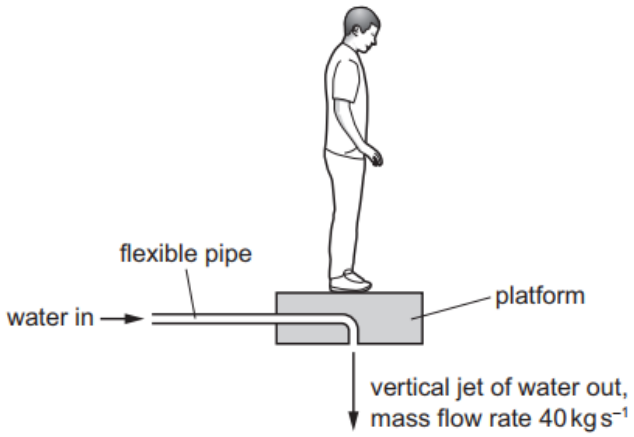
New Topic 3:

3. FORCES

S16/11

1.

11 The diagram shows a man standing on a platform that is attached to a flexible pipe. Water is pumped through the pipe so that the man and platform remain at a constant height.



The resultant vertical force on the platform is zero. The combined mass of the man and platform is 96 kg. The mass of water that is discharged vertically downwards from the platform each second is 40 kg.

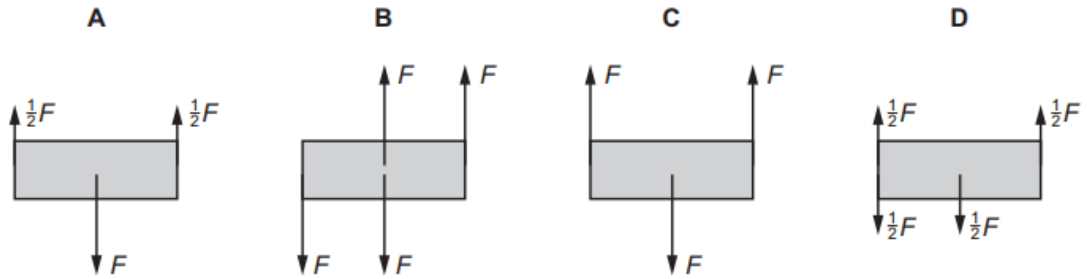
What is the speed of the water leaving the platform?

A 2.4 m s^{-1} **B** 6.9 m s^{-1} **C** 24 m s^{-1} **D** 47 m s^{-1}

2.

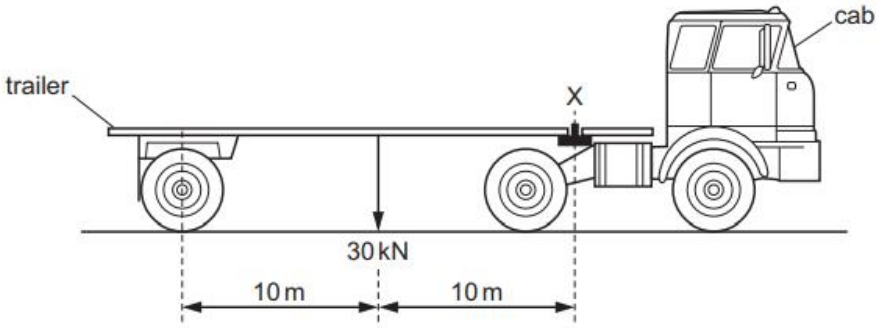
12 Forces are applied to a rigid body. The forces all act in the same plane.

In which diagram is the body in equilibrium?



3.

14 A trailer of weight 30 kN is attached to a cab at X, as shown in the diagram.

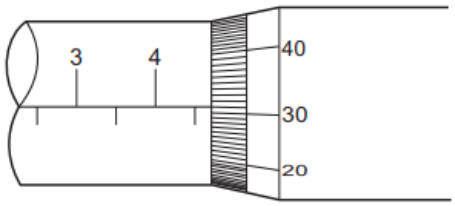


What is the upward force exerted at X by the cab on the trailer?

A 3 kN **B** 15 kN **C** 30 kN **D** 60 kN

4.

15 The diameter of a solid metal sphere is measured using a micrometer screw gauge. The diagram shows an enlargement of the shaft of the micrometer screw gauge when taking the measurement.



The mass of the sphere is 0.450 g.

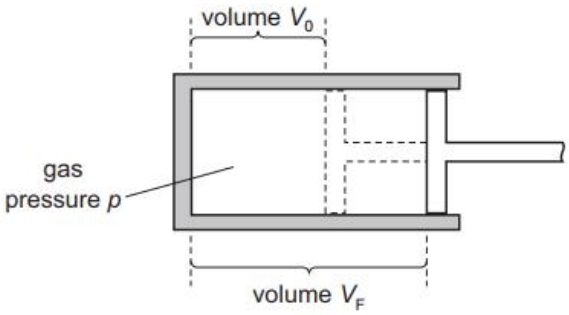
What is the density of the metal used to make the sphere?

A 965 kg m^{-3} **B** 1340 kg m^{-3} **C** 7720 kg m^{-3} **D** 10 700 kg m^{-3}

5.

16 Some gas in a cylinder is supplied with thermal energy q.

The gas does useful work in expanding at constant pressure p from volume V_0 to volume V_F, as shown.



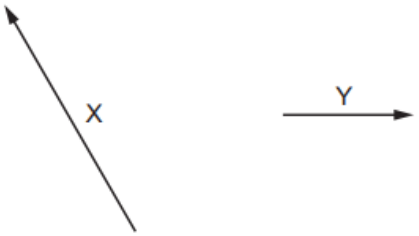
Which expression gives the efficiency of this change?

A $\frac{pV_0}{q}$ **B** $\frac{V_F}{V_0 q}$ **C** $\frac{p(V_F - V_0)}{q}$ **D** $\frac{(V_F - V_0)}{V_0 q}$

S16/12

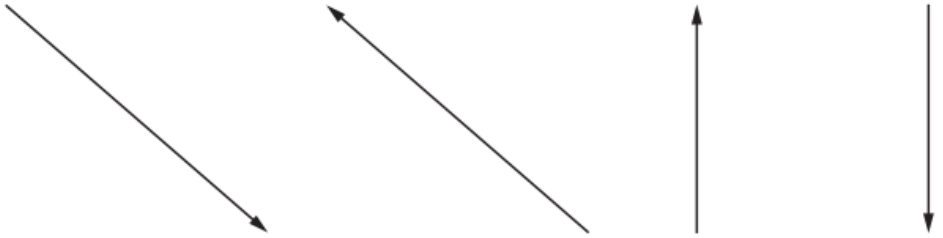
6.

3 The diagram shows two vectors X and Y, drawn to scale.



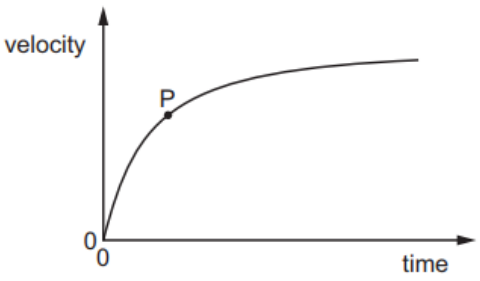
If X = Y – Z, which diagram best represents the vector Z?

A **B** **C** **D**



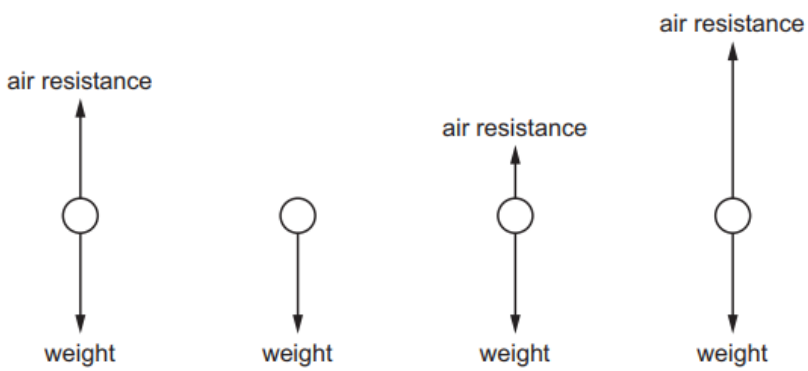
7.

10 A sphere falls from rest through the air. The graph shows the variation with time of the sphere's velocity.



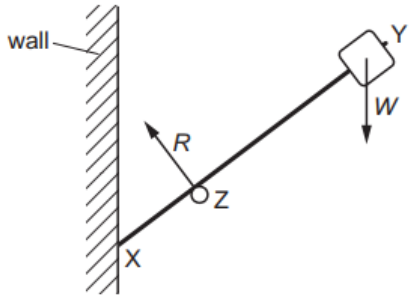
Which diagram shows the forces acting on the sphere when it is at the velocity corresponding to point P on the graph?

A **B** **C** **D**



8.

12 A light rigid rod XY has an object of weight *W* fixed at one end. The rod is in equilibrium, resting on a roller at Z and a vertical wall at X. The roller exerts a force *R* on the rod as shown. The diagram shows the directions, but not the magnitudes, of the forces *R* and *W*.



What is the direction of the force on the rod at X?

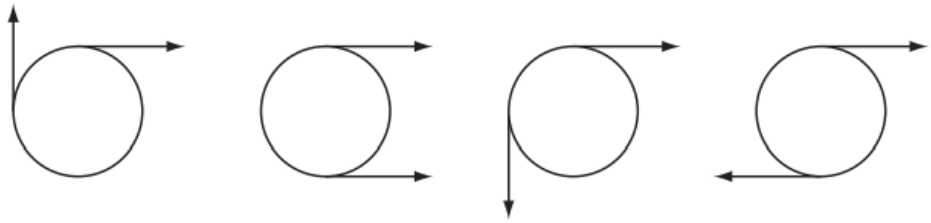
A B C D

9.

14 Two coplanar forces act on the rim of a wheel. The forces are equal in magnitude.

Which arrangement of forces provides only a couple?

A B C D

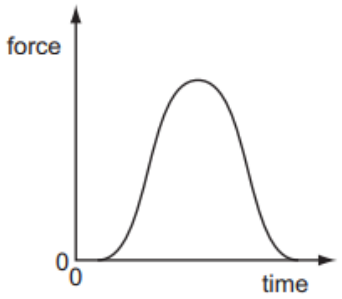


10.

W15/11

11.

10 A golf ball is hit by a club. The graph shows the variation with time of the force exerted on the ball by the club.



Which quantity, for the time of contact, **cannot** be found from the graph?

A the average force on the ball

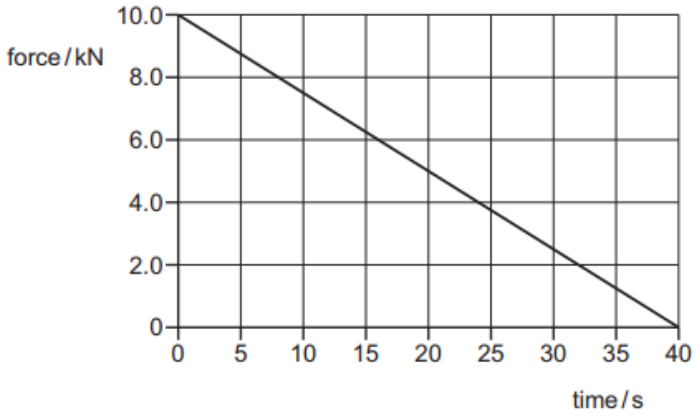
B the change in momentum of the ball

C the contact time between the ball and the club

D the maximum acceleration of the ball

12.

11 A glider of mass 1500 kg is launched from rest on a straight and level track using a catapult. The graph shows the variation with time of the resultant force.



What is the speed of the glider when the resultant force acting on it reaches zero?

A $133\,m\,s^{-1}$ **B** $200\,m\,s^{-1}$ **C** $250\,m\,s^{-1}$ **D** $267\,m\,s^{-1}$

13.

13 In which example is it **not** possible for the underlined body to be in equilibrium?

A an aeroplane climbs at a steady rate

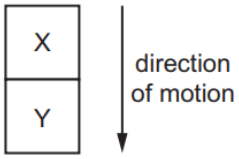
B an aeroplane tows a glider at a constant altitude

C a speedboat changes direction at a constant speed

D two tug boats tow a ship into harbour

14.

14 Two blocks X and Y are falling through a vacuum in a uniform gravitational field, as shown.



Block X has weight $2w$.

Block Y has weight w.

The blocks do not move apart.

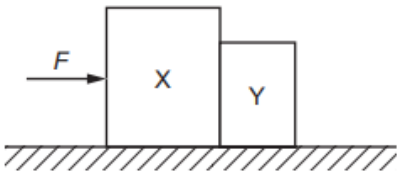
Which value best represents the force exerted by block X on block Y?

A 0 **B** w **C** $1.5w$ **D** $2w$

W15/12

15.

11 A single horizontal force F is applied to a block X which is in contact with a separate block Y as shown.



The blocks remain in contact as they accelerate along a horizontal frictionless surface. Air resistance is negligible. X has a greater mass than Y.

Which statement is correct?

A The acceleration of X is equal to force F divided by the mass of X.

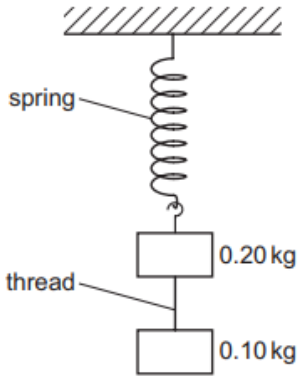
B The force that X exerts on Y is equal to F.

C The force that X exerts on Y is less than F.

D The force that X exerts on Y is less than the force that Y exerts on X.

16.

12 A mass of 0.20 kg is suspended from the lower end of a light spring. A second mass of 0.10 kg is suspended from the first mass by a thread. The arrangement is allowed to come into static equilibrium and then the thread is burned through.



At this instant, what is the upward acceleration of the 0.20 kg mass? (Assume $g = 10\,m\,s^{-2}$.)

A $5.0\,m\,s^{-2}$ **B** $6.7\,m\,s^{-2}$ **C** $10\,m\,s^{-2}$ **D** $15\,m\,s^{-2}$

W15/13

17.

11 A rocket of mass 30 000 kg sits on a launch pad on the Earth's surface. The rocket motors provide an upward force of 330 kN on the rocket.

What is the initial acceleration of the rocket?

A $0.12\,m\,s^{-2}$

B $1.1\,m\,s^{-2}$

C $1.2\,m\,s^{-2}$

D $11\,m\,s^{-2}$

18.

14 Which statement best describes a couple?

A a pair of forces of equal magnitude acting in opposite directions which produce rotational motion but not translational motion

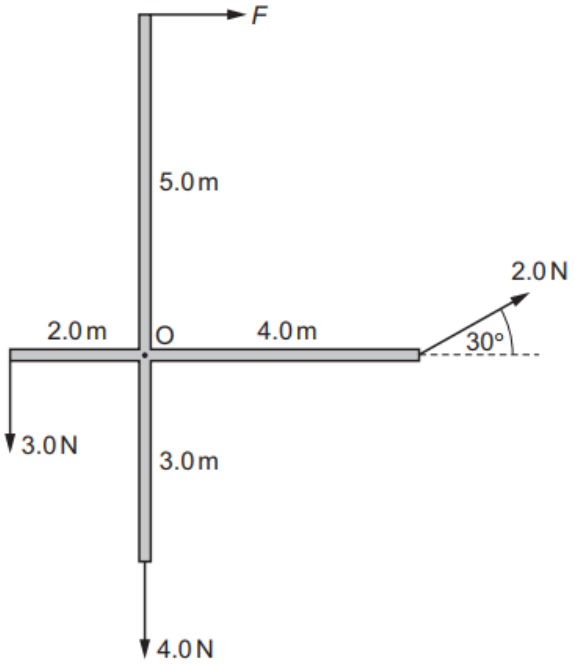
B a pair of forces of equal magnitude acting in opposite directions which produce translational motion but not rotational motion

C a pair of forces of equal magnitude acting in the same direction which produce rotational motion but not translational motion

D a pair of forces of equal magnitude acting in the same direction which produce translational motion but not rotational motion

19.

15 A cross-shaped structure, freely pivoted at O, has arms of lengths 5.0 m, 4.0 m, 3.0 m and 2.0 m. It is acted on by forces of 2.0 N, 3.0 N, 4.0 N and an unknown force *F*. The structure is in rotational equilibrium.

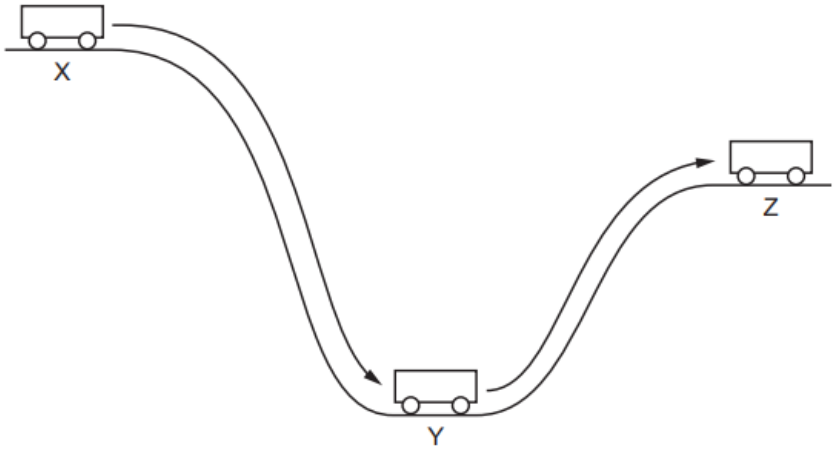


What is the magnitude of force *F*?

A 0.40 N **B** 2.0 N **C** 2.6 N **D** 4.4 N

20.

16 A trolley starts from rest at X. It rolls down to Y and eventually comes to rest at Z.



Which row is a possible summary of the energy changes during this process?

	X to Y	Y to Z
A	p.e. → k.e.	k.e. → p.e.
B	p.e. → k.e.	k.e. → p.e. + heat
C	p.e. → k.e. + heat	k.e. → p.e.
D	p.e. → k.e. + heat	k.e. → p.e. + heat

key
p.e. = potential energy
k.e. = kinetic energy

S15/11

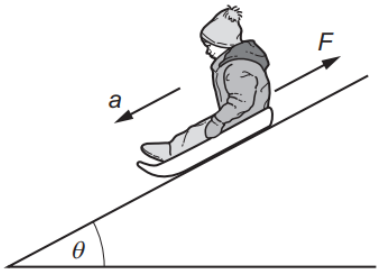
21.

10 What is a reasonable estimate of the average gravitational force acting on a fully grown woman standing on the Earth?

A 60 N **B** 250 N **C** 350 N **D** 650 N

22.

12 A child on a sledge slides down a hill with acceleration a. The hill makes an angle θ with the horizontal.



The total mass of the child and the sledge is m. The acceleration of free fall is g.

What is the friction force F?

A $m(g\cos\theta - a)$

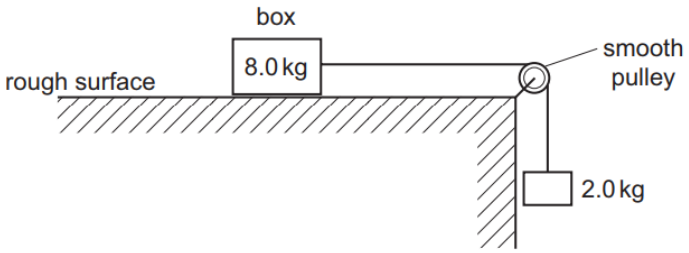
B $m(g\cos\theta + a)$

C $m(g\sin\theta - a)$

D $m(g\sin\theta + a)$

23.

13 A box of mass 8.0 kg rests on a horizontal rough surface. A string attached to the box passes over a smooth pulley and supports a 2.0 kg mass at its other end.



When the box is released, a frictional force of 6.0 N acts on it.

What is the acceleration of the box?

A $1.4\,m\,s^{-2}$ **B** $1.7\,m\,s^{-2}$ **C** $2.0\,m\,s^{-2}$ **D** $2.6\,m\,s^{-2}$

24.

14 What is the **definition** of the force on a body?

A the mass of the body multiplied by its acceleration

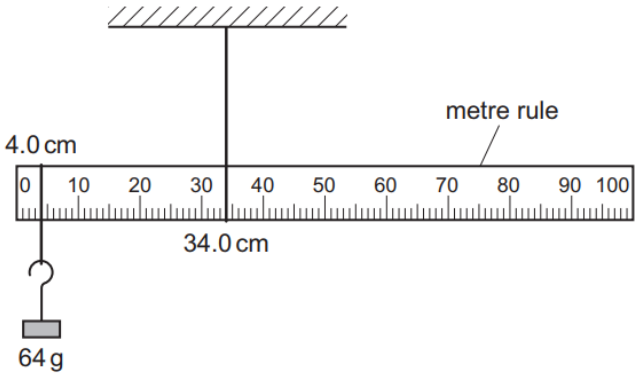
B the power input to the body divided by its velocity

C the rate of change of momentum of the body

D the work done on the body divided by its displacement

25.

15 A uniform metre rule is pivoted at the 34.0 cm mark, as shown.



The rule balances when a 64 g mass is hung from the 4.0 cm mark.

What is the mass of the metre rule?

A 38 g **B** 44 g **C** 120 g **D** 136 g

S15/12

26.

12 An astronaut throws a stone with a horizontal velocity near to the Moon's surface.

Which row describes the horizontal and vertical forces acting on the stone after release?

	horizontal force	vertical force
A	constant	constant
B	constant	decreasing
C	zero	constant
D	zero	decreasing

27.

13 Newton's third law of motion is often summarised as 'Every action (force) has an equal and opposite reaction.'

A book rests on a table.

If the weight of the book is the 'action' force, what is the 'reaction' force?

A the pull of the book on the Earth

B the pull of the Earth on the book

C the push of the book on the table

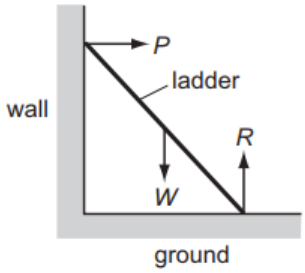
D the push of the table on the book

28.

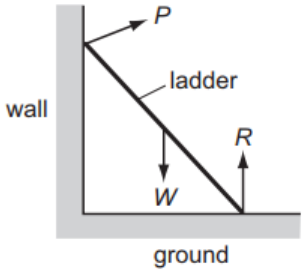
14 A ladder is positioned on icy (frictionless) ground and is leant against a rough wall. At the instant of release it begins to slide.

Which diagram correctly shows the directions of the forces *P*, *W* and *R* acting on the ladder as it slides?

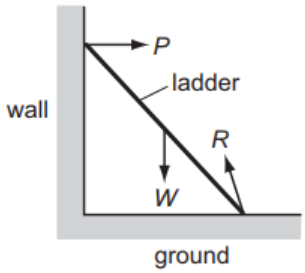
A



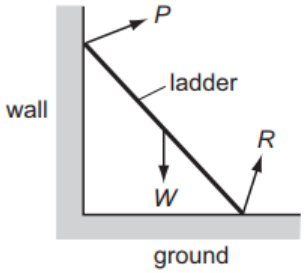
B



C



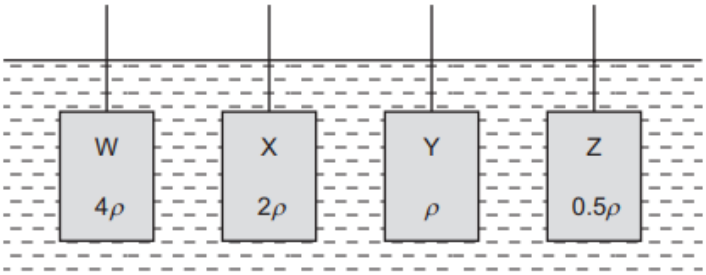
D



S15/13

29.

14 Four cuboids with identical length, breadth and height are immersed in water. The cuboids are held at the same depth and in identical orientations by vertical rods, as shown.



Water has density ρ.
Cuboid W is made of material of density 4ρ.
Cuboid X is made of material of density 2ρ.
Cuboid Y is made of material of density ρ.
Cuboid Z is made of material of density 0.5ρ.

Which statement is correct?

A The upthrust of the water on each of the cuboids is the same.

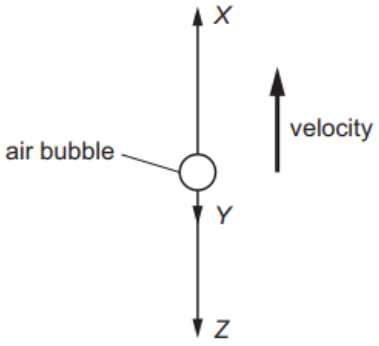
B The upthrust of the water on W is twice the upthrust of the water on X.

C The upthrust of the water on X is twice the upthrust of the water on W.

D The upthrust of the water on Y is zero.

30.

15 An air bubble in a tank of water is rising with constant velocity. The forces acting on the bubble are *X*, *Y* and *Z* as shown.



What describes the three forces?

A *Z* is the viscous drag on the bubble, *Y* is the weight of the bubble, *X* is the upthrust on the bubble and $X = Y + Z$.

B *Z* is the viscous drag on the bubble, *Y* is the weight of the bubble, *X* is the upthrust on the bubble and $X > Y + Z$.

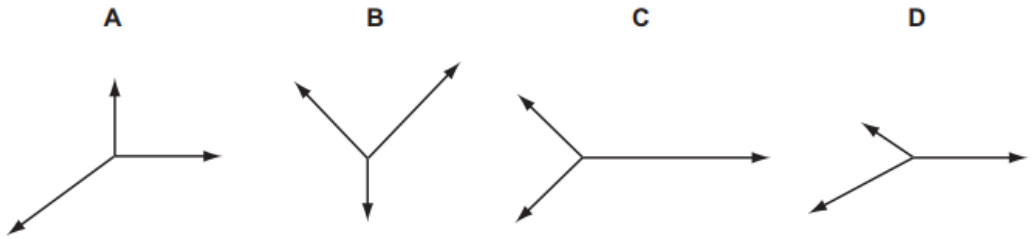
C *Z* is the weight of the bubble, *Y* is the viscous drag on the bubble, *X* is the upthrust on the bubble and $X = Y + Z$.

D *Z* is the weight of the bubble, *Y* is the viscous drag on the bubble, *X* is the upthrust on the bubble and $X > Y + Z$.

31.

16 The diagrams represent systems of coplanar forces acting at a point. The lengths of the force vectors represent the magnitudes of the forces.

Which system of forces is in equilibrium?



W14/11

32.

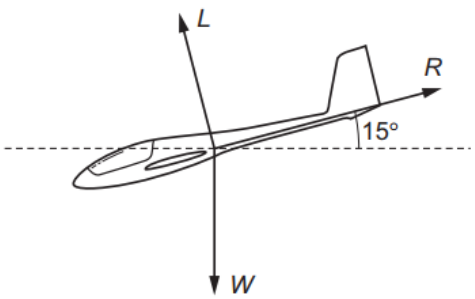
8 Water is pumped through a hose-pipe at a rate of 90 kg per minute. It emerges from the hose-pipe horizontally with a speed of 20 m s^{-1}.

Which force is required from a person holding the hose-pipe to prevent it moving backwards?

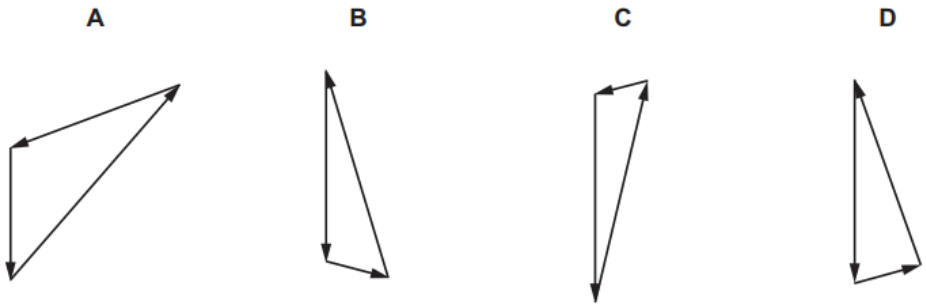
A 30 N **B** 270 N **C** 1800 N **D** 10 800 N

33.

10 A glider is descending at constant speed at an angle of 15° to the horizontal. The diagram shows the directions of the lift *L*, air resistance *R* and weight *W* acting on the glider.



Which vector triangle could represent the forces acting on the glider?



34.

11 A ball is falling at terminal speed in still air. The forces acting on the ball are upthrust, viscous drag and weight.

What is the order of increasing magnitude of these three forces?

A upthrust → viscous drag → weight

B viscous drag → upthrust → weight

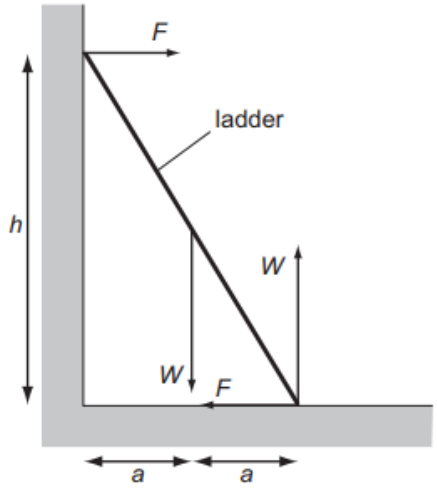
C viscous drag → weight → upthrust

D weight → upthrust → viscous drag

35.

12 A uniform ladder rests against a vertical wall where there is negligible friction. The bottom of the ladder rests on rough ground where there is friction. The top of the ladder is at a height *h* above the ground and the foot of the ladder is at a distance 2*a* from the wall.

The diagram shows the forces that act on the ladder.



Which equation is formed by taking moments?

A $Wa + Fh = 2Wa$

B $Fa + Wa = Fh$

C $Wa + 2Wa = Fh$

D $Wa - 2Wa = 2Fh$

W14/13

36.

9 A man weighs 240 N on Mars where the acceleration of free fall g is $4\,m\,s^{-2}$. On the Moon, g is $2\,m\,s^{-2}$.

Which statement is correct?

A The man has a mass on Mars of 60 N.

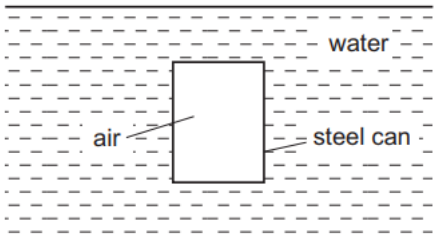
B The man has a mass on the Moon of 120 kg.

C The man weighs 120 N on the Moon.

D The man weighs 240 N on the Moon.

37.

12 A sealed cylindrical steel can is situated below the surface of water.



What is the origin of the upthrust that acts on the can?

A The air pressure in the can is less than the water pressure outside the can.

B The average density of the air and steel is less than the density of water.

C The water pressure on the bottom of the can is greater than the water pressure on the top.

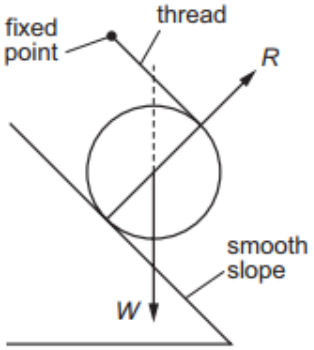
D The weight of displaced water acts upwards on the can.

38.

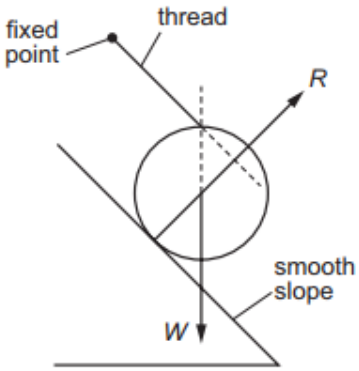
13 A cylinder of weight *W* is placed on a smooth slope. The contact force of the slope on the cylinder is *R*. A thread is attached to the surface of the cylinder. The other end of the thread is fixed.

Which diagram shows the cylinder in equilibrium?

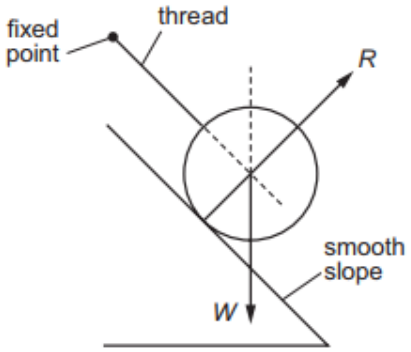
A



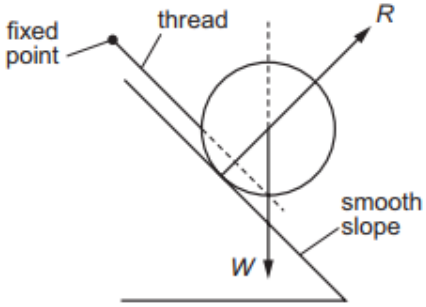
B



C

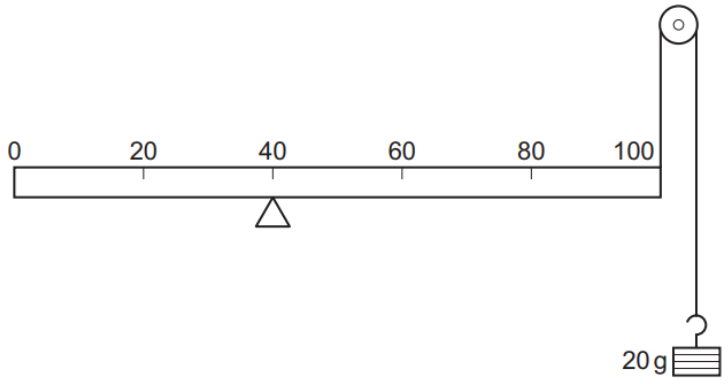


D



39.

14 A uniform metre rule of mass 100 g is supported by a pivot at the 40 cm mark and a string at the 100 cm mark. The string passes round a frictionless pulley and carries a mass of 20 g as shown in the diagram.



At which mark on the rule must a 50 g mass be suspended so that the rule balances?

A 4 cm **B** 36 cm **C** 44 cm **D** 64 cm

S14/11

40.

11 The diagrams show two ways of hanging the same picture.

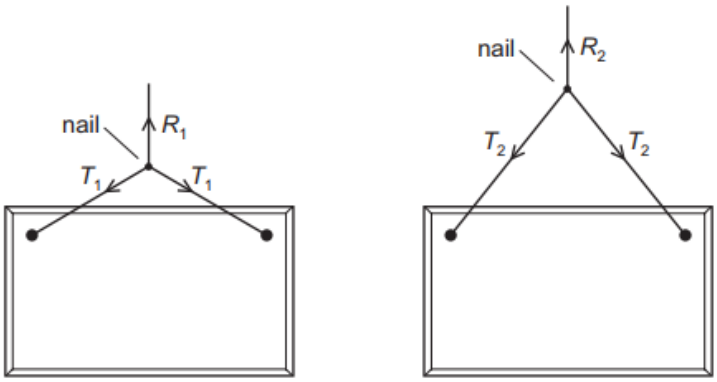


diagram 1 diagram 2

In both cases, a string is attached to the same points on the picture and looped symmetrically over a nail in a wall. The forces shown are those that act on the nail.

In diagram 1, the string loop is shorter than in diagram 2.

Which information about the magnitude of the forces is correct?

A $R_1 = R_2$ $T_1 = T_2$

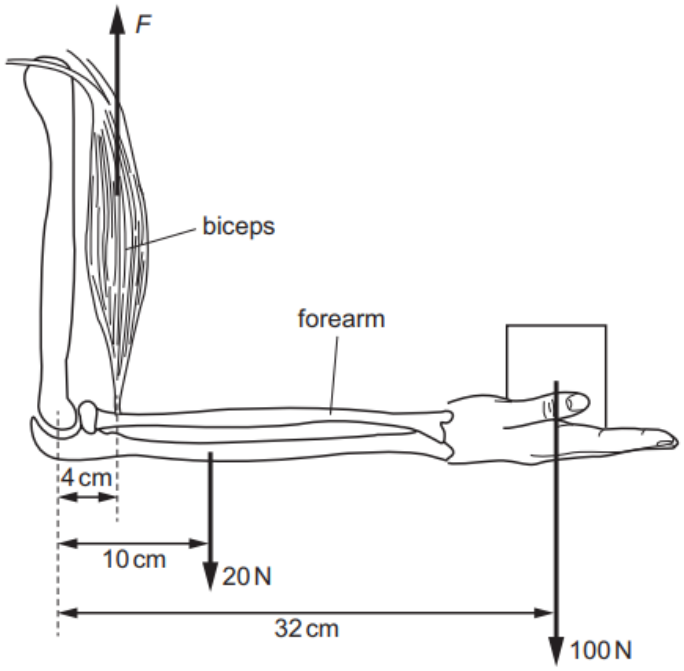
B $R_1 = R_2$ $T_1 > T_2$

C $R_1 > R_2$ $T_1 < T_2$

D $R_1 < R_2$ $T_1 = T_2$

41.

12 A man holds a 100 N load stationary in his hand. The combined weight of the forearm and hand is 20 N. The forearm is held horizontal, as shown.

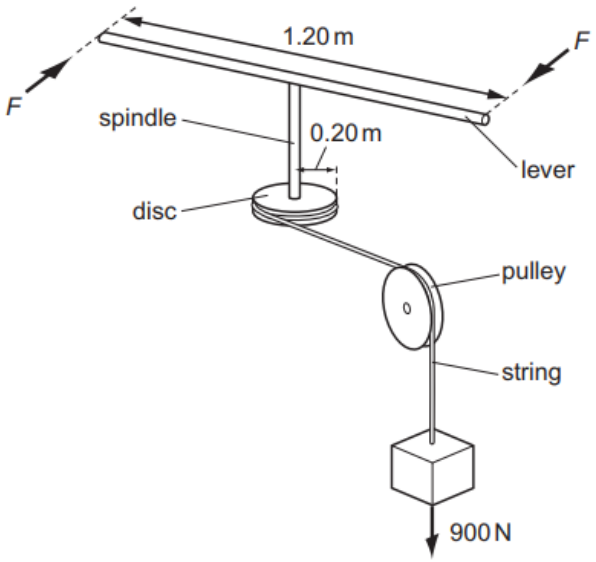


What is the vertical force *F* needed in the biceps?

A 750 N **B** 800 N **C** 850 N **D** 900 N

42.

13 A spindle is attached at one end to the centre of a lever of length 1.20 m and at its other end to the centre of a disc of radius 0.20 m. A string is wrapped round the disc, passes over a pulley and is attached to a 900 N weight.



What is the minimum force *F*, applied to each end of the lever, that could lift the weight?

A 75 N **B** 150 N **C** 300 N **D** 950 N

S14/12

43.

9 A ship of mass 8.4×10^7 kg is approaching a harbour with speed $16.4\,m\,s^{-1}$. By using reverse thrust it can maintain a constant total stopping force of 920 000 N.

How long will it take to stop?

A 15 seconds

B 150 seconds

C 25 minutes

D 250 minutes

44.

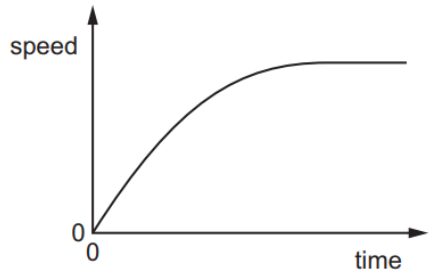
10 A tractor of mass 1000 kg is connected by a tow-bar to a trailer of mass 1000 kg. The total resistance to motion has a constant value of 4000 N. One quarter of this resistance acts on the trailer.

When the tractor and trailer are moving along horizontal ground at a constant speed of $6\,m\,s^{-1}$, what is the force exerted on the tractor by the tow-bar?

A 0 N **B** 1000 N **C** 3000 N **D** 4000 N

45.

11 The graph shows the variation with time of the speed of a raindrop falling vertically through air.



Which statement is correct?

A The acceleration decreases to produce a steady speed.

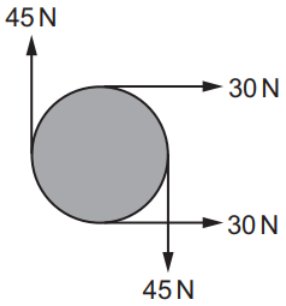
B The acceleration increases as the speed increases.

C The air resistance decreases as the speed increases.

D The resultant force increases as the speed increases.

46.

13 The diagram shows four forces applied to a circular object.



Which of the following describes the resultant force and resultant torque on the object?

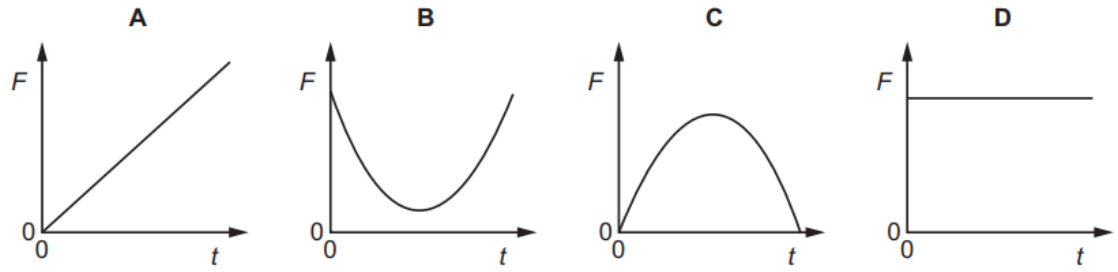
	resultant force	resultant torque
A	non-zero	non-zero
B	non-zero	zero
C	zero	non-zero
D	zero	zero

S14/13

47.

10 A tennis ball is dropped onto a table and bounces back up. The table exerts a force *F* on the ball.

Which graph best shows the variation with time *t* of the force *F* while the ball is in contact with the table?



48.

13 What is the condition for an object to be in equilibrium?

A The object's velocity and the resultant torque on it must both be zero.

B The object's velocity must be zero.

C The resultant force and the resultant torque on the object must both be zero.

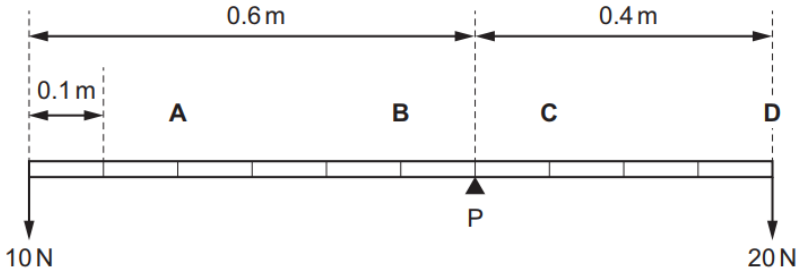
D The resultant force on the object must be zero.

49.

15 A uniform beam is pivoted at P as shown. Weights of 10 N and 20 N are attached to its ends.

The length of the beam is marked at 0.1 m intervals. The weight of the beam is 100 N.

At which point should a further weight of 20 N be attached to achieve equilibrium?



50.

17 A shot-put champion accelerates a 7.0 kg metal ball in a straight line. The ball moves from rest to a speed of 12 m s^{-1} in a distance of 1.2 m.

What is the average resultant force on the metal ball?

A 70 N **B** 210 N **C** 420 N **D** 840 N

W13/11

51.

9 What is meant by the mass and by the weight of an object on the Earth?

	mass	weight
A	its momentum divided by its velocity	the work done in lifting it one metre
B	the gravitational force on it	the property that resists its acceleration
C	the pull of the Earth on it	its mass divided by the acceleration of free fall
D	the property that resists its acceleration	the pull of the Earth on it

52.

10 An astronaut of mass *m* in a spacecraft experiences a gravitational force $F = mg$ when stationary on the launchpad.

What is the gravitational force on the astronaut when the spacecraft is launched vertically upwards with an acceleration of $0.2g$?

A $1.2mg$ **B** mg **C** $0.8mg$ **D** 0

53.

11 A beam of α-particles collides with a lead sheet. Each α-particle in the beam has a mass of 6.6×10^{-27} kg and a speed of $1.5 \times 10^{7}\,m\,s^{-1}$.

5.0×10^{4} α-particles per second collide with an area of $1.0\,cm^{2}$ of lead. Almost all of the α-particles are absorbed by the lead so that they have zero speed after collision.

What is an estimate of the average pressure exerted on the lead by the α-particles?

A 5.0×10^{-15} Pa

B 5.0×10^{-13} Pa

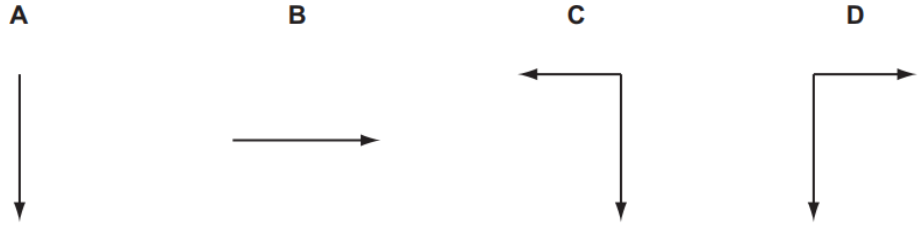
C 5.0×10^{-11} Pa

D 5.0×10^{-9} Pa

54.

12 An object in air is thrown upwards and towards the left.

Which diagram shows the force(s) acting on the body when it is at its highest point?



55.

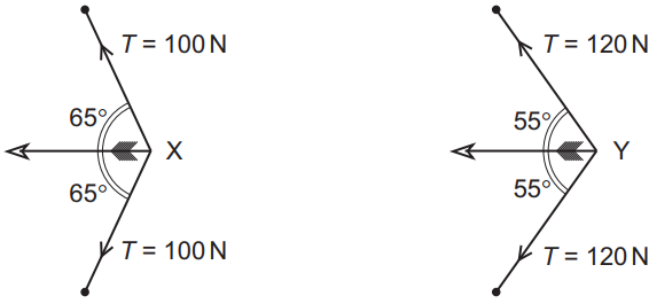
13 A particle is in a uniform field. The particle experiences a force in the opposite direction to the field.

Which field is the particle in, and on which property of the particle is the field acting?

	field	property of particle on which the field acts
A	electric	charge
B	electric	current
C	gravitational	mass
D	gravitational	weight

56.

14 An archer draws his bowstring back to position X. The bowstring and arrow are shown. The tension *T* in the string is also shown. Then he draws the bowstring back further to position Y.



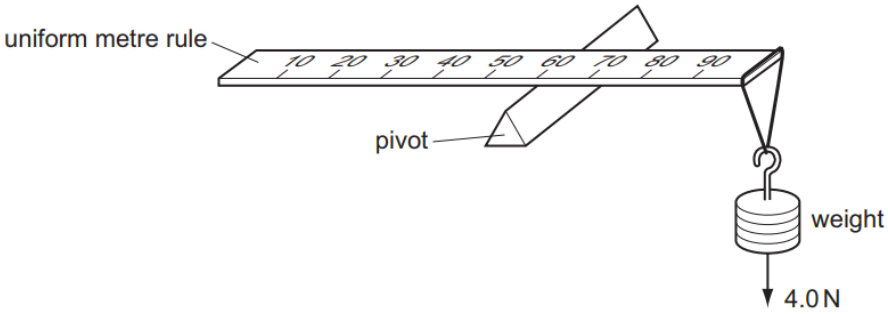
The resultant force on the arrow is greater when the arrow is released from position Y.

What is the increase in force?

A 15 N **B** 27 N **C** 40 N **D** 53 N

57.

15 A uniform metre rule of weight 2.0 N is pivoted at the 60 cm mark. A 4.0 N weight is suspended from one end, causing the rule to rotate about the pivot.



At the instant when the rule is horizontal, what is the resultant turning moment about the pivot?

A zero **B** 1.4 N m **C** 1.6 N m **D** 1.8 N m

58.

W13/13

59.

12 A mass accelerates uniformly when the resultant force acting on it

A is zero.

B is constant but not zero.

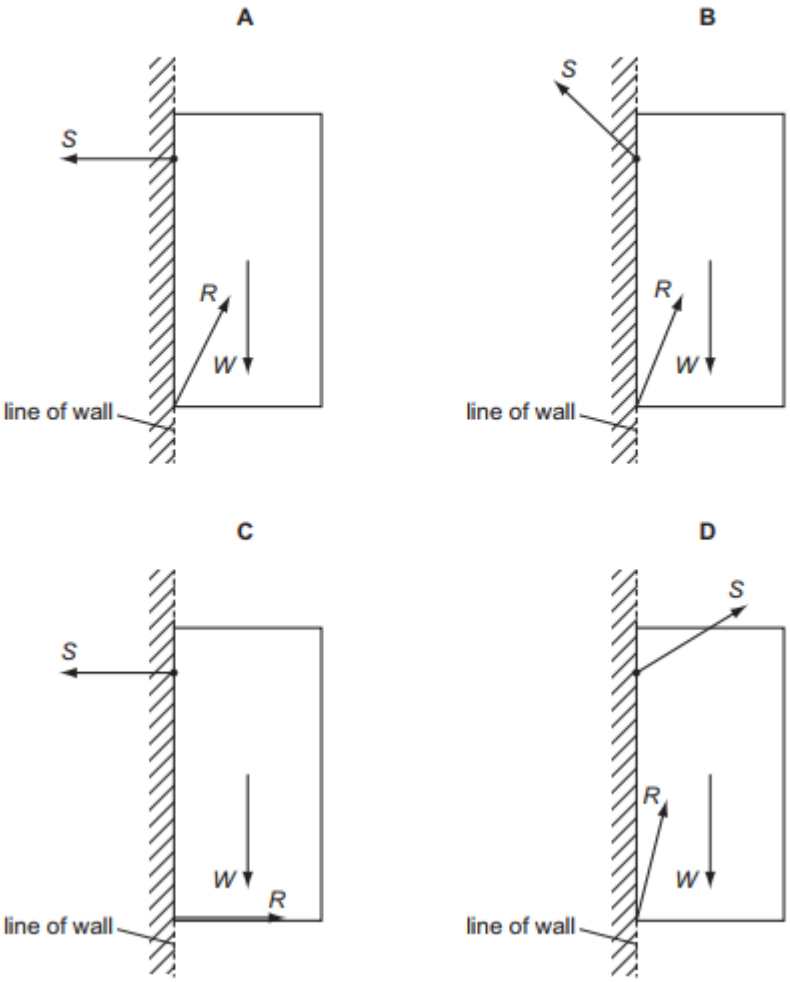
C increases uniformly with respect to time.

D is proportional to the displacement from a fixed point.

60.

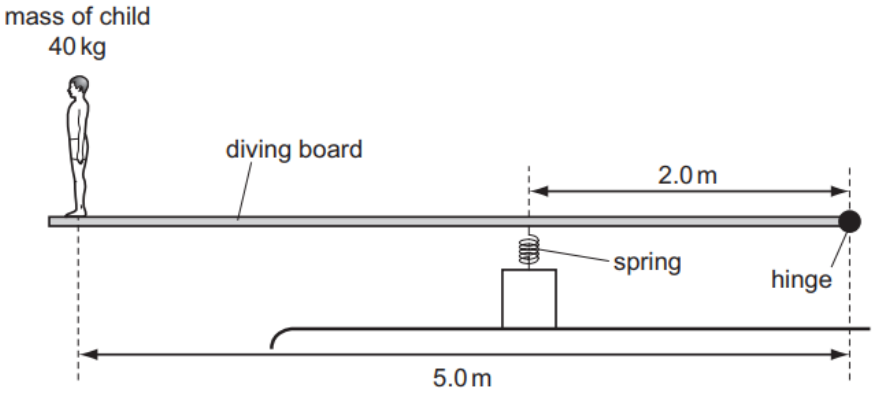
14 A cupboard is attached to a wall by a screw.

Which force diagram shows the cupboard in equilibrium, with the weight *W* of the cupboard, the force *S* that the screw exerts on the cupboard and the force *R* that the wall exerts on the cupboard?



61.

15 A diving board of length 5.0 m is hinged at one end and supported 2.0 m from this end by a spring of spring constant 10 kN m^{-1}. A child of mass 40 kg stands at the far end of the board.



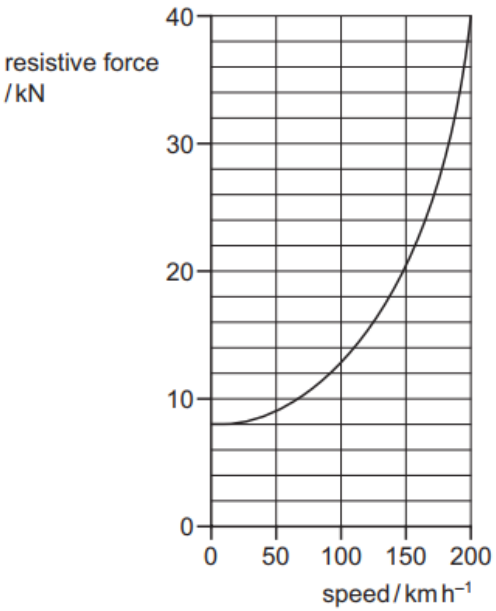
What is the extra compression of the spring caused by the child standing on the end of the board?

A 1.0 cm **B** 1.6 cm **C** 9.8 cm **D** 16 cm

62.

16 The graph shows how the total resistive force acting on a train varies with its speed.

Part of this force is due to wheel friction, which is constant. The rest is due to wind resistance.



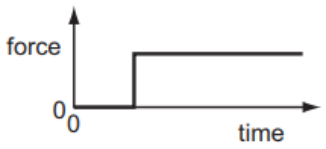
What is the ratio $\frac{\text{wind resistance}}{\text{wheel friction}}$ at a speed of 200 km h^{-1}?

A 4 **B** 5 **C** 8 **D** 10

S13/11

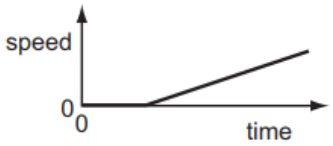
63.

9 A car is stationary at traffic lights. When the traffic lights go green, the driver presses down sharply on the accelerator. The resultant horizontal force acting on the car varies with time as shown.

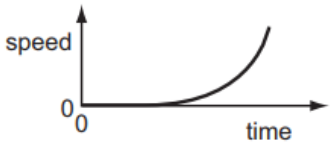


Which graph shows the variation with time of the speed of the car?

A



B

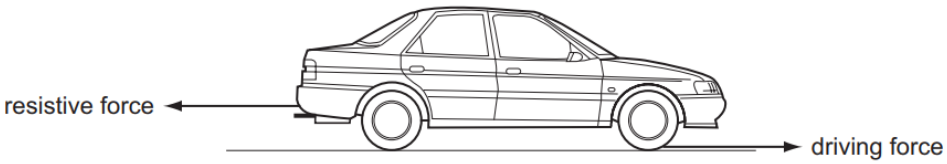


C

D

64.

12 A car of mass 750 kg has a horizontal driving force of 2.0 kN acting on it. It has a forward horizontal acceleration of 2.0 $m\,s^{-2}$.

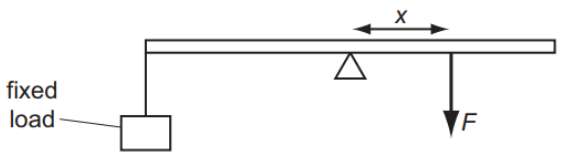


What is the resistive force acting horizontally?

A 0.50 kN **B** 1.5 kN **C** 2.0 kN **D** 3.5 kN

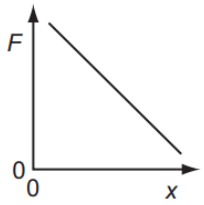
65.

14 A horizontal bar is supported on a pivot at its centre of gravity. A fixed load is attached to one end of the bar. To keep the bar in equilibrium, a force *F* is applied at a distance *x* from the pivot.

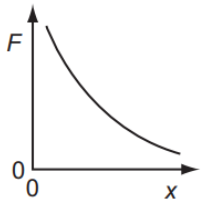


How does *F* vary with *x*?

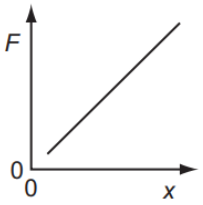
A



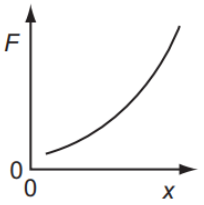
B



C



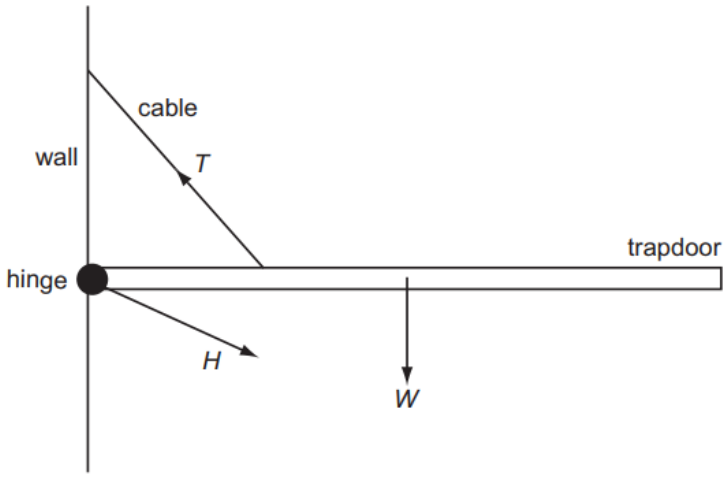
D



66.

16 A hinged trapdoor is held closed in the horizontal position by a cable.

Three forces act on the trapdoor: the weight *W* of the door, the tension *T* in the cable and the force *H* at the hinge.



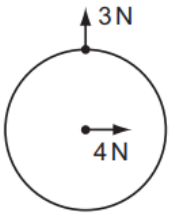
Which list gives the three forces in **increasing** order of magnitude?

A *H*,*T*,*W** **B** *T*,*H*,*W** **C** *W*,*H*,*T** **D** *W*,*T*,*H*

S13/12

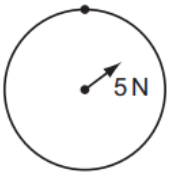
67.

3 Two forces act on a circular disc as shown.

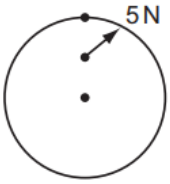


Which diagram shows the line of action of the resultant force?

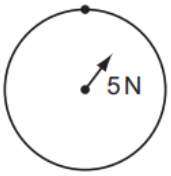
A



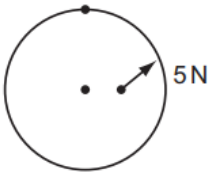
B



C



D

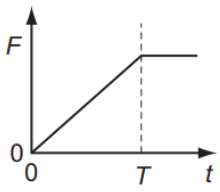


68.

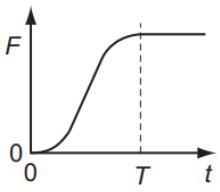
6 A sky diver falls vertically from a stationary balloon. She leaves the balloon at time $t = 0$. At time $t = T$, she reaches terminal velocity. Beyond the time shown in the graphs, she opens her parachute.

Which graph shows the variation with time t of the force F due to air resistance?

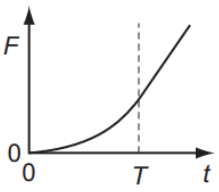
A



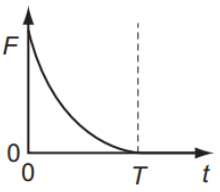
B



C

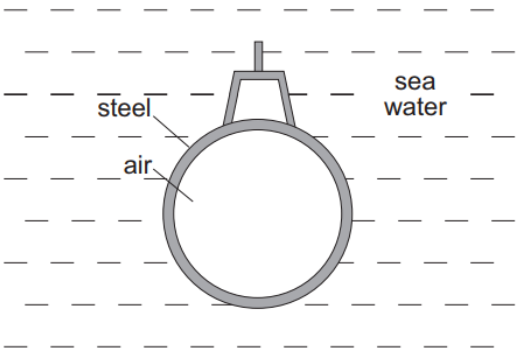


D



69.

11 A submarine is in equilibrium in a fully submerged position.



What causes the upthrust on the submarine?

A The air in the submarine is less dense than sea water.

B The sea water exerts a greater upward force on the submarine than the weight of the steel.

C The submarine displaces its own volume of sea water.

D There is a difference in water pressure acting on the top and on the bottom of the submarine.

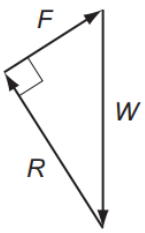
70.

12 A vehicle is at rest on a slope. It is considered to have three forces acting on it to keep it in equilibrium.

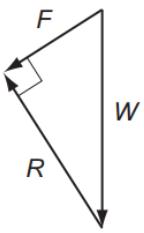
They are its weight *W*, a normal reaction force *R* and a frictional force *F*.

Which triangle of forces is correct?

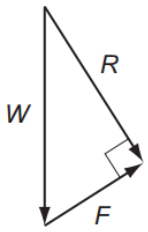
A



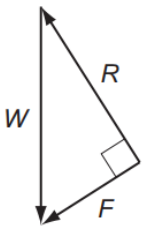
B



C



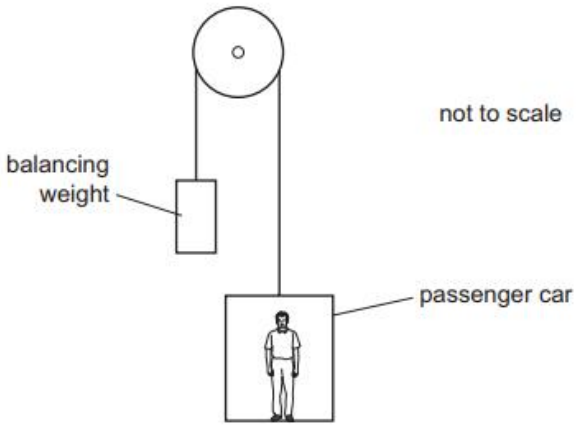
D



S13/13

71.

9 A lift (elevator) consists of a passenger car supported by a cable which runs over a light, frictionless pulley to a balancing weight. The balancing weight falls as the passenger car rises.



Some masses are shown in the table.

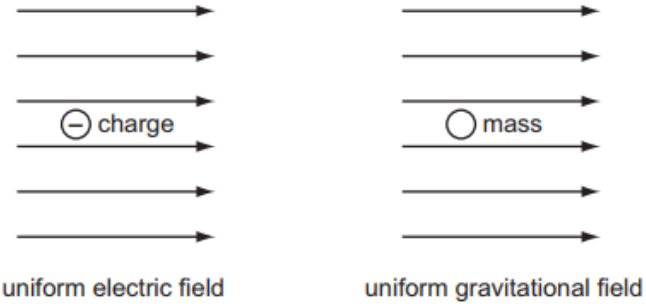
	mass / kg
passenger car	520
balancing weight	640
passenger	80

What is the magnitude of the acceleration of the car when carrying just one passenger and when the pulley is free to rotate?

A $0.032\,m\,s^{-2}$ **B** $0.32\,m\,s^{-2}$ **C** $0.61\,m\,s^{-2}$ **D** $0.65\,m\,s^{-2}$

72.

12 The diagrams show a negative electric charge situated in a uniform electric field and a mass situated in a uniform gravitational field.

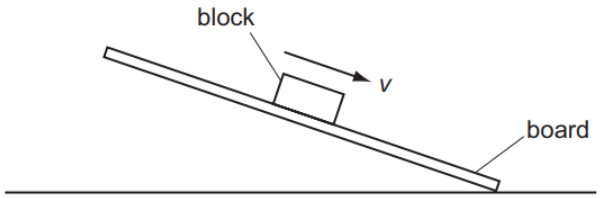


Which row shows the directions of the forces acting on the charge and on the mass?

	charge	mass
A	⊖→	○→
B	←⊖	○→
C	⊖→	○↓
D	←⊖	○↓

73.

13 A wooden block rests on a rough board. The end of the board is then raised until the block slides down the plane of the board at constant velocity *v*.



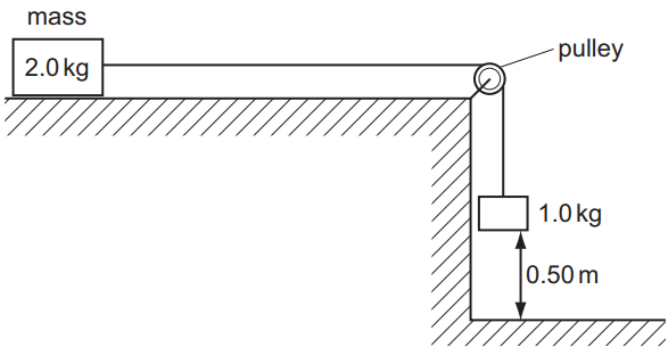
Which row describes the forces acting on the block when sliding with constant velocity?

	frictional force on block	resultant force on block
A	down the plane	down the plane
B	down the plane	zero
C	up the plane	down the plane
D	up the plane	zero

W12/11

74.

13 A mass of 2.0 kg rests on a frictionless surface. It is attached to a 1.0 kg mass by a light, thin string which passes over a frictionless pulley. The 1.0 kg mass is released and it accelerates downwards.

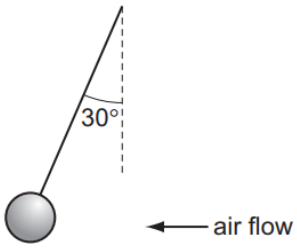


What is the speed of the 2.0 kg mass as the 1.0 kg mass hits the floor, having fallen a distance of 0.50 m?

A 1.8 ms^{-1} **B** 2.2 ms^{-1} **C** 3.1 ms^{-1} **D** 9.8 ms^{-1}

75.

15 The diagram shows an experiment to measure the force exerted on a ball by a horizontal air flow.



The ball is suspended by a light string and weighs 0.15 N.

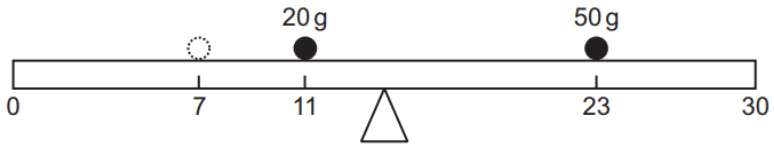
The deflection of the string from vertical is 30°.

What is the force on the ball from the air flow?

A 0.075 N **B** 0.087 N **C** 0.26 N **D** 0.30 N

76.

16 A student balances a 30 cm ruler on a fulcrum set at the 15 cm mark. She then places a 50 g mass on the 23 cm mark and a 20 g mass on the 11 cm mark, as shown.



Which mass should she place on the 7 cm mark to restore the balance?

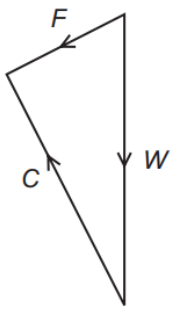
A 30 g **B** 40 g **C** 47 g **D** 133 g

77.

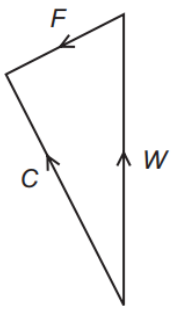
17 A sledge slides down a slope at a constant velocity. The three forces that act on the sledge are the normal contact force *C*, the weight *W* and a constant frictional force *F*.

Which diagram represents these forces acting on the sledge?

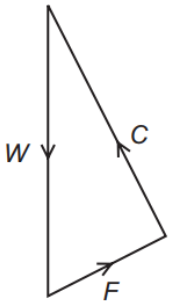
A



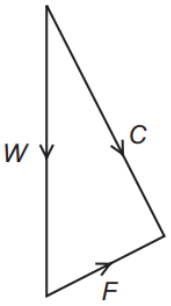
B



C



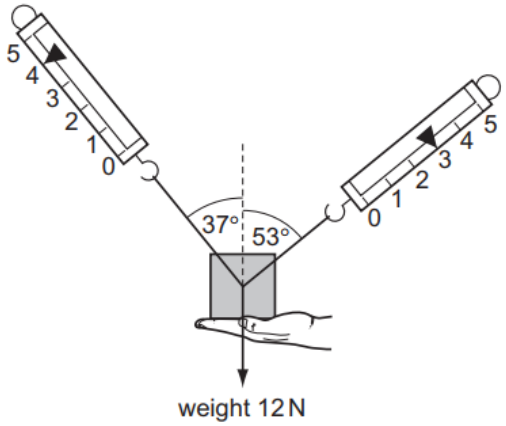
D



W12/12

78.

14 A 1.2 kg mass is supported by a person's hand and two newton-meters as shown.

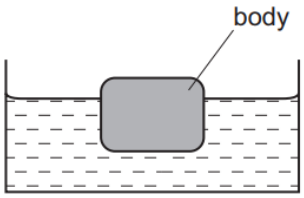


When the person's hand is removed, what is the initial vertical acceleration of the mass?

A $0.6\,ms^{-2}$ **B** $2\,ms^{-2}$ **C** $4\,ms^{-2}$ **D** $6\,ms^{-2}$

79.

16 A stationary body floats in water.



Which statement about the forces acting on the body is correct?

A The gravitational force is equal to the viscous force.

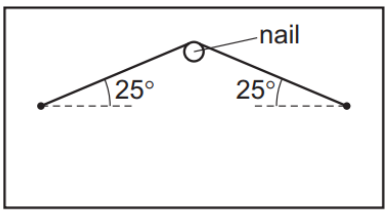
B The gravitational force is greater than the upthrust.

C The upthrust is zero.

D The viscous force is zero.

80.

18 A picture on a wall is supported by a wire looped over a nail.



The mass of the picture is 4.2 kg.

What is the tension in the supporting wire?

A 5.0 N **B** 23 N **C** 49 N **D** 97 N

81.

19 A piston in a gas supply pump has an area of 500 cm^2 and it moves a distance of 30 cm during one stroke.

The pump moves the gas against a fixed pressure of 4000 Pa.

How much work is done by the piston during one stroke?

A 60 J **B** 6.0×10^3 J **C** 6.0×10^5 J **D** 6.0×10^7 J

W12/13

82.

13 The IKAROS satellite has mass 320 kg and moves through space using a solar sail of area 20 m^2. The average solar wind pressure is 1.0×10^{-5} N m^{-2}.

What is the acceleration of the satellite caused by the solar wind?

A 3.1×10^{-8} m s^{-2}

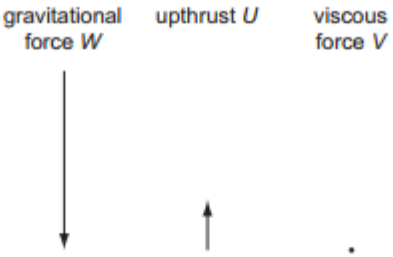
B 6.3×10^{-7} m s^{-2}

C 3.2×10^{-3} m s^{-2}

D 6.4×10^{-2} m s^{-2}

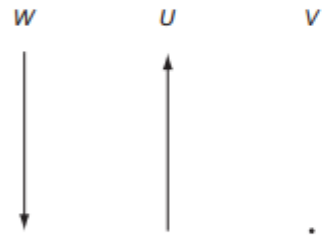
83.

15 A hailstone, initially stationary at the base of a cloud, falls vertically towards the Earth. The diagram shows the magnitudes and directions of the forces acting on the hailstone as it starts to drop.

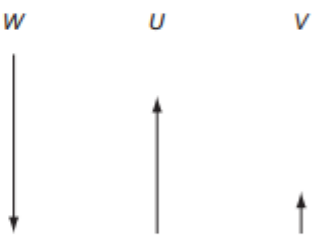


Which diagram shows the magnitudes and directions of these forces when the hailstone attains a terminal (constant) speed in the air (of uniform density)?

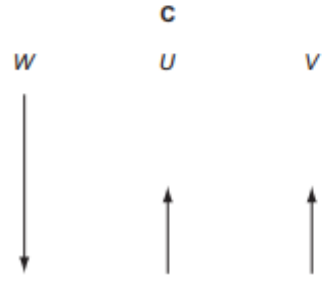
A



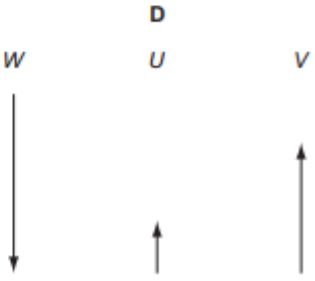
B



C



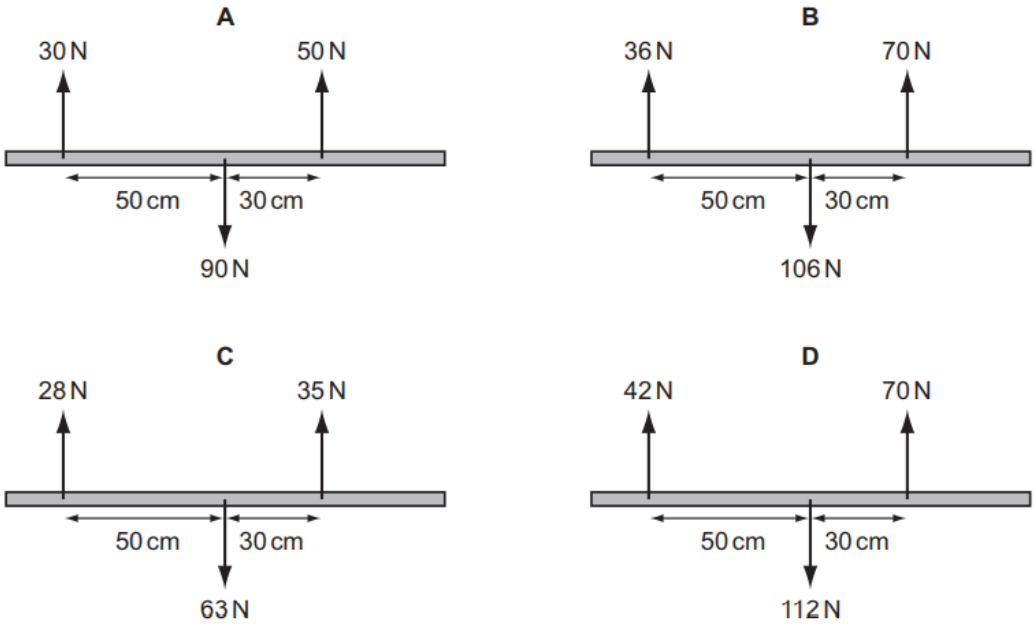
D



84.

16 Four beams of the same length each have three forces acting on them.

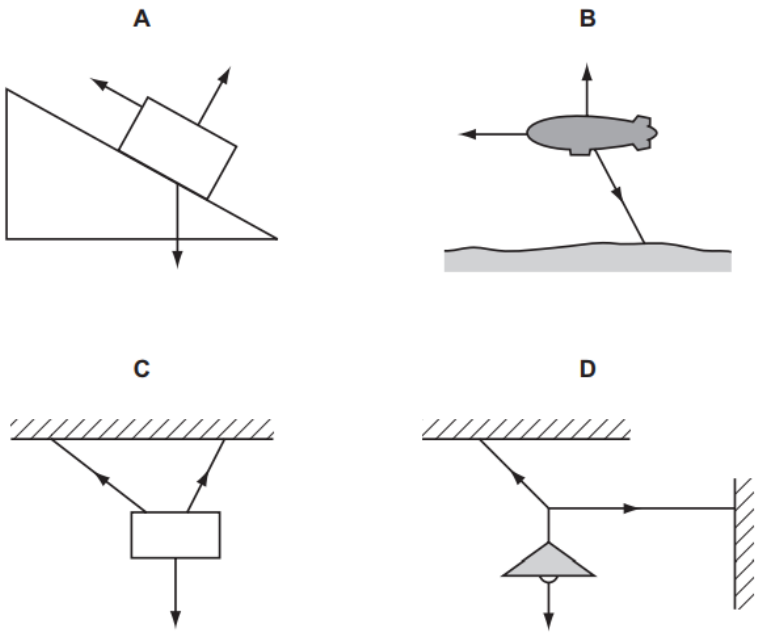
Which beam has both zero resultant force and zero resultant torque acting?



85.

17 The diagrams show the forces acting on different bodies.

Which body **cannot** be in equilibrium?



S12/11

86.

10 Each option gives a correct word equation involving force.

Which option gives the definition of force?

A force = energy divided by displacement

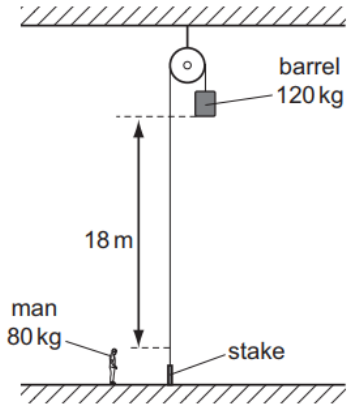
B force = mass × acceleration

C force = pressure × area

D force = rate of change of momentum

87.

12 The diagram shows a barrel suspended from a frictionless pulley on a building. The rope supporting the barrel goes over the pulley and is secured to a stake at the bottom of the building.



A man stands close to the stake. The bottom of the barrel is 18 m above the man's head. The mass of the barrel is 120 kg and the mass of the man is 80 kg.

The man keeps hold of the rope after untying it from the stake and is lifted upwards as the barrel falls.

What is the man's upward speed when his head is level with the bottom of the barrel? (Use $g = 10\,m\,s^{-2}$.)

A $6\,m\,s^{-1}$ **B** $8\,m\,s^{-1}$ **C** $13\,m\,s^{-1}$ **D** $19\,m\,s^{-1}$

88.

13 A cylindrical block of wood has cross-sectional area A and weight W. It is totally immersed in water with its axis vertical. The block experiences pressures p_t and p_b at its top and bottom surfaces respectively.

Which expression is equal to the upthrust on the block?

A $(p_b - p_t)A + W$

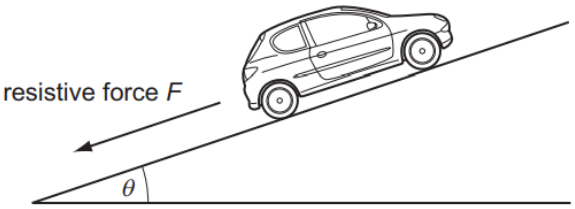
B $(p_b - p_t)$

C $(p_b - p_t)A$

D $(p_b - p_t)A - W$

89.

14 A car of mass m travels at constant speed up a slope at an angle θ to the horizontal, as shown in the diagram. Air resistance and friction provide a resistive force F.



What force is needed to propel the car at this constant speed?

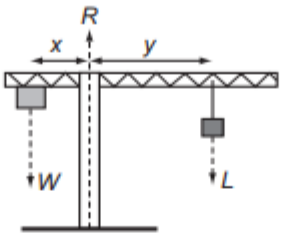
A $mg \cos \theta$

B $mg \sin \theta$

C $mg \cos \theta + F$

D $mg \sin \theta + F$

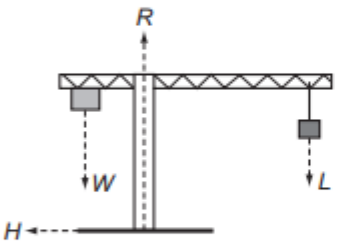
15 The diagram shows a crane supporting a load *L*.



A mass provides a balancing load *W*. The position of the load is such that the system is perfectly balanced with $Wx = Ly$. The ground provides a reaction force *R*. The distance *x* does not change.

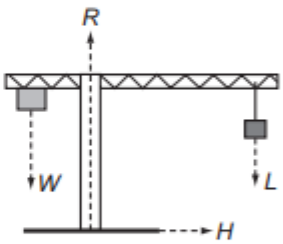
If the load is moved further out so that the distance *y* increases and the crane does not topple, which statement is correct?

A



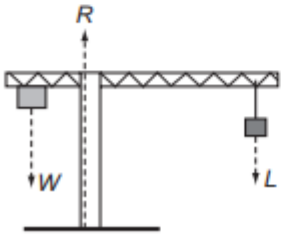
A horizontal force *H* acts on the base of the support column towards the left.

B



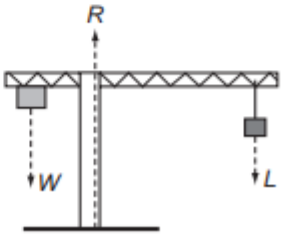
A horizontal force *H* acts on the base of the support column towards the right.

C



The reaction force *R* moves to the left.

D



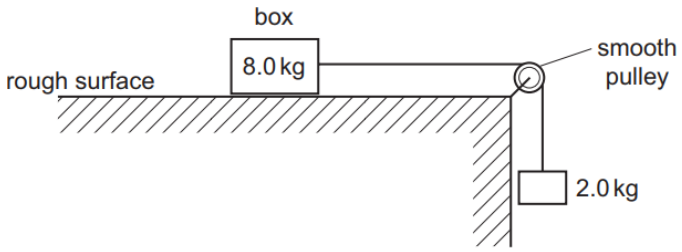
The reaction force *R* moves to the right.

90.

S12/12

91.

13 A box of mass 8.0 kg rests on a horizontal, rough surface. A string attached to the box passes over a smooth pulley and supports a 2.0 kg mass at its other end.



When the box is released, a frictional force of 6.0 N acts on it.

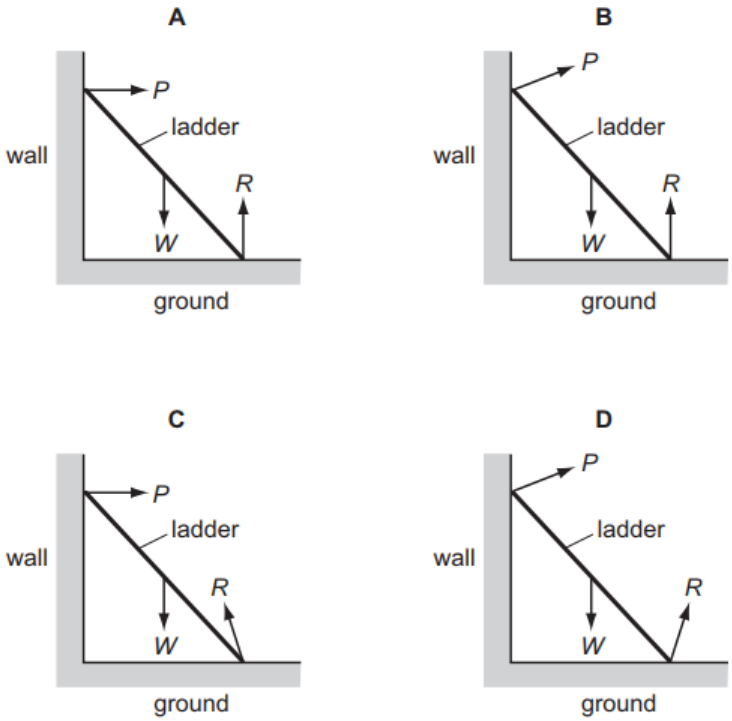
What is the acceleration of the box?

A $1.4\,m\,s^{-2}$ **B** $1.7\,m\,s^{-2}$ **C** $2.0\,m\,s^{-2}$ **D** $2.5\,m\,s^{-2}$

92.

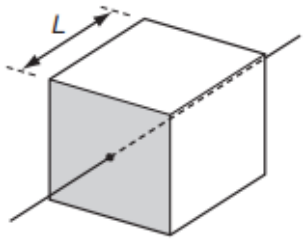
14 A ladder is positioned on icy (frictionless) ground and is leant against a rough wall. At the instant of release it begins to slide.

Which diagram correctly shows the directions of the forces *P*, *W* and *R* acting on the ladder as it begins to slide?

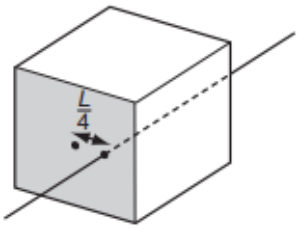


93.

15 The diagram shows a solid cube with weight W and sides of length L. It is supported by a frictionless spindle that passes through the centres of two opposite vertical faces. One of these faces is shaded.



The spindle is now removed and replaced at a distance $\frac{L}{4}$ to the right of its original position.



When viewing the shaded face, what is the torque of the couple that will now be needed to stop the cube from toppling?

A $\frac{WL}{2}$ anticlockwise

B $\frac{WL}{2}$ clockwise

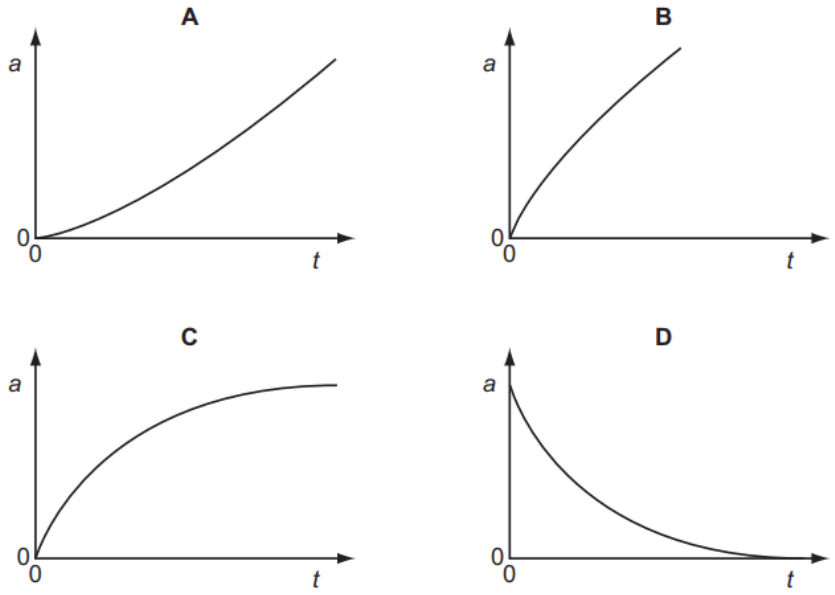
C $\frac{WL}{4}$ anticlockwise

D $\frac{WL}{4}$ clockwise

94.

16 A sphere is released from rest in a viscous fluid.

Which graph represents the variation with time *t* of the acceleration *a* of the sphere?



W11/11

95.

10 What is the **definition** of the force on a body?

A the mass of the body multiplied by its acceleration

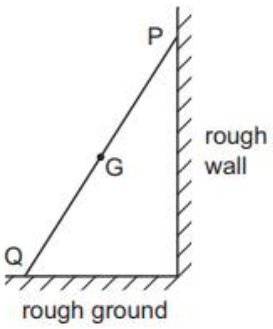
B the power input to the body divided by its velocity

C the rate of change of momentum of the body

D the work done on the body divided by its displacement

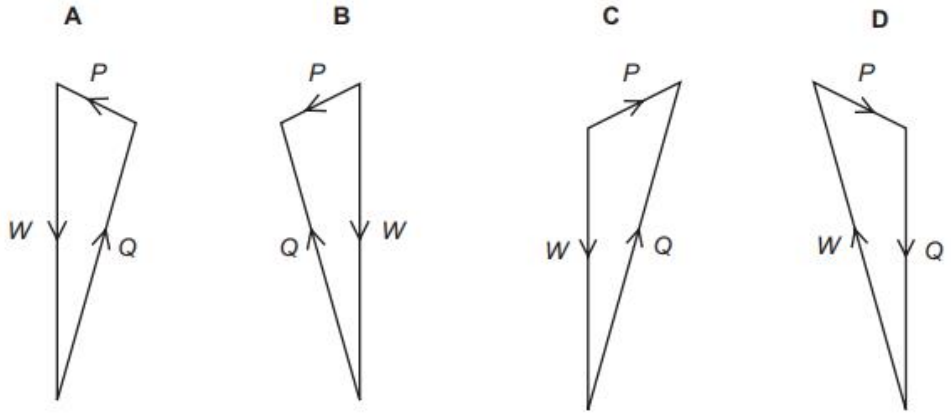
96.

13 A ladder rests in equilibrium on rough ground against a rough wall.



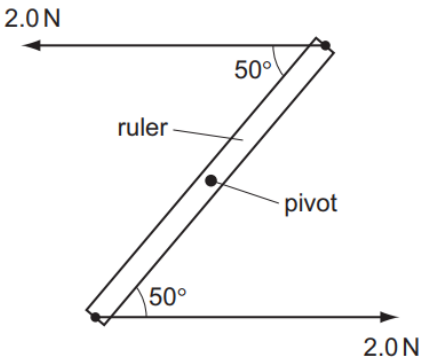
Its weight *W* acts through the centre of gravity G. Forces also act on the ladder at P and at Q. These forces are *P* and *Q* respectively.

Which vector triangle represents the forces on the ladder?



97.

14 A ruler of length 0.30 m is pivoted at its centre. Equal and opposite forces of magnitude 2.0 N are applied to the ends of the ruler, creating a couple as shown.

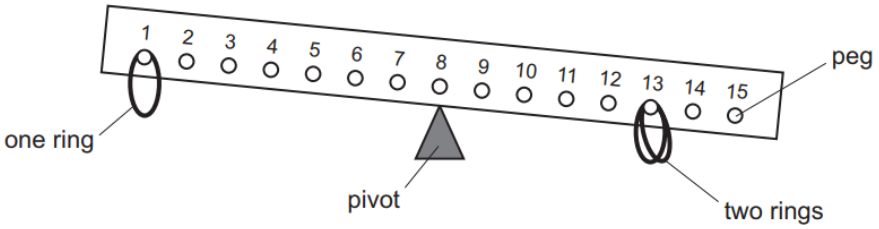


What is the magnitude of the torque of the couple on the ruler when it is in the position shown?

A 0.23 N m **B** 0.39 N m **C** 0.46 N m **D** 0.60 N m

98.

15 The diagram shows a child's balancing game.



The wooden rod is uniform and all the rings are of equal mass. Two rings are hung on peg 13 and one on peg 1.

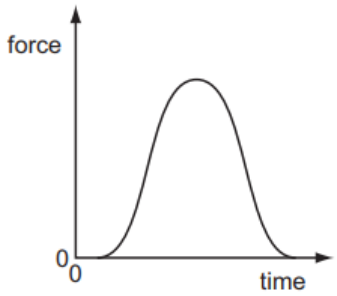
On which hook must a fourth ring be hung in order to balance the rod?

A 2 **B** 3 **C** 5 **D** 6

W11/12

99.

9 A golf ball is hit by a club. The graph shows the variation with time of the force exerted on the ball by the club.



Which quantity, for the time of contact, **cannot** be found from the graph?

A the average force on the ball

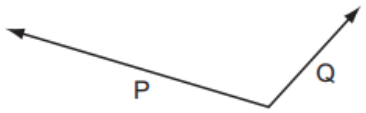
B the change in momentum of the ball

C the contact time between the ball and the club

D the maximum acceleration of the ball

100.

12 Two possible displacements of an object are represented by the vectors P and Q.



Which vector best represents the resultant displacement (P – Q) of the object?

A

B

C

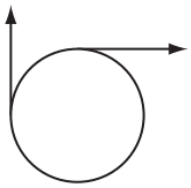
D

101.

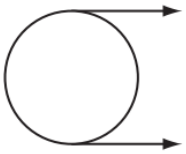
13 Two co-planar forces act on the rim of a wheel. The forces are equal in magnitude.

Which arrangement of forces provides only a couple?

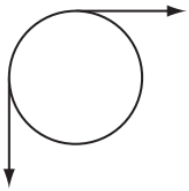
A



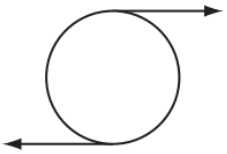
B



C

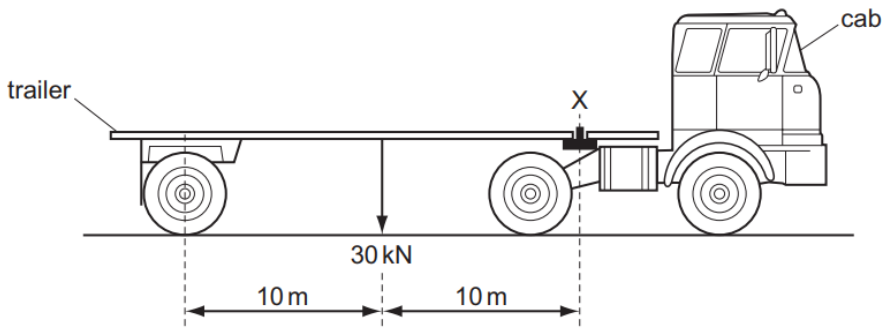


D



102.

14 A trailer of weight 30 kN is hitched to a cab at X, as shown in the diagram.



What is the upward force exerted by the cab on the trailer at X?

A 3 kN **B** 15 kN **C** 30 kN **D** 60 kN

S11/11

103.

8 A body has a weight of 58.9 N when on the Earth. On the Moon, the acceleration of free fall is $1.64\,m\,s^{-2}$.

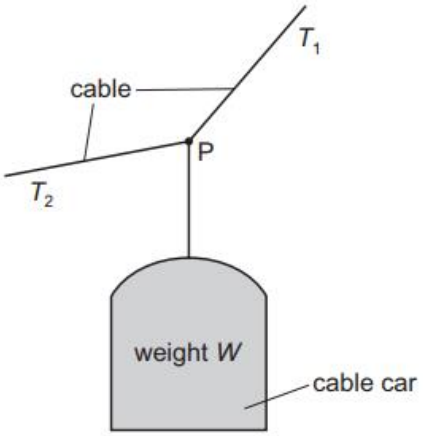
What are the weight and the mass of the body when it is on the Moon?

	weight / N	mass / kg
A	9.85	1.00
B	9.85	6.00
C	58.9	1.00
D	58.9	6.00

104.

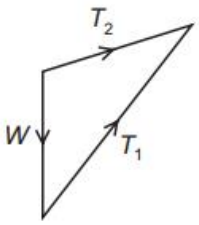
11 A cable car of weight W hangs in equilibrium from its cable at point P.

The cable has tensions T_1 and T_2 as shown.

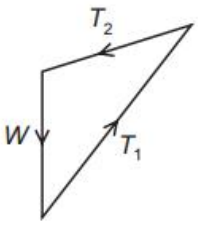


Which diagram correctly represents the forces acting at point P?

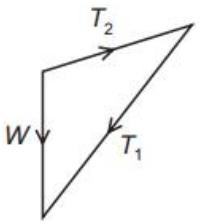
A



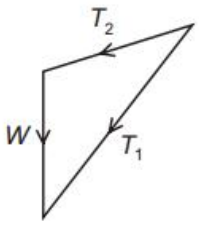
B



C

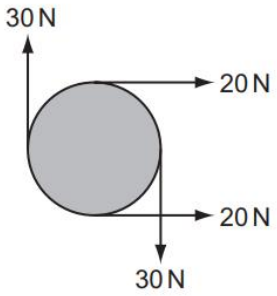


D



105.

12 The diagram shows four forces applied to a circular object.

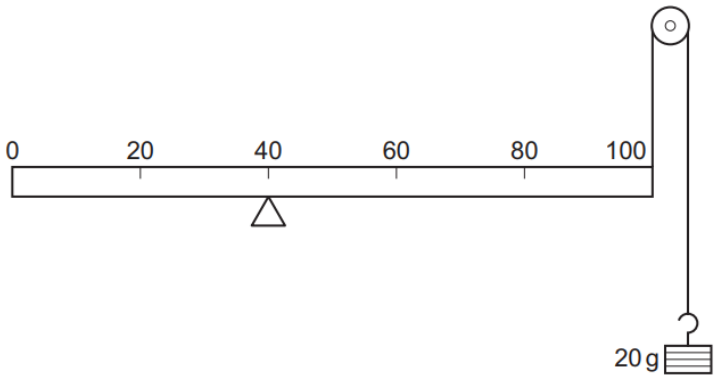


Which row describes the resultant force and resultant torque on the object?

	resultant force	resultant torque
A	zero	zero
B	zero	non-zero
C	non-zero	zero
D	non-zero	non-zero

106.

13 A uniform metre rule of mass 100 g is supported by a pivot at the 40 cm mark and a string at the 100 cm mark. The string passes round a frictionless pulley and carries a mass of 20 g as shown in the diagram.



At which mark on the rule must a 50 g mass be suspended so that the rule balances?

A 4 cm **B** 36 cm **C** 44 cm **D** 64 cm

S11/12

107.

10 A force *F* is applied to a freely moving object. At one instant of time, the object has velocity *v* and acceleration *a*.

Which quantities **must** be in the same direction?

A *a* and *v* only

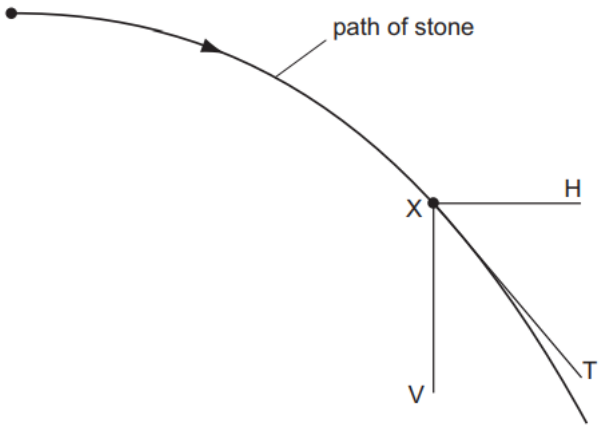
B *a* and *F* only

C *v* and *F* only

D *v*, *F* and *a*

108.

14 A stone is projected horizontally in a vacuum and moves along the path shown.



X is a point on this path. XV and XH are vertical and horizontal lines respectively through X. XT is the tangent to the path at X.

Along which directions do forces act on the stone at X?

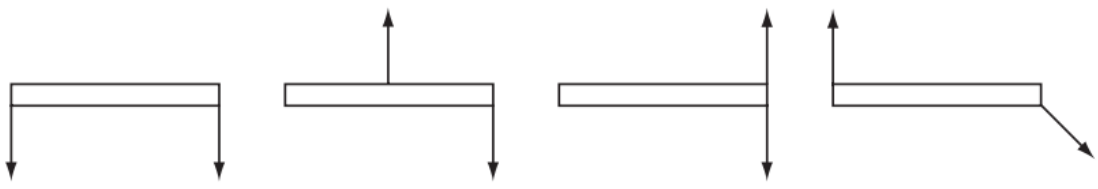
A XV only **B** XH only **C** XV and XH **D** XT only

109.

15 The diagrams all show a pair of equal forces acting on a metre rule.

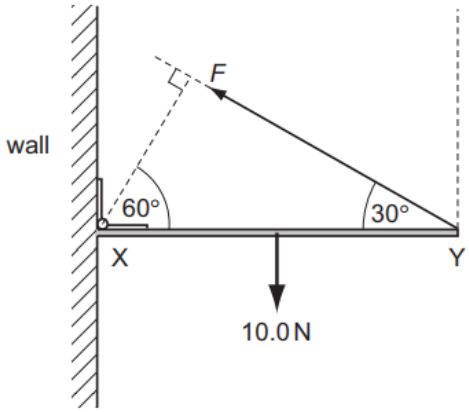
Which diagram shows forces that provide a couple and zero resultant force?

A **B** **C** **D**



110.

16 A uniform rod XY of weight 10.0 N is freely hinged to a wall at X. It is held horizontal by a force *F* acting from Y at an angle of 30° to the horizontal, as shown.

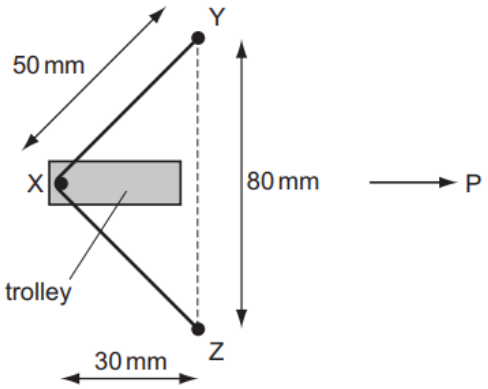


What is the value of *F*?

A 5.0 N **B** 8.7 N **C** 10.0 N **D** 20.0 N

111.

17 The diagram shows two fixed pins, Y and Z. A length of elastic is stretched between Y and Z and around pin X, which is attached to a trolley.



X is at the centre of the elastic and the trolley is to be propelled in the direction P at right angles to YZ. The tension in the elastic is 4 N.

What is the force accelerating the trolley in the direction P when the trolley is released?

A 2.4 N **B** 3.2 N **C** 4.8 N **D** 6.4 N

W10/11

112.

10 The gravitational field strength on the surface of planet P is one tenth of that on the surface of planet Q.

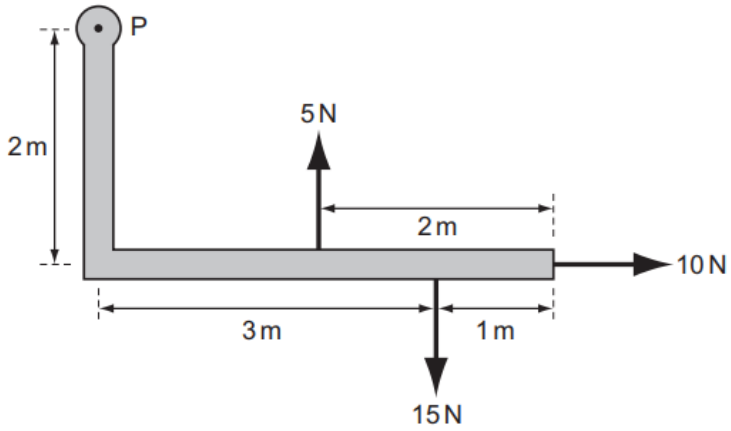
On the surface of P, a body has a mass of 1.0 kg and a weight of 1.0 N.

What are the mass and weight of the same body on the surface of planet Q?

	mass on Q / kg	weight on Q / N
A	1.0	0.1
B	1.0	10
C	10	10
D	10	100

113.

13 A rigid L-shaped lever arm is pivoted at point P.



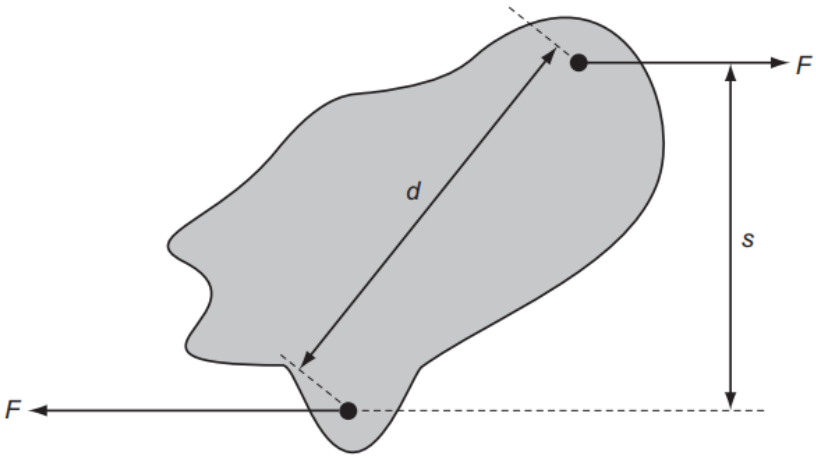
Three forces act on the lever arm, as shown in the diagram.

What is the magnitude of the resultant moment of these forces about point P?

A 15 N m **B** 20 N m **C** 35 N m **D** 75 N m

114.

14 Two parallel forces, each of magnitude F, act on a body as shown.

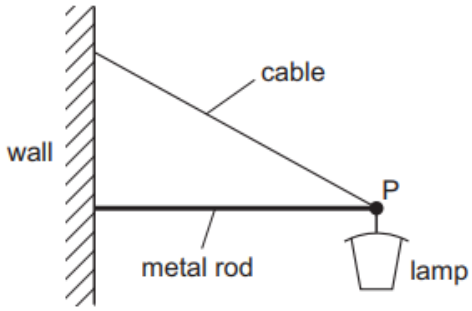


What is the magnitude of the torque on the body produced by these forces?

A Fd **B** Fs **C** $2Fd$ **D** $2Fs$

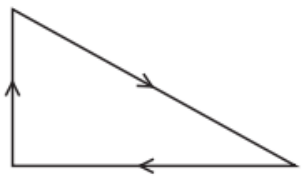
115.

15 A street lamp is fixed to a wall by a metal rod and a cable.

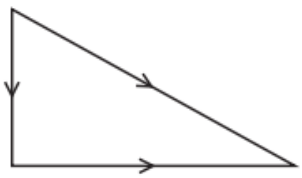


Which vector triangle represents the forces acting at point P?

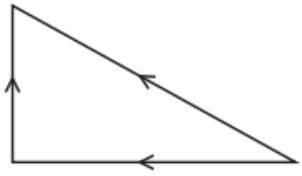
A



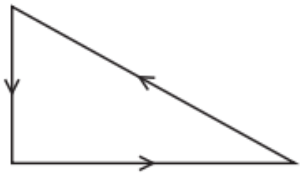
B



C



D



W10/12

116.

6 A football is dropped from the top of a three-storey building. It falls through air until it reaches the ground.

What remains constant throughout the fall?

A acceleration of the football

B air resistance on the football

C velocity of the football

D weight of the football

117.

10 Which defines the weight of a body?

A the amount of matter in the body

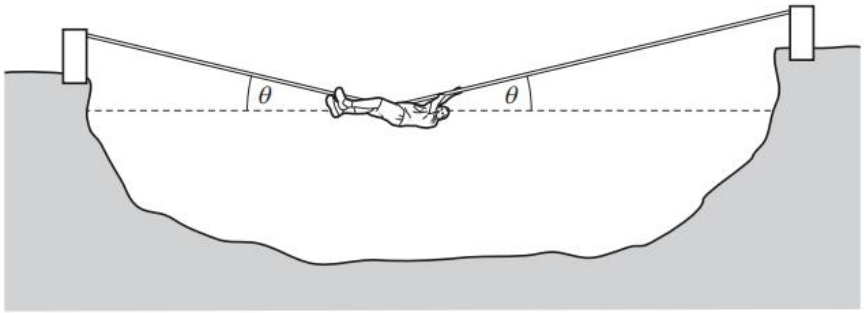
B the force of gravity on the body

C the number of particles in the body

D the product of the body's volume and density

118.

11 The diagram shows a rope bridge that a student makes on an adventure training course. The student has a weight W.

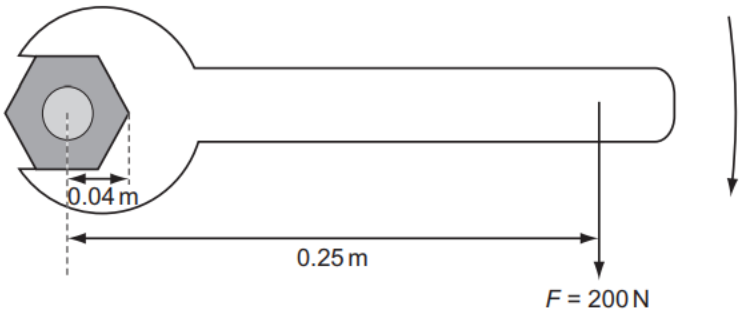


Which formula gives the tension T in the rope?

A $T = \frac{W}{2\cos\theta}$ **B** $T = \frac{W}{2\sin\theta}$ **C** $T = \frac{W}{\cos\theta}$ **D** $T = \frac{W}{\sin\theta}$

119.

12 A spanner is used to tighten a nut as shown.



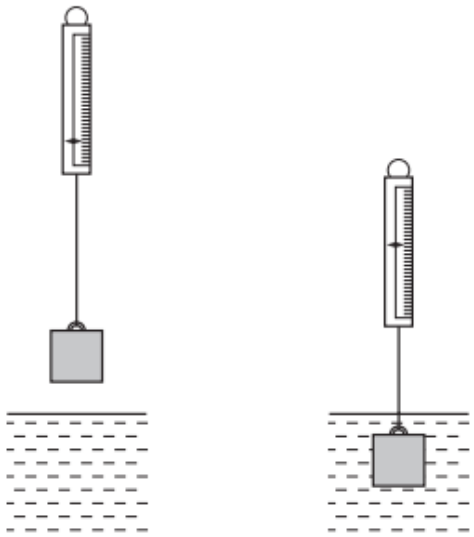
A force *F* is applied at right-angles to the spanner at a distance of 0.25 m from the centre of the nut. When the nut is fully tightened, the applied force is 200 N.

What is the resistive torque, in an anticlockwise direction, preventing further tightening?

A 8 N m **B** 42 N m **C** 50 N m **D** 1250 N m

120.

13 The diagrams show a metal cube suspended from a spring balance before and during immersion in water.



A reduction in the balance reading occurs as a consequence of the immersion.

Which statement is correct?

A The balance reading will be further reduced if the cube is lowered further into the water.

B The balance reading during immersion corresponds to the upthrust of the water on the cube.

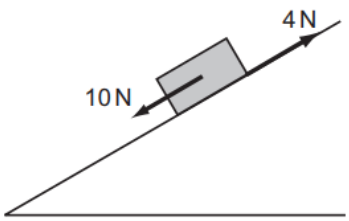
C The forces acting on the vertical sides of the cube contribute to the change in the balance reading.

D The gravitational pull on the cube is unchanged by the immersion.

S10/11

121.

11 A brick weighing 20 N rests on an inclined plane. The weight of the brick has a component of 10 N parallel with the plane. The brick also experiences a frictional force of 4 N.



What is the acceleration of the brick down the plane? Assume that the acceleration of free fall g is equal to $10\,m\,s^{-2}$.

A $0.3\,m\,s^{-2}$ **B** $0.8\,m\,s^{-2}$ **C** $3.0\,m\,s^{-2}$ **D** $8.0\,m\,s^{-2}$

122.

13 Forces of 3 N, 4 N and 5 N act at one point on an object. The angles at which the forces act can vary.

What is the value of the **minimum** resultant force of these forces?

A 0

B between 0 and 2 N

C 2 N

D between 2 N and 4 N

123.

14 An object, immersed in a liquid in a tank, experiences an upthrust.

What is the physical reason for this upthrust?

A The density of the body differs from that of the liquid.

B The density of the liquid increases with depth.

C The pressure in the liquid increases with depth.

D The value of g in the liquid increases with depth.

New Topic 4:

4. MOMENTUM

S16/11

1.

9 Which statement about a perfectly elastic collision between two bodies in an isolated system is correct?

A Both total kinetic energy and total momentum are conserved.

B Total kinetic energy is conserved, but total momentum is not conserved.

C Total momentum is conserved, but total kinetic energy is not conserved.

D Neither total kinetic energy nor total momentum is conserved.

2.

10 Two spheres approach each other along the same straight line. Their speeds are u_1 and u_2 before they collide. After the collision, the spheres separate with speeds v_1 and v_2 in the directions shown below.

The collision is perfectly elastic. Which equation must be correct?

A $u_1 - u_2 = v_2 + v_1$

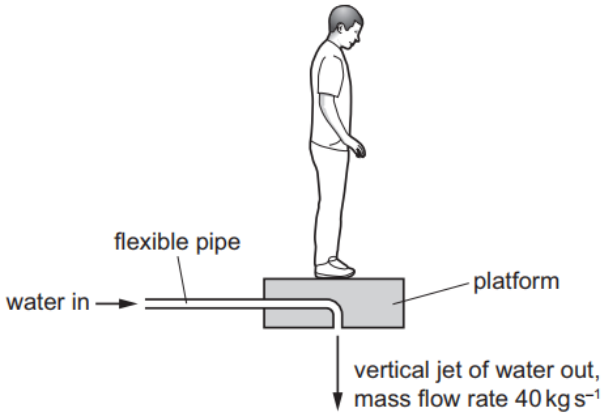
B $u_1 - u_2 = v_2 - v_1$

C $u_1 + u_2 = v_2 + v_1$

D $u_1 + u_2 = v_2 - v_1$

3.

11 The diagram shows a man standing on a platform that is attached to a flexible pipe. Water is pumped through the pipe so that the man and platform remain at a constant height.



The resultant vertical force on the platform is zero. The combined mass of the man and platform is 96 kg. The mass of water that is discharged vertically downwards from the platform each second is 40 kg.

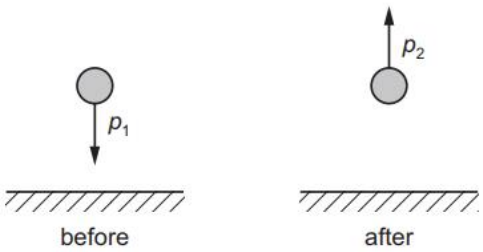
What is the speed of the water leaving the platform?

A $2.4\,m\,s^{-1}$ **B** $6.9\,m\,s^{-1}$ **C** $24\,m\,s^{-1}$ **D** $47\,m\,s^{-1}$

S16/12

4.

9 A ball falls vertically onto horizontal ground and rebounds, as shown.



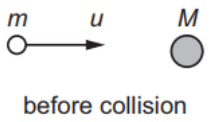
The ball has momentum p_1 downwards just before hitting the ground. After rebounding, the ball leaves the ground with momentum p_2 upwards. The ball is in contact with the ground for 0.020 s. During this time interval, an average resultant force of 25 N acts on the ball.

What is a possible combination of values for p_1 and p_2?

	p_1 / kg m s^{-1}	p_2 / kg m s^{-1}
A	0.15	0.65
B	0.20	0.30
C	0.30	0.20
D	0.65	0.15

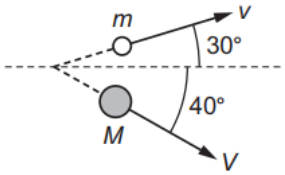
5.

11 A ball of mass m travelling at velocity u collides with a stationary ball of mass M. After collision the two balls travel at velocities v and V respectively, in the directions shown.



before collision

not to scale



after collision

A student writes three equations relating to the collision.

Which row in the table indicates the correct and incorrect equations?

	$mu = MV + mv$	$mv \sin 30° = MV \sin 40°$	$mu = mv \cos 30° + MV \cos 40°$
A	correct	correct	correct
B	incorrect	correct	incorrect
C	correct	incorrect	incorrect
D	incorrect	correct	correct

S16/13

6.

9 Which row in the table gives the quantities that are conserved in a perfectly elastic collision between two gas molecules?

	total momentum	total kinetic energy
A	conserved	conserved
B	conserved	not conserved
C	not conserved	conserved
D	not conserved	not conserved

7.

10 Two equal masses travel towards each other on a frictionless track at speeds of $60\,cm\,s^{-1}$ and $30\,cm\,s^{-1}$. They stick together on impact.

What is the speed of the masses after impact?

A $15\,cm\,s^{-1}$ **B** $20\,cm\,s^{-1}$ **C** $30\,cm\,s^{-1}$ **D** $45\,cm\,s^{-1}$

8.

11 The IKAROS satellite has mass 320 kg and moves through space using a solar sail of area 20 m^2. The average solar wind pressure is 1.0×10^{-5} N m^{-2}.

What is the acceleration of the satellite caused by the solar wind?

A 3.1×10^{-8} m s^{-2}

B 6.3×10^{-7} m s^{-2}

C 3.2×10^{-3} m s^{-2}

D 6.4×10^{-2} m s^{-2}

W15/11

9.

12 Which statement about a ball that strikes a tennis racket and rebounds is **always** correct?

A The total kinetic energy of the ball is conserved.

B The total kinetic energy of the system is conserved.

C The total momentum of the ball is conserved.

D The total momentum of the system is conserved.

10.

13 In which example is it **not** possible for the underlined body to be in equilibrium?

A an aeroplane climbs at a steady rate

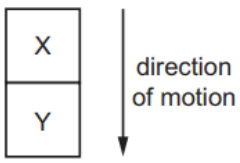
B an aeroplane tows a glider at a constant altitude

C a speedboat changes direction at a constant speed

D two tug boats tow a ship into harbour

11.

14 Two blocks X and Y are falling through a vacuum in a uniform gravitational field, as shown.



Block X has weight $2w$.

Block Y has weight w.

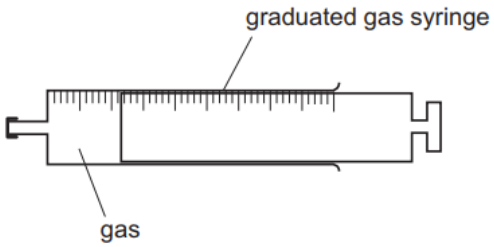
The blocks do not move apart.

Which value best represents the force exerted by block X on block Y?

A 0 **B** w **C** $1.5w$ **D** $2w$

12.

15 A gas is contained inside a sealed syringe, as shown.



The volume of gas at room temperature is 2.0 cm^3.

Atmospheric pressure is 101 kPa.

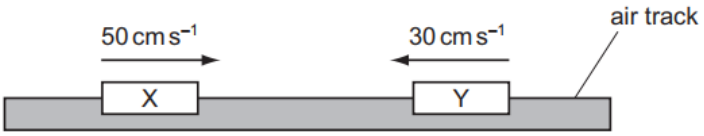
What is the work done by the gas when it is heated and expands to a volume of 6.0 cm^3?

A 404 μJ **B** 404 mJ **C** 404 J **D** 404 kJ

W15/13

13.

12 Two equal masses X and Y are moving towards each other on a frictionless air track as shown. The masses make an elastic collision.



Which row gives possible velocities for the two masses after the collision?

	velocity of X	velocity of Y
A	zero	20 cm s^{-1} to the right
B	10 cm s^{-1} to the right	10 cm s^{-1} to the right
C	20 cm s^{-1} to the left	zero
D	30 cm s^{-1} to the left	50 cm s^{-1} to the right

14.

13 Which statement is correct with reference to perfectly elastic collisions between two bodies?

A Neither total momentum nor total kinetic energy need be conserved but total energy must be conserved.

B Total momentum and total energy are conserved but total kinetic energy may be changed into some other form of energy.

C Total kinetic energy and total energy are both conserved but total momentum is conserved only if the two bodies have equal masses.

D Total momentum, total kinetic energy and total energy are all conserved.

S15/11

15.

11 A molecule of mass m travelling at speed v hits a wall in a direction perpendicular to the wall. The collision is elastic.

What are the changes in the momentum and in the kinetic energy of the molecule caused by the collision?

	change in momentum	change in kinetic energy
A	0	0
B	0	mv^2
C	$2mv$	0
D	mv^2	0

S15/12

16.

11 Trolley X, moving along a horizontal frictionless track, collides with a stationary trolley Y. The two trolleys become attached and move off together.

Which statement about this interaction is correct?

A Some of the kinetic energy of trolley X is changed to momentum in the collision.

B Some of the momentum of trolley X is changed to kinetic energy in the collision.

C Trolley X loses some of its momentum as heat in the collision.

D Trolley X shares its momentum with trolley Y but some of its kinetic energy is lost.

S15/13

17.

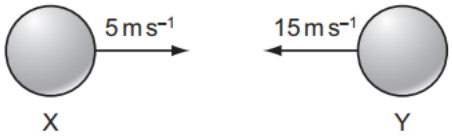
11 A moving object strikes a stationary object. The collision is inelastic. The objects move off together.

Which row shows the possible values of total momentum and total kinetic energy for the system before and after the collision?

	total momentum before collision / kg m s^{-1}	total momentum after collision / kg m s^{-1}	total kinetic energy before collision / J	total kinetic energy after collision / J
A	6	2	90	30
B	6	6	30	90
C	6	6	90	30
D	6	6	90	90

18.

12 Two balls X and Y are moving towards each other with speeds of $5\,m\,s^{-1}$ and $15\,m\,s^{-1}$ respectively.



They make a perfectly elastic head-on collision and ball Y moves to the right with a speed of $7\,m\,s^{-1}$.

What is the speed and direction of ball X after the collision?

A $3\,m\,s^{-1}$ to the left

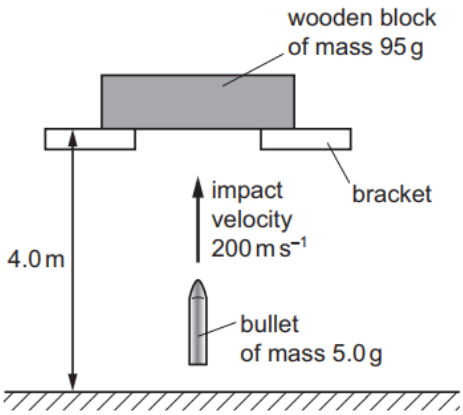
B $13\,m\,s^{-1}$ to the left

C $3\,m\,s^{-1}$ to the right

D $13\,m\,s^{-1}$ to the right

19.

13 A wooden block is freely supported on brackets at a height of 4.0 m above the ground, as shown.



A bullet of mass 5.0 g is shot vertically upwards into the wooden block of mass 95 g. It embeds itself in the block. The impact causes the block to rise above its supporting brackets.

The bullet hits the block with a velocity of $200\,m\,s^{-1}$. How far above the ground will the block be at the maximum height of its path?

A 5.1 m **B** 5.6 m **C** 9.1 m **D** 9.6 m

W14/11

20.

7 What is the principle of conservation of momentum?

A Force is equal to the rate of change of momentum.

B Momentum is the product of mass and velocity.

C The total momentum of a system remains constant provided no external force acts on it.

D The total momentum of two bodies after collision is equal to their total momentum before collision.

21.

9 Two railway trucks of masses m and $3m$ move towards each other in opposite directions with speeds $2v$ and v respectively. These trucks collide and stick together.

What is the speed of the trucks after the collision?

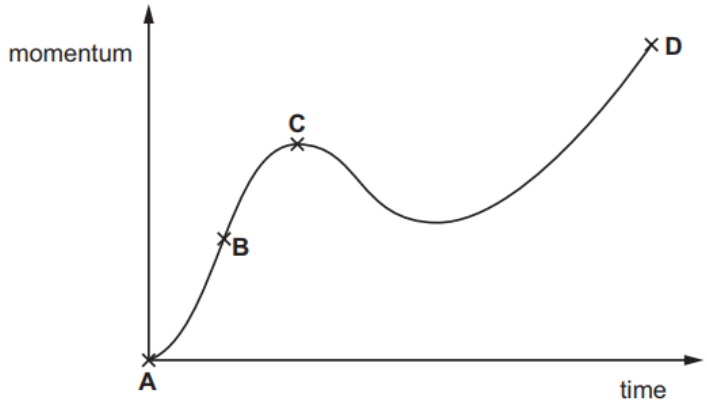
A $\frac{v}{4}$ **B** $\frac{v}{2}$ **C** v **D** $\frac{5v}{4}$

W14/13

22.

10 A body experiences a varying resultant force that causes its momentum to vary, as shown in the graph.

At which point does the resultant force have the largest value?



23.

11 A golf ball of mass m is dropped onto a hard surface from a height h_1 and rebounds to a height h_2.

The momentum of the golf ball just as it reaches the surface is different from its momentum just as it leaves the surface.

What is the total change in the momentum of the golf ball between these two instants? (Ignore air resistance.)

A $m\sqrt{2gh_1} - m\sqrt{2gh_2}$

B $m\sqrt{2gh_1} + m\sqrt{2gh_2}$

C $m\sqrt{2g(h_1 - h_2)}$

D $m\sqrt{2g(h_1 + h_2)}$

S14/11

24.

9 An object of mass 4.0 kg moving with a speed of 3.0 m s^{-1} strikes a stationary object in an inelastic collision.

Which statement is correct?

A After collision, the total kinetic energy is 18 J.

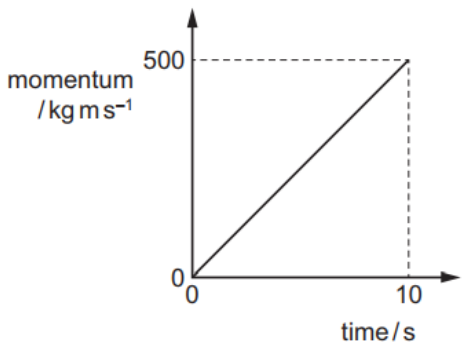
B After collision, the total kinetic energy is less than 18 J.

C Before collision, the total kinetic energy is 12 J.

D Before collision, the total kinetic energy is less than 12 J.

25.

10 The graph shows how the momentum of a motorcycle changes with time.



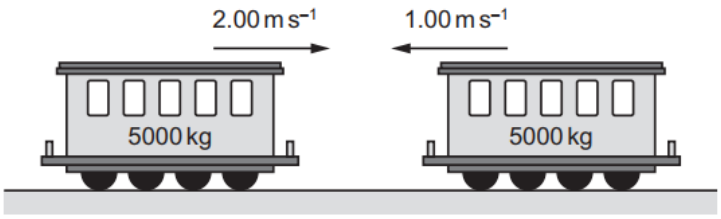
What is the resultant force on the motorcycle?

A 50 N **B** 500 N **C** 2500 N **D** 5000 N

S14/12

26.

7 Two train carriages each of mass 5000 kg roll toward one another on a level track. One is travelling at 2.00 m s^{-1} and the other at 1.00 m s^{-1}, as shown.



They collide and join together.

What is the kinetic energy lost during the collision?

A 1250 J **B** 7500 J **C** 11 250 J **D** 12 500 J

27.

8 A resultant force causes a body to accelerate.

What is equal to the resultant force?

A the acceleration of the body per unit mass

B the change in kinetic energy of the body per unit time

C the change in momentum of the body per unit time

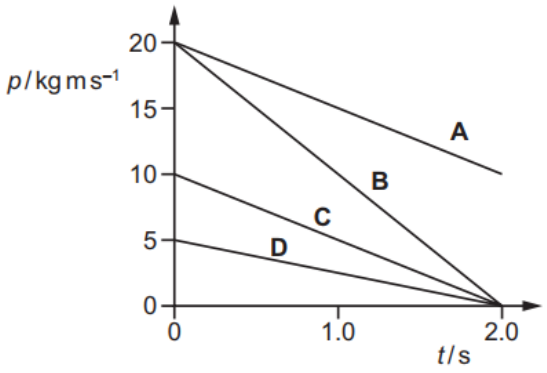
D the change in velocity of the body per unit time

S14/13

28.

11 A resultant force of 10 N acts on a body for a time of 2.0 s.

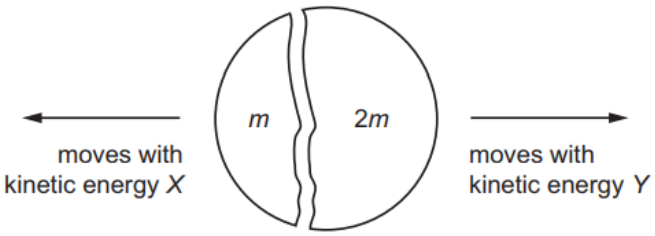
Which graph could show the variation with time t of the momentum p of the body?



29.

12 A stationary body explodes into two components of masses m and $2m$.

The components gain kinetic energies X and Y respectively.



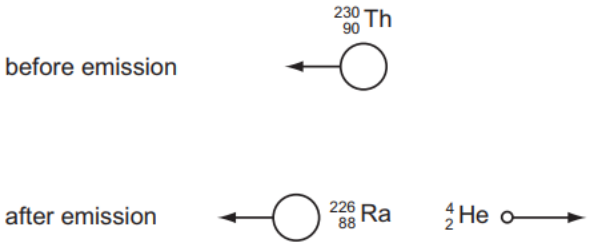
What is the value of the ratio $\frac{X}{Y}$?

A $\frac{1}{4}$ **B** $\frac{1}{2}$ **C** $\frac{2}{1}$ **D** $\frac{4}{1}$

W13/13

30.

10 A moving thorium nucleus $^{230}_{90}Th$ spontaneously emits an α-particle. The nucleus formed is a radium nucleus $^{226}_{88}Ra$, as shown.



Which statement is correct?

A The kinetic energy of the α-particle equals the kinetic energy of the radium nucleus.

B The momentum of the α-particle equals the momentum of the radium nucleus.

C The total momentum before the emission equals the total momentum after the emission.

D The velocity of the α-particle equals the velocity of the radium nucleus.

31.

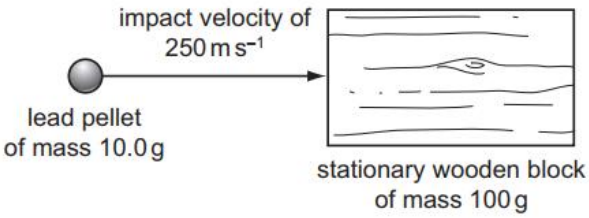
11 An isolated system consists of two bodies on which no external forces act. The two bodies collide with each other and stick together on impact.

Which row correctly compares the total kinetic energy and the total momentum of the bodies before and after the collision?

	total kinetic energy before and after the collision	total momentum before and after the collision
A	different	different
B	different	the same
C	the same	different
D	the same	the same

32.

13 A lead pellet of mass 10.0 g is shot horizontally into a stationary wooden block of mass 100 g. The pellet hits the block with an impact velocity of 250 m s^{-1}. It embeds itself in the block and it does not emerge.



What will be the speed of the block immediately after the pellet is embedded?

A 23 m s^{-1} **B** 25 m s^{-1} **C** 75 m s^{-1} **D** 79 m s^{-1}

S13/11

33.

10 Which of the following is a statement of the principle of conservation of momentum?

A In an elastic collision momentum is constant.

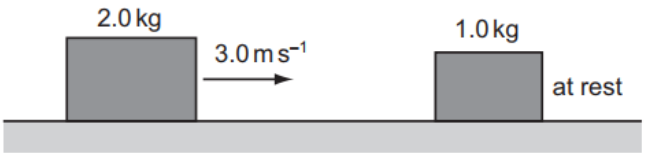
B Momentum is the product of mass and velocity.

C The force acting on a body is proportional to its rate of change of momentum.

D The momentum of an isolated system is constant.

34.

11 A 2.0 kg mass travelling at 3.0 m s^{-1} on a frictionless surface collides head-on with a stationary 1.0 kg mass. The masses stick together on impact.



How much kinetic energy is lost on impact?

A zero **B** 2.0 J **C** 2.4 J **D** 3.0 J

S13/12

35.

9 A strong wind of speed 33 m s^{-1} blows against a wall. The density of the air is 1.2 kg m^{-3}. The wall has an area of 12 m^2 at right angles to the wind velocity. The air has its speed reduced to zero when it hits the wall.

What is the approximate force exerted by the air on the wall?

A 330 N **B** 400 N **C** 480 N **D** 16 000 N

36.

10 Two bodies travelling in a straight line collide in a perfectly elastic collision. Which of the following statements **must** be correct?

A The initial speed of one body will be the same as the final speed of the other body.

B The relative speed of approach between the two bodies equals their relative speed of separation.

C The total momentum is conserved but the total kinetic energy will be reduced.

D One of the bodies will be stationary at one instant.

37.

13 All external forces on a body cancel out.

Which statement **must** be correct?

A The body does not move.

B The momentum of the body remains unchanged.

C The speed of the body remains unchanged.

D The total energy (kinetic and potential) of the body remains unchanged.

S13/13

38.

10 A stationary nucleus has nucleon number A.

The nucleus decays by emitting a proton with speed v to form a new nucleus with speed u. The new nucleus and the proton move away from one another in opposite directions.

Which equation gives v in terms of A and u?

A $v = (\frac{A}{4} - 1)u$

B $v = (A - 1)u$

C $v = Au$

D $v = (A + 1)u$

49.

11 Two spheres travel along the same line with velocities u_1 and u_2. They collide and after collision their velocities are v_1 and v_2.

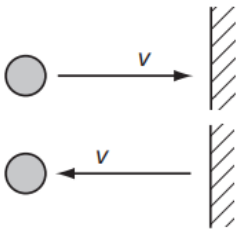
Which collision is **not** elastic?

	u_1 / m s^{-1}	u_2 / m s^{-1}	v_1 / m s^{-1}	v_2 / m s^{-1}
A	2	–5	–5	–2
B	3	–3	0	6
C	3	–2	1	6
D	5	2	3	6

W12/11

40.

11 An object travelling with velocity v strikes a wall and rebounds as shown.



Which property of the object is **not** conserved?

A kinetic energy

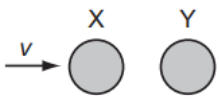
B mass

C momentum

D speed

41.

12 A particle X has speed v and collides with a stationary identical particle Y. The collision is perfectly elastic.

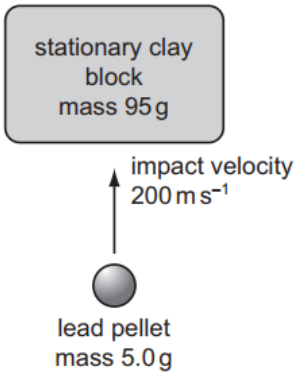


What are the speed and direction of motion of each of the two particles after the collision?

	X	Y
A	stationary	v to the right
B	$\frac{v}{2}$ to the right	$\frac{v}{2}$ to the right
C	$\frac{v}{2}$ to the left	$\frac{v}{2}$ to the right
D	v to the left	stationary

42.

14 A lead pellet is shot vertically upwards into a clay block that is stationary at the moment of impact but is able to rise freely after impact.



The pellet hits the block with an initial velocity of 200 m s^{-1}. It embeds itself in the block and does not emerge.

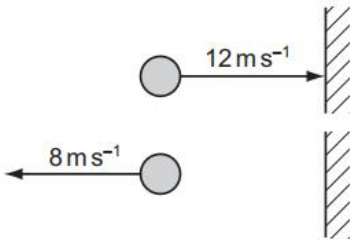
How high above its initial position will the block rise?
(Mass of pellet = 5.0 g; mass of clay block = 95 g.)

A 5.1 m **B** 5.6 m **C** 10 m **D** 2000 m

W12/12

43.

12 A ball of mass 0.5 kg is thrown against a wall at a speed of 12 m s^{-1}. It bounces back with a speed of 8 m s^{-1}. The collision lasts for 0.10 s.

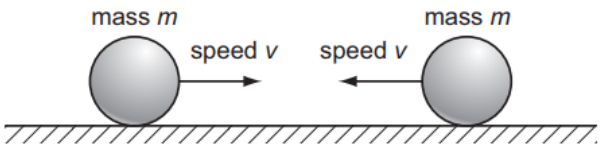


What is the average force on the ball due to the collision?

A 0.2 N **B** 1 N **C** 20 N **D** 100 N

44.

13 Two identical, perfectly elastic spheres have the same mass m. They travel towards each other with the same speed v along a horizontal frictionless surface.



Which statement about the sum of the kinetic energies of the spheres is correct?

A The sum of their kinetic energies before impact is zero.

B The sum of their kinetic energies before impact is $\frac{1}{2}mv^2$.

C The sum of their kinetic energies after impact is zero.

D The sum of their kinetic energies after impact is mv^2.

45.

15 A lorry of mass 20 000 kg has a constant resultant force F acting on it.

It accelerates from 6.0 m s^{-1} to 30.0 m s^{-1} in a time of 300 s.

What is the change in momentum of the lorry and the value of F?

	change in momentum / N s	force F / N
A	48 000	160
B	480 000	1600
C	600 000	2000
D	600 000	20 000

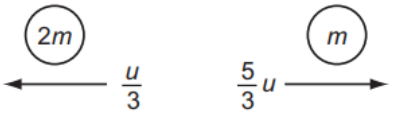
W12/13

46.

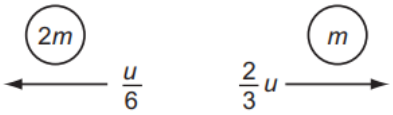
11 The diagram shows two spherical masses approaching each other head-on at an equal speed u. One is of mass m and the other of mass $2m$.

Which diagram, showing the situation after the collision, is **not** consistent with the principle of conservation of momentum?

A

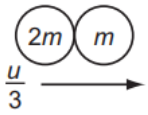


B



C

D



the spheres stick together

47.

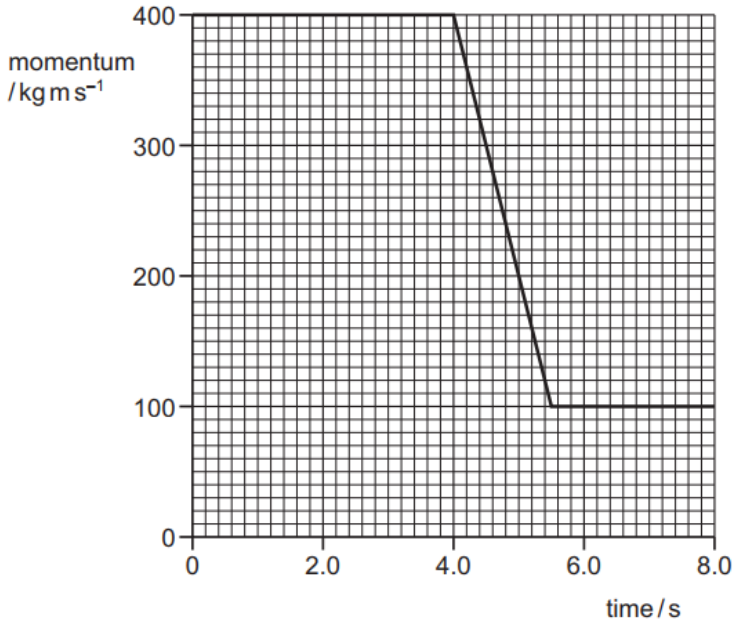
12 A molecule of mass m travelling at speed v hits a wall in a direction perpendicular to the wall. The collision is elastic.

What are the changes in the kinetic energy and in the momentum of the molecule caused by the collision?

	change in momentum	change in kinetic energy
A	0	0
B	0	mv^2
C	$2mv$	0
D	mv^2	0

48.

14 The graph shows the momentum of a cyclist over a period of 8.0 s.



At time 4.0 s, she applies the brakes.

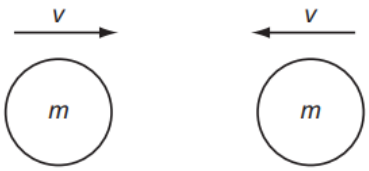
What is the resultant force on the cyclist during the period when the brakes are applied?

A 55 N **B** 200 N **C** 270 N **D** 450 N

S12/11

49.

11 Two similar spheres, each of mass m and travelling with speed v, are moving towards each other.



The spheres have a head-on elastic collision.

Which statement is correct?

A The spheres stick together on impact.

B The total kinetic energy after impact is mv^2.

C The total kinetic energy before impact is zero.

D The total momentum before impact is $2mv$.

S12/12

50.

11 Which row correctly states whether momentum and kinetic energy are conserved in an inelastic collision in which there are no external forces?

	momentum	kinetic energy
A	conserved	conserved
B	conserved	not conserved
C	not conserved	conserved
D	not conserved	not conserved

51.

12 Two spheres approach each other along the same straight line. Their speeds are u_1 and u_2 before collision. After the collision, the spheres separate with speeds v_1 and v_2 in the directions shown below.

Which equation must be correct if the collision is perfectly elastic?

A $u_1 - u_2 = v_2 + v_1$

B $u_1 - u_2 = v_2 - v_1$

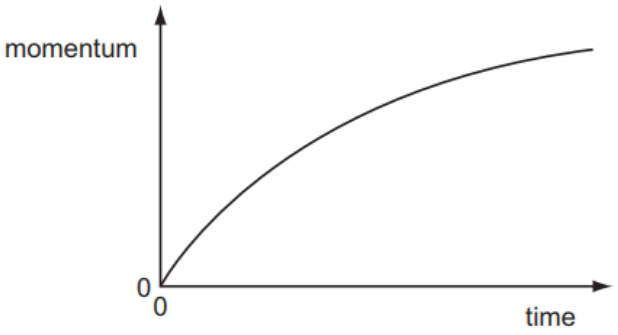
C $u_1 + u_2 = v_2 + v_1$

D $u_1 + u_2 = v_2 - v_1$

W11/11

52.

11 A car accelerates from rest. The graph shows the momentum of the car plotted against time.



What is the meaning of the gradient of the graph at a particular time?

A the resultant force on the car

B the velocity of the car

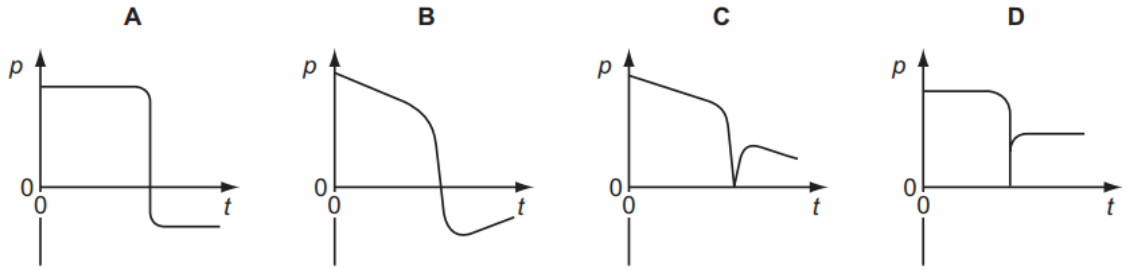
C the kinetic energy of the car

D the rate of change of kinetic energy of the car

53.

12 An ice-hockey puck slides along a horizontal, frictionless ice-rink surface. It collides inelastically with a wall at right angles to its path, and then rebounds along its original path.

Which graph shows the variation with time t of the momentum p of the puck?



54.

16 The diagram shows a particle X, with kinetic energy E_k, about to collide with a stationary particle Y. Both particles have the same mass.

After colliding, X and Y travel onwards together as a single larger particle.

How much kinetic energy is lost in the collision?

A 0 **B** $\frac{E_k}{4}$ **C** $\frac{E_k}{2}$ **D** $\frac{3E_k}{4}$

W11/12

55.

10 A group of students investigating the principle of conservation of momentum use a small truck travelling over a frictionless surface.

Sand is dropped into the truck as it passes X. At Y, a trapdoor in the bottom of the truck opens and the sand falls out.

How does the velocity of the truck change when the sand is added to the truck at X and then leaves the truck at Y?

	at X	at Y
A	decreases	increases
B	decreases	stays the same
C	stays the same	increases
D	stays the same	stays the same

56.

11 An object of mass 20 kg is travelling at a constant speed of $6.0\,m\,s^{-1}$.

It collides with an object of mass 12 kg travelling at a constant speed of $15\,m\,s^{-1}$ in the opposite direction. The objects stick together.

What is the speed of the objects immediately after the collision?

A $1.9\,m\,s^{-1}$ **B** $9.0\,m\,s^{-1}$ **C** $9.4\,m\,s^{-1}$ **D** $21\,m\,s^{-1}$

S11/11

57.

9 A body of mass m, moving at velocity v, collides with a stationary body of the same mass and sticks to it.

Which row describes the momentum and kinetic energy of the two bodies after the collision?

	momentum	kinetic energy
A	mv	$\frac{1}{4}mv^2$
B	mv	$\frac{1}{8}mv^2$
C	$2mv$	$\frac{1}{2}mv^2$
D	$2mv$	mv^2

58.

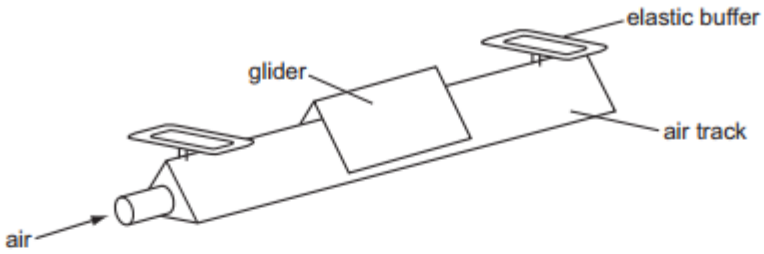
10 A molecule of mass *m* travelling horizontally with velocity *u* hits a vertical wall at right-angles to its velocity. It then rebounds horizontally with the same speed.

What is its change in momentum?

A zero **B** mu **C** $-mu$ **D** $-2mu$

S11/12

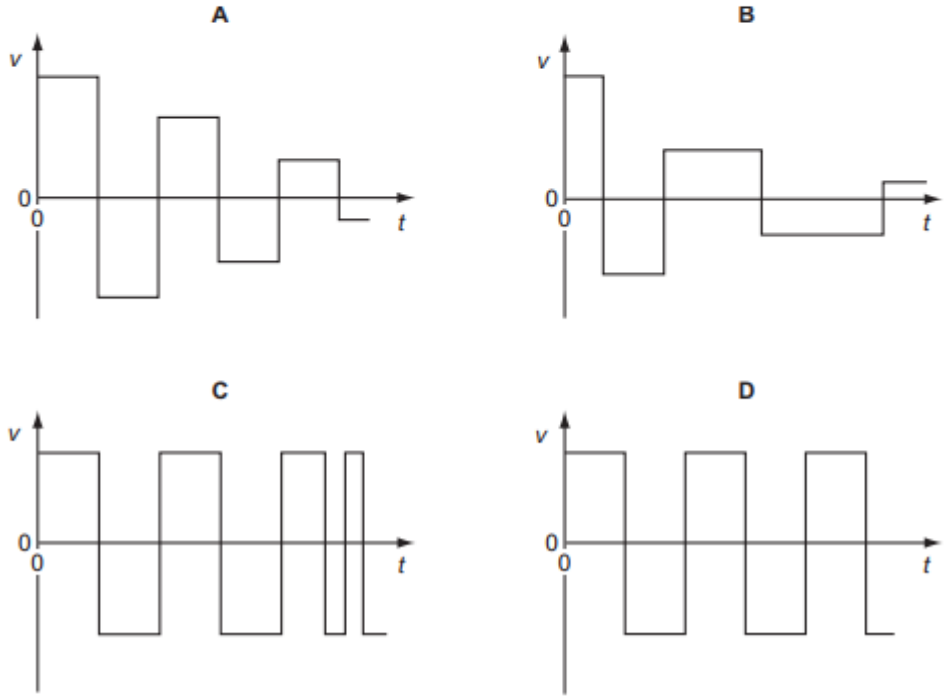
9 A small glider moves along a friction-free horizontal air track as shown below.



At each end of the air track there is a perfectly elastic buffer.

Which graph represents the variation with time t of the velocity v of the glider as it moves between the two buffers?

59.



60.

11 The momentum of an object changes from 160 kg m s^{-1} to 240 kg m s^{-1} in 2 s.

What is the mean resultant force on the object during the change?

A 40 N **B** 80 N **C** 200 N **D** 400 N

61.

12 A car accelerates in a straight line.

A graph of the momentum of the car is plotted against time.

What is evaluated by finding the gradient of the graph at a particular time?

A the acceleration of the car

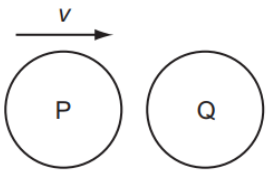
B the resultant force on the car

C the kinetic energy of the car

D the power supplied to the car

62.

13 The diagram shows a particle P, travelling at speed v, about to collide with a stationary particle Q of the same mass. The collision is perfectly elastic.



Which statement describes the motion of P and of Q immediately after the collision?

A P rebounds with speed $\frac{1}{2}v$ and Q acquires speed $\frac{1}{2}v$.

B P rebounds with speed v and Q remains stationary.

C P and Q both travel in the same direction with speed $\frac{1}{2}v$.

D P comes to a standstill and Q acquires speed v.

W10/11

63.

11 A body, initially at rest, explodes into two masses M_1 and M_2 that move apart with speeds v_1 and v_2 respectively.

What is the ratio $\frac{v_1}{v_2}$?

A $\frac{M_1}{M_2}$ **B** $\frac{M_2}{M_1}$ **C** $\sqrt{\frac{M_1}{M_2}}$ **D** $\sqrt{\frac{M_2}{M_1}}$

64.

12 Two experiments are carried out using two trolleys of equal mass. All moving parts of the trolleys are frictionless, as is the surface that the trolleys move over. In both experiments, trolley X moves towards trolley Y, which is initially stationary.

After the collision in experiment 1, X is stationary and Y moves off to the right.

After the collision in experiment 2, the trolleys join and move off together.

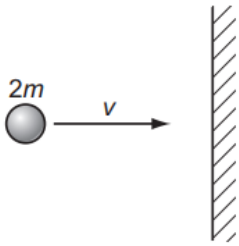
What types of collision occur in these experiments?

	experiment 1	experiment 2
A	elastic	elastic
B	elastic	inelastic
C	inelastic	elastic
D	inelastic	inelastic

W10/12

65.

9 A particle of mass $2m$ and velocity v strikes a wall.



The particle rebounds along the same path after colliding with the wall. The collision is inelastic.

What is a possible change in the momentum of the ball during the collision?

A mv **B** $2mv$ **C** $3mv$ **D** $4mv$

S10/11

66.

10 Two equal masses travel towards each other on a frictionless air track at speeds of 60 cm s^{-1} and 40 cm s^{-1}. They stick together on impact.

What is the speed of the masses after impact?

A 10 cm s^{-1} **B** 20 cm s^{-1} **C** 40 cm s^{-1} **D** 50 cm s^{-1}

67.

12 The diagram shows two identical spheres X and Y.

Initially, X moves with speed v directly towards Y. Y is stationary. The spheres collide elastically.

What happens?

	X	Y
A	moves with speed $\frac{1}{2}v$ to the right	moves with speed $\frac{1}{2}v$ to the right
B	moves with speed v to the left	remains stationary
C	moves with speed $\frac{1}{2}v$ to the left	moves with speed $\frac{1}{2}v$ to the right
D	stops	moves with speed v to the right

New Topic 5:

5. WORK, ENERGY AND POWER

S16/11

1. D

17 The power P required to move an object through a medium at constant speed depends on the speed v and the resistive force F acting on the object.

The resistive force F also depends on the speed v.

Which row shows a possible relationship between speed v, resistive force F and power P?

	resistive force F	power P
A	proportional to v	constant
B	proportional to v	proportional to v
C	proportional to v^2	proportional to v^2
D	proportional to v^2	proportional to v^3

2. A

18 Which amount of energy is **not** 2400 J?

A the decrease in gravitational potential energy of a body of mass 60 kg when it moves vertically downwards through 40 m near the Earth's surface

B the energy transferred in 15 s by a machine of power 160 W

C the kinetic energy of a body of mass 12 kg moving at a speed of 20 m s^{-1}

D the work done by a gas expanding against a constant external pressure of 120 kPa when its volume increases by 0.020 m^3

3. D

19 A hammer with 10 J of kinetic energy hits a nail and pushes it 5.0 mm into a plank.

Both the hammer and nail come to rest after the collision.

What is the approximate average force that acts on the nail while it moves through 5.0 mm?

A 0.050 N **B** 2.0 N **C** 50 N **D** 2000 N

S16/12

4. B

16 A parachutist is falling at constant (terminal) velocity.

Which statement is **not** correct?

A Gravitational potential energy is converted into kinetic energy of the air.

B Gravitational potential energy is converted into kinetic energy of the parachutist.

C Gravitational potential energy is converted into thermal energy of the air.

D Gravitational potential energy is converted into thermal energy of the parachutist.

5. A

17 A boy on a bicycle starts from rest and rolls down a hill inclined at 30° to the horizontal.

The boy and bicycle have a combined mass of 25 kg.

There is a frictional force of 30 N, which is independent of the velocity of the bicycle.

What is the kinetic energy of the boy and the bicycle after rolling 20 m down the slope?

A 1850 J **B** 2450 J **C** 3050 J **D** 3640 J

6. C

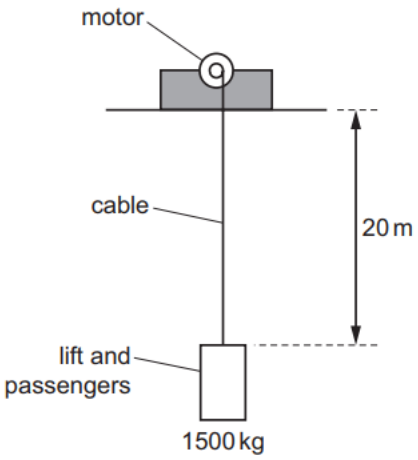
18 An escalator in an underground station has 250 people standing on it and is moving with a velocity of 4.3 m s^{-1}. The average mass of a person is 78 kg and the angle of the escalator to the horizontal is 40°.

What is the minimum power required to lift these people?

A 54 kW **B** 64 kW **C** 530 kW **D** 630 kW

7. B

19 An electric motor operating a lift has an output power of 20 kW.



The lift and passengers have a combined mass of 1500 kg. The motor raises the lift through a distance of 20 m.

How long does it take?

A 6 s **B** 15 s **C** 30 s **D** 60 s

S16/13

8. C

16 A bungee jumper jumps from a platform and is decelerated by an elastic bungee cord, as shown.

When the jumper makes the jump, his initial gravitational potential energy is converted into his kinetic energy and into elastic potential energy in the cord.

At which part of the jump are all three types of energy non-zero?

A on the platform before the jump

B on the way down before the cord has started to extend

C on the way down as he decelerates

D at the bottom of the jump when he is stationary

9. A

17 An object of mass 0.30 kg is thrown vertically upwards from the ground with an initial velocity of 8.0 m s^{-1}. The object reaches a maximum height of 1.9 m.

How much work is done against air resistance as the object rises to its maximum height?

A 4.0 J **B** 5.6 J **C** 9.6 J **D** 15 J

10. A

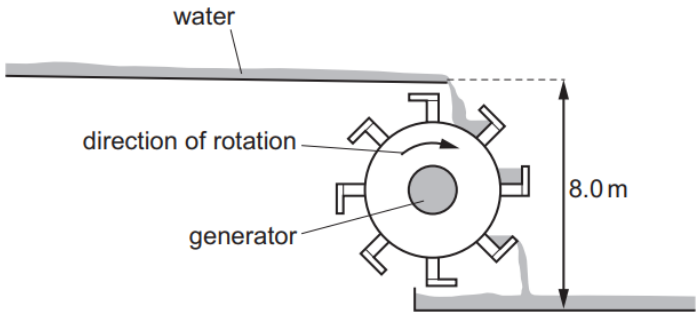
18 A racing car has an output power of 300 kW when travelling at a constant speed of 60 m s^{-1}.

What is the total resistive force acting on the car?

A 5 kN **B** 10 kN **C** 50 kN **D** 100 kN

11. D

19 The diagram shows the design of a water wheel which drives a generator to produce electrical power. The flow rate of the water is 200 kg s^{-1}. The generator supplies a current of 32 A at a voltage of 230 V.



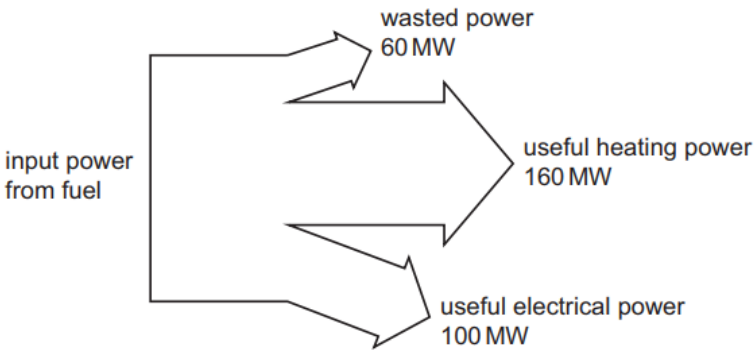
Ignoring any changes in kinetic energy of the water, what is the efficiency of the system?

A 14% **B** 16% **C** 22% **D** 47%

W15/11

12. D

16 A combined heat and power (CHP) station generates electrical power and useful heat. The diagram shows the input and output for a CHP station.



What is the efficiency of the CHP station for producing useful power?

A 31% **B** 38% **C** 50% **D** 81%

13. B

17 In 'normal driving conditions', an electric car has a range of 150 km. This uses all of the 200 MJ energy stored in its batteries.

With the batteries initially fully charged, the car is driven 100 km in 'normal driving conditions'. The batteries are then recharged from a household electrical supply delivering a constant current of 13.0 A at a potential difference (p.d.) of 230 V.

What is the minimum time required to recharge the batteries?

A 0.95 hours

B 12.4 hours

C 18.6 hours

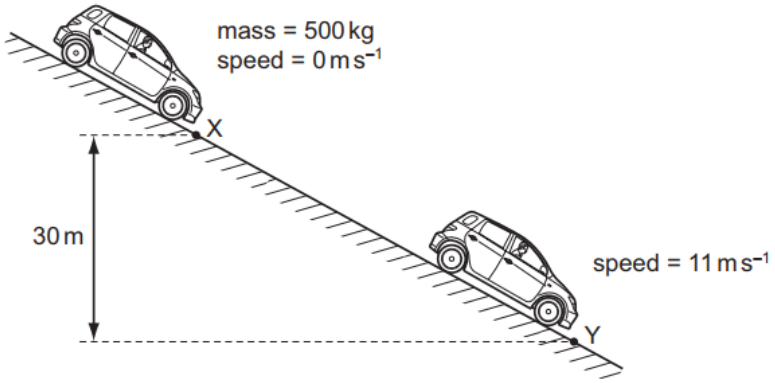
D 27.9 hours

W15/12

14. B

16 A car of mass 500 kg is at rest at point X on a slope, as shown.

The car's brakes are released and the car rolls down the slope with its engine switched off. At point Y the car has moved through a vertical height of 30 m and has a speed of 11 m s^{-1}.



What is the energy dissipated by frictional forces when the car moves from X to Y?

A 3.0×10^4 J **B** 1.2×10^5 J **C** 1.5×10^5 J **D** 1.8×10^5 J

15. C

17 In which situation is **no** work done?

A The air in a bicycle tyre is released because of a puncture.

B A ball is dropped and falls to the ground.

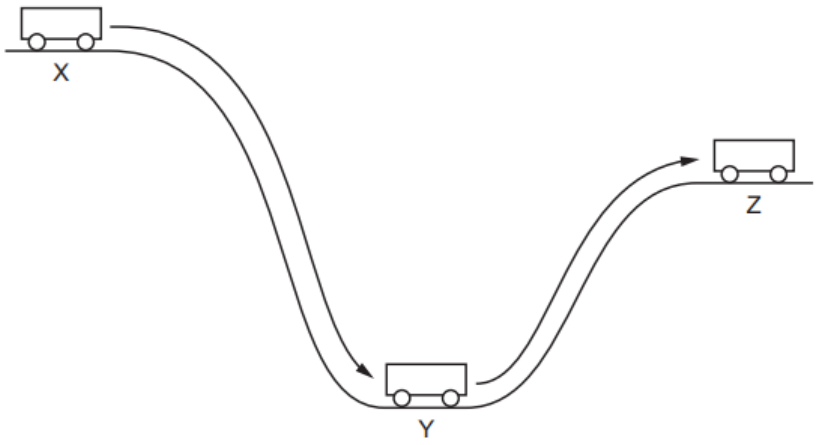
C A box moves at constant speed across a smooth horizontal surface.

D A crane lifts a steel girder at constant speed.

W15/13

16. (1) D

16 A trolley starts from rest at X. It rolls down to Y and eventually comes to rest at Z.



Which row is a possible summary of the energy changes during this process?

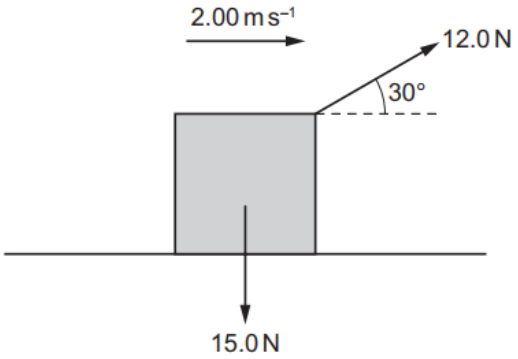
	X to Y	Y to Z
A	p.e. → k.e.	k.e. → p.e.
B	p.e. → k.e.	k.e. → p.e. + heat
C	p.e. → k.e. + heat	k.e. → p.e.
D	p.e. → k.e. + heat	k.e. → p.e. + heat

key
p.e. = potential energy
k.e. = kinetic energy

16.(2) B

17 An object of weight 15.0 N is pulled along a horizontal surface at a constant velocity of 2.00 m s^{-1}.

The force pulling the object is 12.0 N at 30° to the horizontal, as shown.



What is the power used to move the object?

A 12.0 W **B** 20.8 W **C** 24.0 W **D** 30.0 W

S15/11

17. C

16 A team of nine dogs can pull a sledge with a combined force of 800 N at a speed of 1.5 m s^{-1} for 360 minutes.

What is the average work done by each dog during this time?

A 4.8×10^4 J **B** 4.3×10^5 J **C** 2.9×10^6 J **D** 2.6×10^7 J

18. C

17 Which statement is correct?

A A ball lands on the ground and bounces. The kinetic energy changes sign, because the ball changes direction.

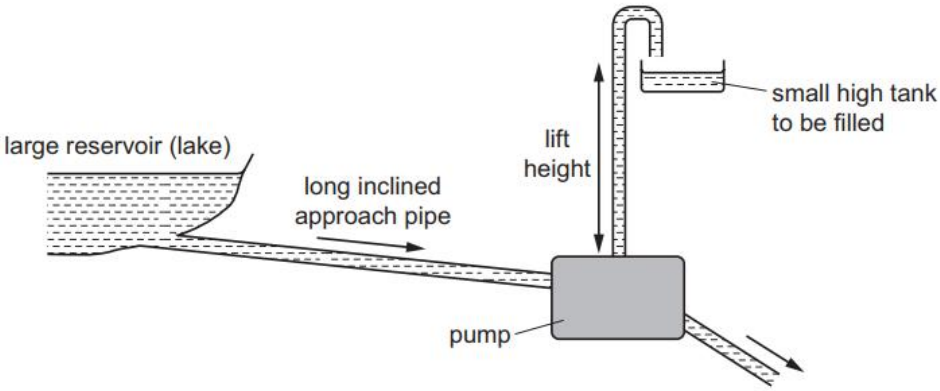
B A car drives up a slope at a steady speed. The power generated by the engine equals the potential energy gained per unit time.

C An electric heater can be 100% efficient.

D It is impossible for momentum to be conserved in a collision.

19. B

18 The diagram shows a pump called a hydraulic ram.



In one such pump the long approach pipe holds 500 kg of water. A valve shuts when the speed of this water reaches 2.0 m s^{-1} and the kinetic energy of this water is used to lift a small quantity of water by a height of 15 m.

The efficiency of the pump is 10%.

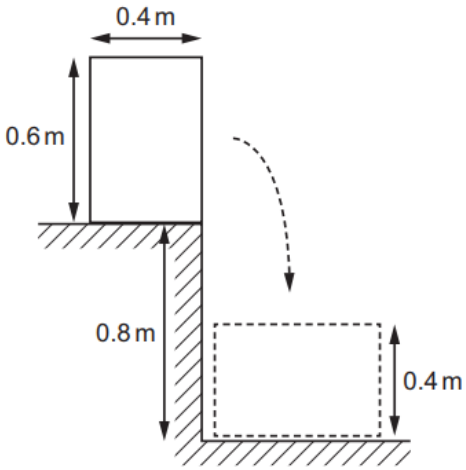
Which mass of water could be lifted 15 m?

A 0.15 kg **B** 0.68 kg **C** 1.5 kg **D** 6.8 kg

S15/12

20. C

15 A uniform solid block has weight 500 N, width 0.4 m and height 0.6 m. The block rests on the edge of a step of depth 0.8 m, as shown.



The block is knocked over the edge of the step and rotates through 90° before coming to rest with the 0.6 m edge horizontal.

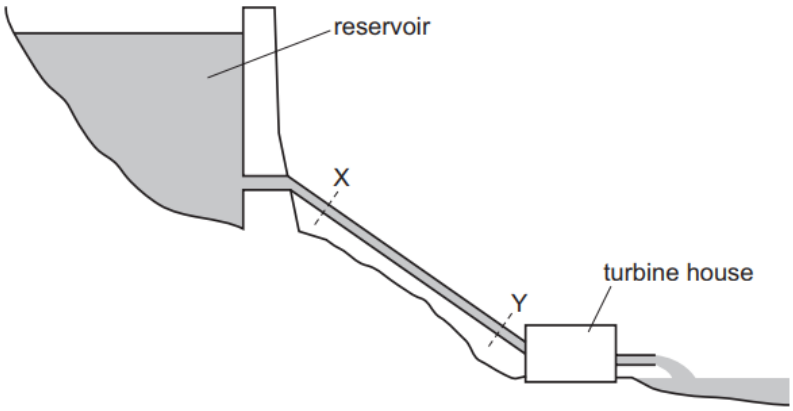
What is the change in gravitational potential energy of the block?

A 300 J **B** 400 J **C** 450 J **D** 550 J

21. D

16 The diagram shows a hydroelectric power station.

The reservoir is linked to the turbines by a pipe of uniform cross-sectional area.



Water flows from X to Y at constant speed. Which statement about the change of energy of the water as it moves from X to Y is correct?

A It gains both gravitational potential energy and kinetic energy.

B It loses both elastic potential energy and kinetic energy.

C It loses both elastic potential energy and gravitational potential energy.

D It loses gravitational potential energy and gains elastic potential energy.

22. D

17 A fisherman lifts a fish of mass 250 g from rest through a vertical height of 1.8 m. The fish gains a speed of 1.1 m s^{-1}.

What is the energy gained by the fish?

A 0.15 J **B** 4.3 J **C** 4.4 J **D** 4.6 J

23. D

18 Water from a reservoir is fed to the turbine of a hydroelectric system at a rate of 500 kg s^{-1}. The reservoir is 300 m above the level of the turbine.

The electrical output from the generator driven by the turbine is 200 A at a potential difference of 6000 V.

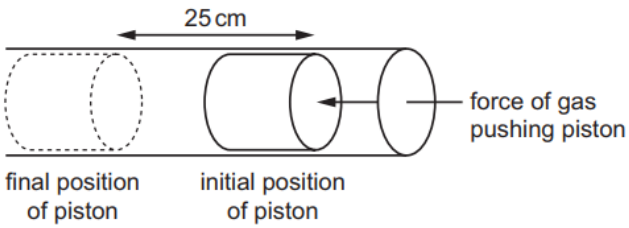
What is the efficiency of the system?

A 8.0% **B** 8.2% **C** 80% **D** 82%

S15/13

24. A

17 The gas in an engine does work on a piston of cross-sectional area 80 cm^2. The pressure on the piston has a constant value of 4.6×10^5 Pa.



How much work is done by the gas on the piston when it moves through a distance of 25 cm?

A 9.2×10^2 J **B** 9.2×10^4 J **C** 9.2×10^6 J **D** 9.2×10^8 J

25. C

18 A loaded aeroplane has a total mass of 1.2×10^5 kg while climbing after take-off. It climbs at an angle of 23° to the horizontal with a speed of 50 m s^{-1}. What is the rate at which it is gaining potential energy at this time?

A 2.3×10^6 J s^{-1}

B 2.5×10^6 J s^{-1}

C 2.3×10^7 J s^{-1}

D 2.5×10^7 J s^{-1}

26. B

19 When a horizontal force F is applied to a frictionless trolley over a distance s, the kinetic energy of the trolley changes from 4.0 J to 8.0 J.

If a force of $2F$ is applied to the trolley over a distance of $2s$, what will the original kinetic energy of 4.0 J become?

A 16 J **B** 20 J **C** 32 J **D** 64 J

W14/11

27. C

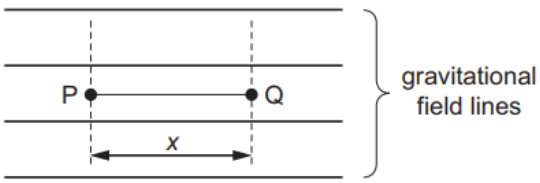
13 A mass attached to the lower end of a spring bounces up and down.

At which points in the path of the mass do the gravitational potential energy of the mass (GPE), the elastic potential energy in the spring (EPE) and the kinetic energy of the mass (KE) have their highest values?

	GPE	EPE	KE
A	bottom	middle	top
B	bottom	top	middle
C	top	bottom	middle
D	top	bottom	top

28. A

14 A mass m is situated in a uniform gravitational field.



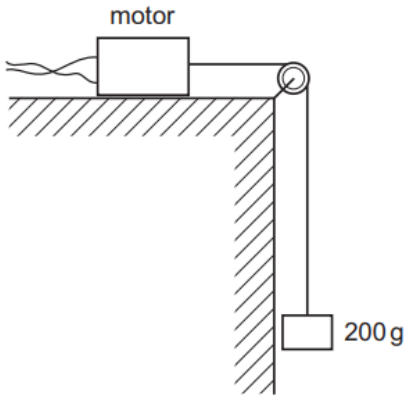
When the mass moves through a displacement x, from P to Q, it loses an amount of potential energy E.

Which row correctly specifies the magnitude and the direction of the acceleration due to gravity in this field?

	magnitude	direction
A	$\frac{E}{mx}$	→
B	$\frac{E}{mx}$	←
C	$\frac{E}{x}$	→
D	$\frac{E}{x}$	←

29. C

15 A small electric motor is mounted on a bench, as shown. The motor is connected to a 6.0 V supply and the current in the motor is 0.50 A. The motor is 50% efficient.



What is the time taken to lift a mass of 200 g up through a height of 90 cm?

A 0.59 s **B** 0.85 s **C** 1.2 s **D** 2.7 s

30. A

16 A projectile is launched at 45° to the horizontal with initial kinetic energy E.

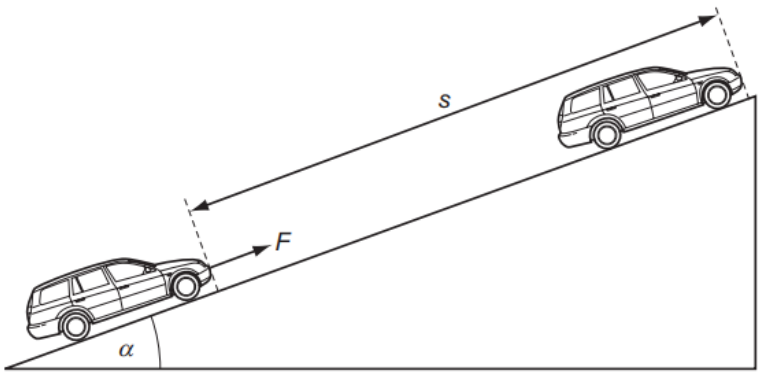
Assuming air resistance to be negligible, what will be the kinetic energy of the projectile when it reaches its highest point?

A $0.50E$ **B** $0.71E$ **C** $0.87E$ **D** E

W14/13

31. D

15 A constant force F, acting on a car of mass m, moves the car up a slope through a distance s at constant velocity v. The angle of the slope to the horizontal is α.



Which expression gives the efficiency of the process?

A $\frac{mgs\sin\alpha}{Fv}$ **B** $\frac{mv}{Fs}$ **C** $\frac{mv^2}{2Fs}$ **D** $\frac{mg\sin\alpha}{F}$

32. C

16 The diagram shows a particle X, with kinetic energy E_k, about to collide with a stationary particle Y. Both particles have the same mass.

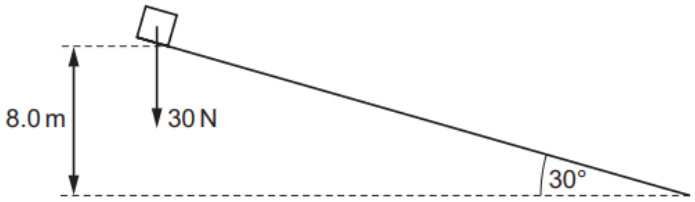
After colliding, X and Y travel onwards together as a single larger particle.

How much kinetic energy is lost in the collision?

A 0 **B** $\frac{E_k}{4}$ **C** $\frac{E_k}{2}$ **D** $\frac{3E_k}{4}$

33. A

17 A box of weight 30 N is released from rest on a ramp that is at an angle of 30° to the horizontal. The box slides down the ramp so that it falls through a vertical distance of 8.0 m. A constant frictional force of 10 N acts on the box while it is moving.



What is the kinetic energy of the box after falling through this distance?

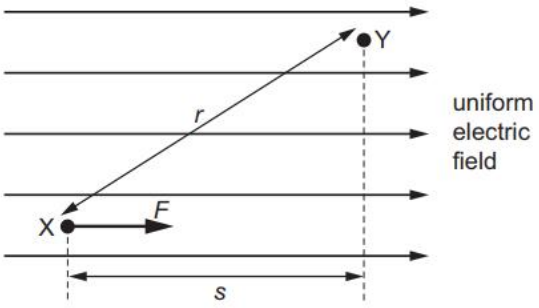
A 80 J **B** 160 J **C** 240 J **D** 400 J

34. A

18 A positive charge experiences a force *F* when placed at point X in a uniform electric field.

The charge is then moved from point X to point Y.

Distances *r* and *s* are shown on the diagram.



What is the change in the potential energy of the charge?

A decreases by *Fs*

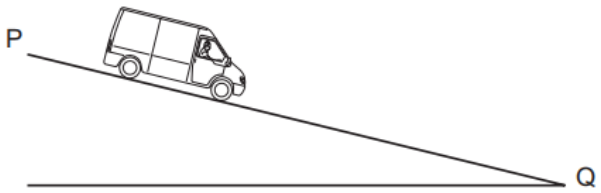
B increases by *Fs*

C decreases by *Fr*

D increases by *Fr*

35. D

19 A van driver adjusts the force on a van's brakes so that the van travels at constant speed down a hill from P to Q.



The magnitude of the change in the van's kinetic energy is ΔE_k. The magnitude of the change in its gravitational potential energy is ΔE_p.

Which statement is correct?

A $\Delta E_k > \Delta E_p$

B $\Delta E_k = \Delta E_p$

C $\Delta E_p > \Delta E_k > 0$

D $\Delta E_k = 0$

S14/11

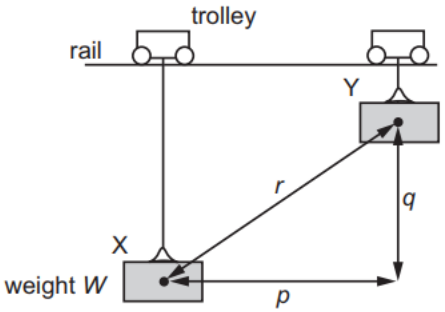
36. D

14 What is the average power output of a laser that can deliver 0.20 J of energy in 10 ns?

A 2 nW **B** 20 mW **C** 200 kW **D** 20 MW

37. C

15 A weight *W* hangs from a trolley that runs along a rail. The trolley moves horizontally through a distance *p* and simultaneously raises the weight through a height *q*.



As a result, the weight moves through a distance *r* from X to Y. It starts and finishes at rest.

How much work is done on the weight during this process?

A *Wp* **B** *W*(*p* + *q*) **C** *Wq* **D** *Wr*

38. B

16 The engine of a car exerts a force of 600 N in moving the car 1.0 km in 150 seconds.

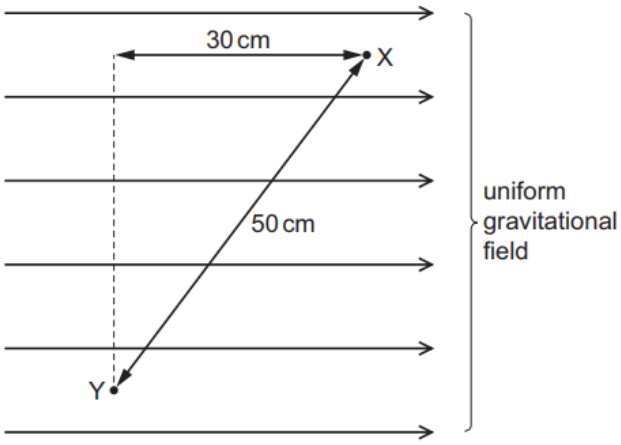
What is the average output power of the engine?

A 4.0 W **B** 4.0 kW **C** 90 kW **D** 90 MW

S14/12

39. C

14 A mass at point X inside a uniform gravitational field experiences a gravitational force of 0.200 N. It has 1.00 J of gravitational potential energy.



The mass is then moved to point Y.

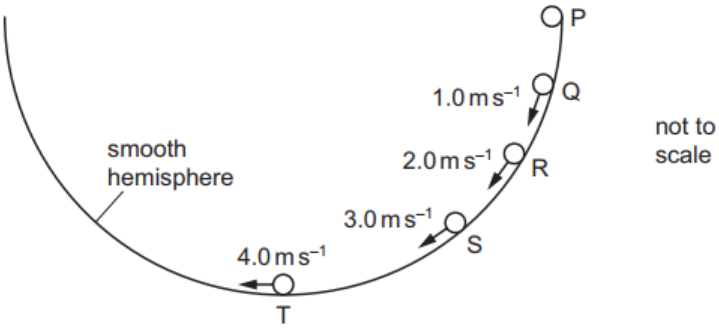
What is its new gravitational potential energy?

A 0.90 J **B** 0.94 J **C** 1.06 J **D** 1.10 J

40. B

15 A small mass is placed at point P on the inside surface of a smooth hemisphere. It is then released from rest. When it reaches the lowest point T, its speed is $4.0\,m\,s^{-1}$.

The diagram (not to scale) shows the speed of the mass at other points Q, R and S as it slides down. Air resistance is negligible.



The mass loses potential energy E in falling from P to T.

At which point has the mass lost potential energy $\frac{E}{4}$?

A Q

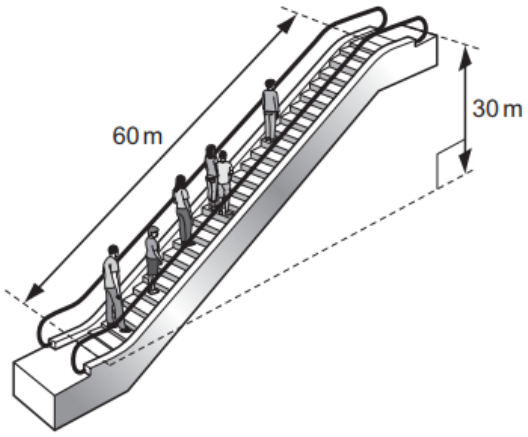
B R

C S

D none of these

41. B

16 An escalator is 60 m long and lifts passengers through a vertical height of 30 m, as shown.



To drive the escalator against the forces of friction when there are no passengers requires a power of 2.0 kW.

The escalator is used by passengers of average mass 60 kg and the power to overcome friction remains constant.

How much power is required to drive the escalator when it is carrying 20 passengers and is travelling at $0.75\,m\,s^{-1}$?

A 4.4 kW **B** 6.4 kW **C** 8.8 kW **D** 10.8 kW

S14/13

42. A

14 A uniform solid cuboid of concrete of dimensions 0.50 m × 1.20 m × 0.40 m and weight 4000 N rests on a flat surface with the 1.20 m edge vertical as shown in diagram 1.

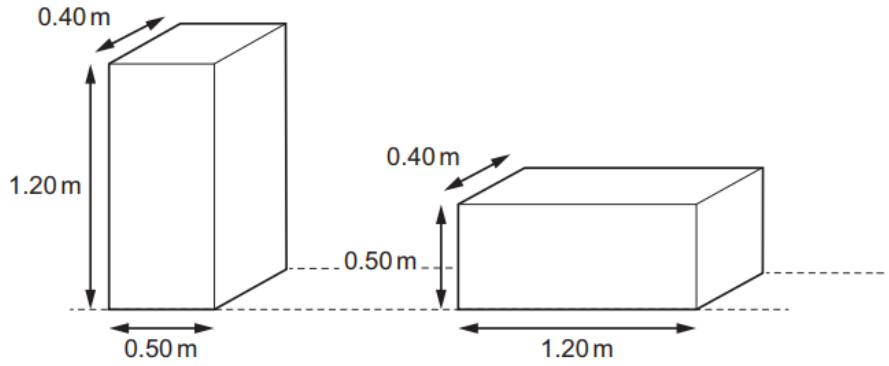


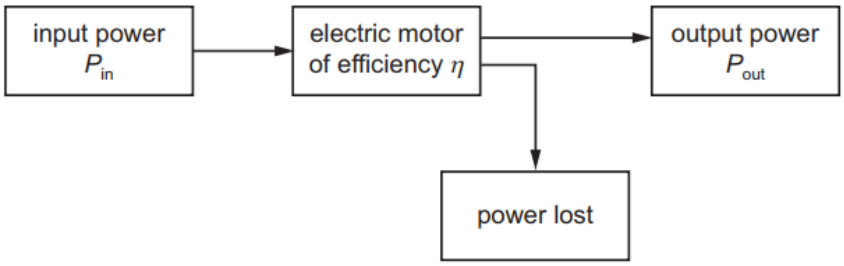
diagram 1 diagram 2

What is the minimum energy required to roll the cuboid through 90° to the position shown in diagram 2 with the 0.50 m edge vertical?

A 200 J **B** 400 J **C** 1400 J **D** 2600 J

43. D

16 An electric motor has an input power P_{in}, useful output power P_{out} and efficiency η.



How much power is lost by the motor?

A ηP_{in} **B** $\left(\frac{1}{\eta}-1\right)P_{in}$ **C** ηP_{out} **D** $\left(\frac{1}{\eta}-1\right)P_{out}$

44. B

18 A ball drops onto a horizontal surface and bounces elastically.

What happens to the kinetic energy of the ball during the very short time that it is in contact with the surface?

A Most of the kinetic energy is lost as heat and sound energy.

B The kinetic energy decreases to zero and then returns to its original value.

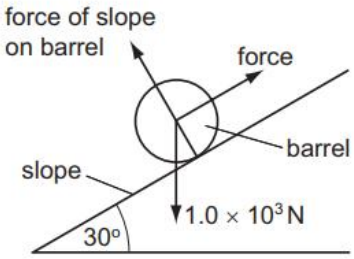
C The kinetic energy remains constant because it is an elastic collision.

D The kinetic energy remains constant in magnitude but changes direction.

W13/11

45. A

17 The diagram shows a barrel of weight 1.0×10^3 N on a frictionless slope inclined at 30° to the horizontal.



A force is applied to the barrel to move it up the slope at constant speed. The force is parallel to the slope.

What is the work done in moving the barrel a distance of 5.0 m up the slope?

A 2.5×10^3 J **B** 4.3×10^3 J **C** 5.0×10^3 J **D** 1.0×10^4 J

46. C

18 A car travelling on a level road at a steady 20 m s^{-1} against a constant resistive force develops a power of 40 kW.

What is the magnitude of the resistive force?

A 200 N **B** 800 N **C** 2000 N **D** 4000 N

47. B

19 A turbine at a hydroelectric power station is situated 30 m below the level of the surface of a large lake. The water passes through the turbine at a rate of 340 m^3 per minute.

The overall efficiency of the turbine and generator system is 90%.

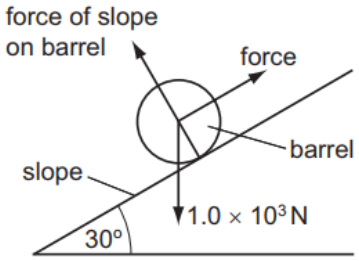
What is the output power of the power station? (The density of water is 1000 kg m^{-3}.)

A 0.15 MW **B** 1.5 MW **C** 1.7 MW **D** 90 MW

W13/13

48. D

17 The diagram shows a barrel of weight 1.0×10^3 N on a frictionless slope inclined at 30° to the horizontal.



A force is applied to the barrel to move it up the slope at constant speed. The force is parallel to the slope.

What is the work done in moving the barrel a distance of 5.0 m up the slope?

A 2.5×10^3 J **B** 4.3×10^3 J **C** 5.0×10^3 J **D** 1.0×10^4 J

49. D

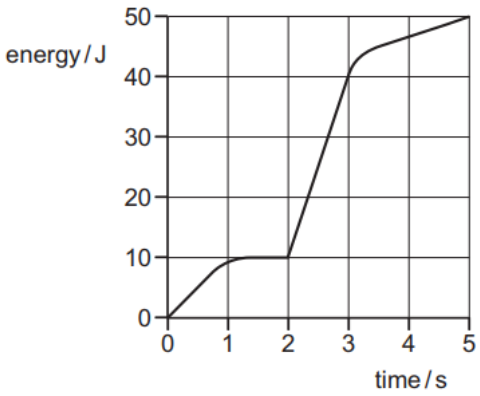
18 A car travelling on a level road at a steady 20 m s^{-1} against a constant resistive force develops a power of 40 kW.

What is the magnitude of the resistive force?

A 200 N **B** 800 N **C** 2000 N **D** 4000 N

50. C

19 An electrical generator is started at time zero. The total electrical energy generated during the first 5 seconds is shown in the graph.



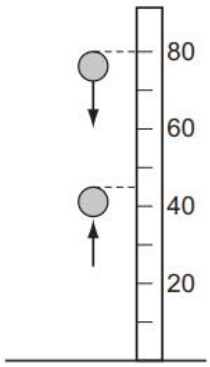
What is the maximum electrical power generated at any instant during these first 5 seconds?

A 10 W **B** 13 W **C** 30 W **D** 50 W

S13/11

51. B

17 A solid rubber ball has a diameter of 8.0 cm. It is released from rest with the top of the ball 80 cm above a horizontal surface. It falls vertically and then bounces back up so that the maximum height reached by the top of the ball is 45 cm, as shown.



If the kinetic energy of the ball is 0.75 J just before it strikes the surface, what is its kinetic energy just after it leaves the surface?

A 0.36 J **B** 0.39 J **C** 0.40 J **D** 0.42 J

52. B

18 A wind turbine has blades that sweep an area of 2000 m^2. It converts the power available in the wind to electrical power with an efficiency of 50%.

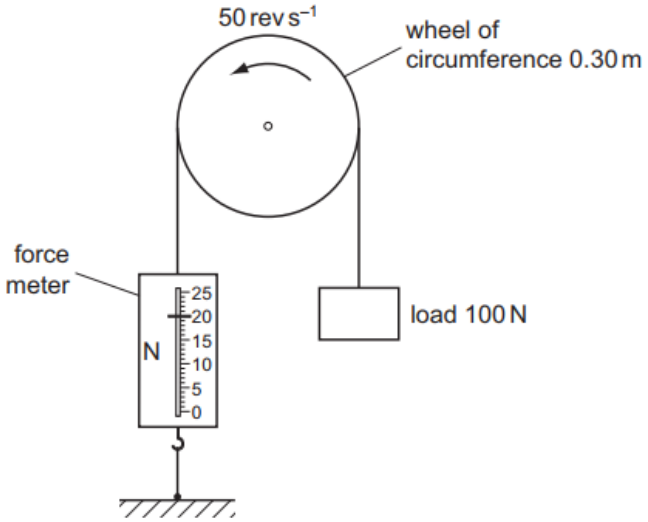
What is the electrical power generated if the wind speed is 10 $m\,s^{-1}$? (The density of air is 1.3 $kg\,m^{-3}$.)

A 130 kW **B** 650 kW **C** 1300 kW **D** 2600 kW

53. B

19 The diagram shows a wheel of circumference 0.30 m. A rope is fastened at one end to a force meter. The rope passes over the wheel and supports a freely hanging load of 100 N. The wheel is driven by an electric motor at a constant rate of 50 revolutions per second.

When the wheel is turning at this rate, the force meter reads 20 N.



What is the output power of the motor?

A 0.3 kW **B** 1.2 kW **C** 1.8 kW **D** 3.8 kW

S13/12

54. B

15 A ball is thrown vertically upwards.

Neglecting air resistance, which statement is correct?

A The kinetic energy of the ball is greatest at the greatest height attained.

B By the principle of conservation of energy, the total energy of the ball is constant throughout its motion.

C By the principle of conservation of momentum, the momentum of the ball is constant throughout its motion.

D The potential energy of the ball increases uniformly with time during its ascent.

55. B

16 A bow of mass 400 g shoots an arrow of mass 120 g vertically upwards. The potential energy stored in the bow just before release is 80 J. The system has an efficiency of 28%.

What is the height reached by the arrow when air resistance is neglected?

A 4 m **B** 19 m **C** 187 m **D** 243 m

56. C

17 A train on a mountain railway is carrying 200 people of average mass 70 kg up a slope at an angle of 30° to the horizontal and at a speed of 6.0 m s^{-1}. The train itself has a mass of 80 000 kg. The percentage of the power from the engine which is used to raise the passengers and the train is 40 %.

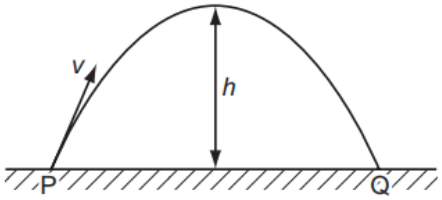
What is the power of the engine?

A 1.1 MW **B** 2.8 MW **C** 6.9 MW **D** 14 MW

S13/13

57. A

14 A ball of mass *m* is thrown up to height *h* in air with an initial velocity *v*, as shown.



Air resistance is considered negligible. The acceleration of free fall is *g*.

What is the **total** work done by the gravitational force on the ball during its flight from P to Q?

A zero **B** $\frac{1}{2}mv^2$ **C** mgh **D** $2mgh$

58. A

15 A spring of unextended length 40 mm is suspended from a fixed point. A load of 16 N is applied to the free end of the spring. This causes the spring to extend so that its final length is five times its original length. The spring obeys Hooke's Law.

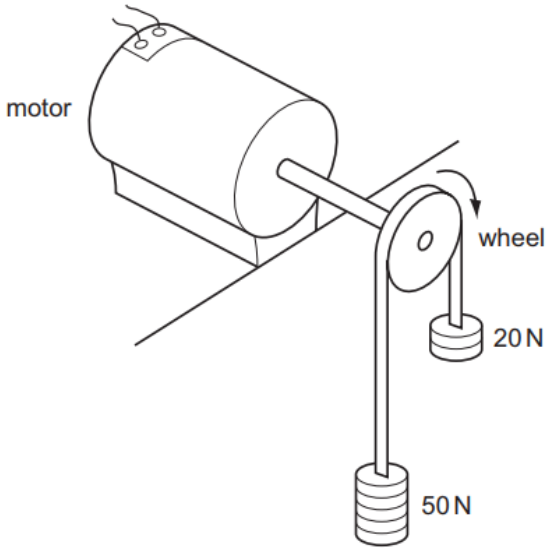
What is the energy stored in the spring due to this extension?

A 1.3 J **B** 1.6 J **C** 2.6 J **D** 3.2 J

59. A

16 The diagram shows an arrangement used to find the output power of an electric motor.

The wheel attached to the motor's axle has a circumference of 0.5 m and the belt which passes over it is stationary when the weights have the values shown.



If the wheel is making 20 revolutions per second, what is the output power of the motor?

A 300 W **B** 500 W **C** 600 W **D** 700 W

W12/11

60. A

18 The kinetic energy of a particle is increased by a factor of 4.

By what factor does its speed increase?

A 2 **B** 4 **C** 8 **D** 16

61. A

19 A piston in a gas supply pump has an area of 600 cm^2 and it moves a distance of 40 cm during one stroke. The pump moves the gas against a fixed pressure of 5000 Pa.

How much work is done by the piston during one stroke?

A 1.2×10^2 J **B** 1.2×10^4 J **C** 1.2×10^6 J **D** 1.2×10^8 J

62. C

20 A railway engine accelerates a train of total mass 800 tonnes (1 tonne = 1000 kg) from rest to a speed of 50 $m\,s^{-1}$.

How much work must be done on the train to reach this speed?

A 1.0×10^6 J **B** 2.0×10^6 J **C** 1.0×10^9 J **D** 2.0×10^9 J

63. D

21 Water from a reservoir is fed to the turbine of a hydroelectric system at a rate of 500 kg s^{-1}. The reservoir is 300 m above the level of the turbine.

The electrical output from the generator driven by the turbine is 200 A at a potential difference of 6000 V.

What is the efficiency of the system?

A 8.0 % **B** 8.2 % **C** 80 % **D** 82 %

W12/12

64. A

19 A piston in a gas supply pump has an area of 500 cm^2 and it moves a distance of 30 cm during one stroke.

The pump moves the gas against a fixed pressure of 4000 Pa.

How much work is done by the piston during one stroke?

A 60 J **B** 6.0×10^3 J **C** 6.0×10^5 J **D** 6.0×10^7 J

65. D

20 A railway engine accelerates a train of total mass 1200 tonnes (1 tonne = 1000 kg) from rest to a speed of 75 m s^{-1}.

How much useful work must be done on the train to reach this speed?

A 1.7×10^6 J **B** 3.4×10^6 J **C** 1.7×10^9 J **D** 3.4×10^9 J

66. D

21 A crane is being used to lift containers off a ship. One container has a mass of 14 000 kg and is being lifted vertically with a speed of 3.2 m s^{-1}.

The electric motor being used to supply the power to lift the container is using a current of 240 A at a potential difference of 2200 V.

What is the efficiency of the system?

A 8.1 % **B** 8.5 % **C** 48 % **D** 83 %

67. A

22 Trains supply coal to a power station. The table below gives quantities describing the operation of the power station.

	symbol	unit
power station output	*P*	W
number of trains per day	*N*	
mass of coal on a train	*M*	kg
energy from 1 kg of coal	*J*	J
number of seconds in one day	*S*	

Which expression gives the efficiency of the power station?

A $\frac{PS}{NMJ}$ **B** $\frac{PSN}{MJ}$ **C** $\frac{NMJ}{PS}$ **D** $\frac{NM}{PSJ}$

W12/13

68. B

18 A car travelling with speed 28 m s^{-1} leaves a motorway on an exit road. The end of the exit road is 22 m higher than the motorway.

If only the force of gravity is considered, what will be the speed of the car at the end of the exit road?

A 7.3 m s^{-1} **B** 19 m s^{-1} **C** 21 m s^{-1} **D** 24 m s^{-1}

69. A

19 A piston in a gas supply pump has an area of 400 cm^2 and it moves a distance of 25 cm during one stroke.

The pump moves the gas against a fixed pressure of 3000 Pa.

How much work is done by the piston during one stroke?

A 30 J **B** 3.0×10^3 J **C** 3.0×10^5 J **D** 3.0×10^7 J

70. D

20 A transformer has the following input and output.

	potential difference / V	current / A
input	11 000	28
output	240	1200

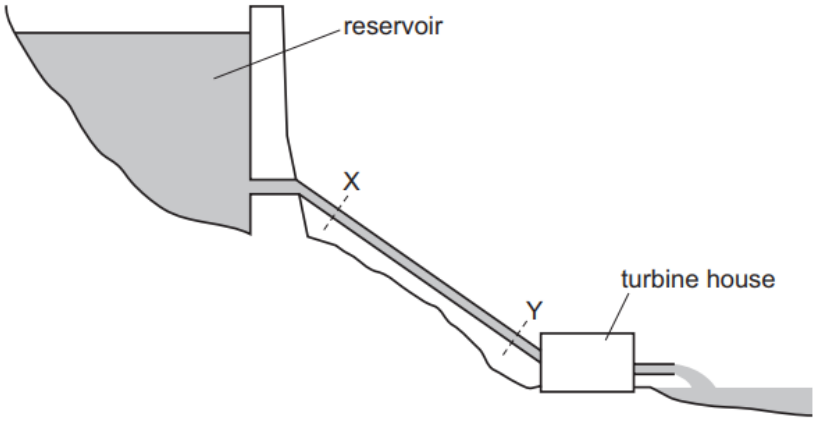
What is the efficiency of the transformer?

A 0.94 % **B** 1.0 % **C** 11 % **D** 94 %

71. B

21 The diagram shows a hydroelectric power station.

The reservoir is linked to the turbines by a pipe of uniform cross-sectional area. Water flows from the reservoir, through the pipe and through the turbines at a constant rate.



Which statement about the change of energy of the water as it moves from X to Y is correct?

A It gains both gravitational potential energy and kinetic energy.

B It loses gravitational potential energy and gains elastic potential energy.

C It loses gravitational potential energy and gains kinetic energy.

D It loses both elastic potential energy and gravitational potential energy.

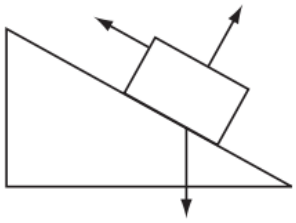
W12/13

72. A

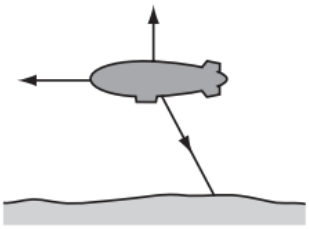
17 The diagrams show the forces acting on different bodies.

Which body **cannot** be in equilibrium?

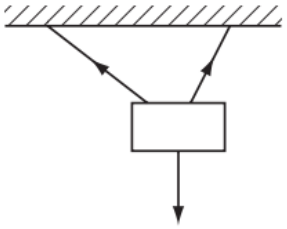
A



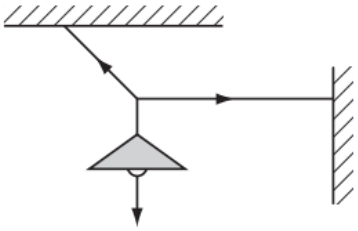
B



C



D



73. B

18 A car travelling with speed 28 m s^{-1} leaves a motorway on an exit road. The end of the exit road is 22 m higher than the motorway.

If only the force of gravity is considered, what will be the speed of the car at the end of the exit road?

A 7.3 m s^{-1} **B** 19 m s^{-1} **C** 21 m s^{-1} **D** 24 m s^{-1}

74. A

19 A piston in a gas supply pump has an area of 400 cm^2 and it moves a distance of 25 cm during one stroke.

The pump moves the gas against a fixed pressure of 3000 Pa.

How much work is done by the piston during one stroke?

A 30 J **B** 3.0×10^3 J **C** 3.0×10^5 J **D** 3.0×10^7 J

75.(1) D

20 A transformer has the following input and output.

	potential difference / V	current / A
input	11 000	28
output	240	1200

What is the efficiency of the transformer?

A 0.94 % **B** 1.0 % **C** 11 % **D** 94 %

W11/11

76. A

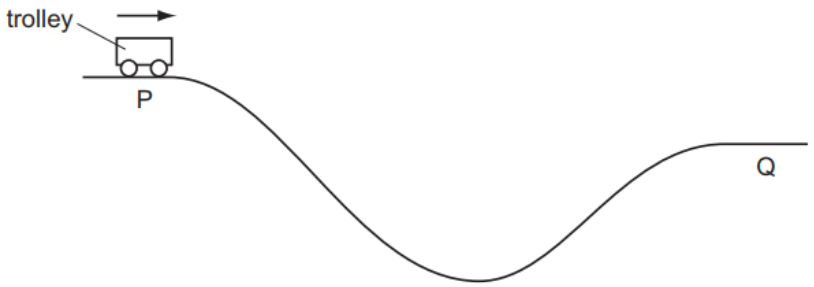
17 The first column in the table gives four examples of work being done. The second column gives more detail of the action.

Which row is **not** correct?

	example	detail
A	a girl dives from a diving board into a swimming pool	work is done by the girl against gravity as she falls
B	a man pushes a car along a level road	work is done by the man against friction
C	an electron is accelerated towards a positively-charged plate	work is done on the electron by the electric field of the plate
D	a piston is pushed outwards as a gas expands	work is done on the atmosphere by the gas

77. B

18 A trolley runs from P to Q along a track. At Q its potential energy is 50 kJ less than at P.



At P, the kinetic energy of the trolley is 5 kJ. Between P and Q, the work the trolley does against friction is 10 kJ.

What is the kinetic energy of the trolley at Q?

A 35 kJ **B** 45 kJ **C** 55 kJ **D** 65 kJ

78. C

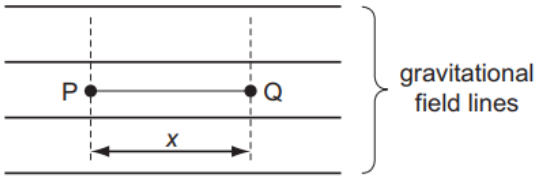
19 An electric motor is required to produce 120 W of mechanical output power. The efficiency of the motor is 80 %.

Which row is correct?

	electrical power input to motor / W	waste heat output from motor / W
A	120	24
B	120	96
C	150	30
D	150	120

79. A

20 A mass *m* is situated in space in a uniform gravitational field.



When the mass moves through a displacement *x*, from P to Q, it loses an amount of potential energy *E*.

Which row correctly specifies the magnitude and the direction of the acceleration due to the gravity in this field?

	magnitude	direction
A	$\frac{E}{mx}$	→
B	$\frac{E}{mx}$	←
C	$\frac{E}{x}$	→
D	$\frac{E}{x}$	←

W11/12

80. B

15 When a horizontal force *F* is applied to a frictionless trolley over a distance *s*, the kinetic energy of the trolley changes from 4 J to 8 J.

If a force of 2*F* is applied to the trolley over a distance of 2*s*, what will the original kinetic energy of 4 J become?

A 16 J **B** 20 J **C** 32 J **D** 64 J

81. B

16 The kinetic energy of a vehicle of mass 1000 kg is 4.5×10^5 J. It is braked with a total constant braking force of 6000 N.

What will be its stopping distance?

A 37 m **B** 75 m **C** 150 m **D** 300 m

82. A

17 In many old-style filament lamps, as much as 92 J of energy is emitted as thermal energy for every 8 J of energy emitted as light.

What is the efficiency of the lamp, as the percentage of electrical energy converted to light energy?

A 8% **B** 9% **C** 91% **D** 92%

83. D

18 What is the unit of power in SI base units?

A $kg\,m\,s^{-2}$ **B** $kg\,m\,s^{-3}$ **C** $kg\,m^2\,s^{-2}$ **D** $kg\,m^2\,s^{-3}$

S11/11

84. C

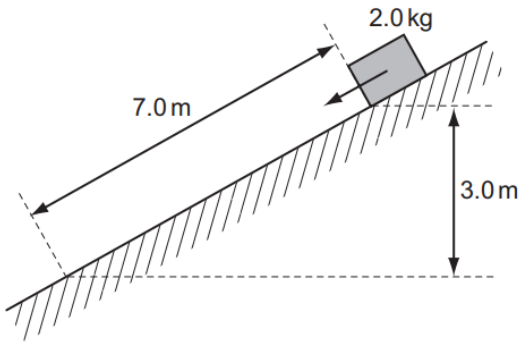
14 A steel sphere is dropped vertically onto a horizontal metal plate. The sphere hits the plate with a speed u, leaves it at a speed v, and rebounds vertically to half of its original height.

Which expression gives the value of $\frac{v}{u}$?

A $\frac{1}{2^2}$ **B** $\frac{1}{2}$ **C** $\frac{1}{\sqrt{2}}$ **D** $1 - \frac{1}{\sqrt{2}}$

85. A

15 A block of mass 2.0 kg is released from rest on a slope. It travels 7.0 m down the slope and falls a vertical distance of 3.0 m. The block experiences a frictional force parallel to the slope of 5.0 N.



What is the speed of the block after falling this distance?

A $4.9\,m\,s^{-1}$ **B** $6.6\,m\,s^{-1}$ **C** $8.6\,m\,s^{-1}$ **D** $10.1\,m\,s^{-1}$

86. B

16 A man has a mass of 80 kg. He ties himself to one end of a rope which passes over a single fixed pulley. He pulls on the other end of the rope to lift himself up at an average speed of 50 cm s^{-1}.

What is the average useful power at which he is working?

A 40 W **B** 0.39 kW **C** 4.0 kW **D** 39 kW

87. C

17 A body travelling with a speed of 10 m s^{-1} has kinetic energy 1500 J.

If the speed of the body is increased to 40 m s^{-1}, what is its new kinetic energy?

A 4500 J **B** 6000 J **C** 24 000 J **D** 1 350 000 J

S11/12

88. D

18 An electric motor produces 120 W of useful mechanical output power. The efficiency of the motor is 60 %.

Which row is correct?

	electrical power input / W	waste heat power output / W
A	72	48
B	192	72
C	200	72
D	200	80

89. D

19 A hammer with 10 J of kinetic energy hits a nail and pushes it 5.0 mm into a plank.

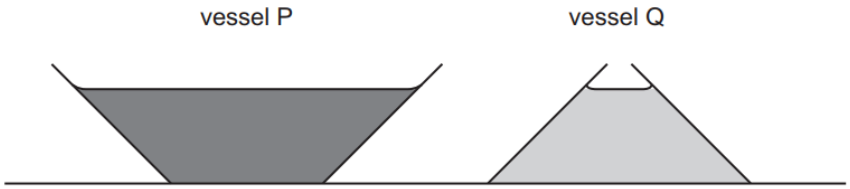
Both the hammer and nail come to rest after the collision.

What is the average force that acts on the nail while it moves the 5.0 mm?

A 0.050 N **B** 2.0 N **C** 50 N **D** 2000 N

90. A

20 The diagram shows two vessels, P and Q, both with sides inclined at 45°.



Vessel P tapers outwards and vessel Q tapers inwards, as shown.

Both vessels contain a liquid. The depth of the liquid in the vessels is the same. The liquid in vessel P is twice as dense as the liquid in vessel Q.

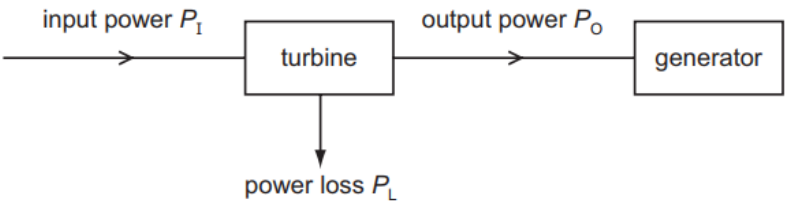
What is the ratio $\frac{\text{pressure due to the liquid on the base of P}}{\text{pressure due to the liquid on the base of Q}}$?

A $\frac{2}{1}$ **B** $\frac{\sqrt{2}}{1}$ **C** $\frac{1}{\sqrt{2}}$ **D** $\frac{1}{2}$

W10/11

91. D

17 A steam turbine is used to drive a generator. The input power to the turbine is P_I and the output power P_O. The power loss in the turbine is P_L, as shown below.

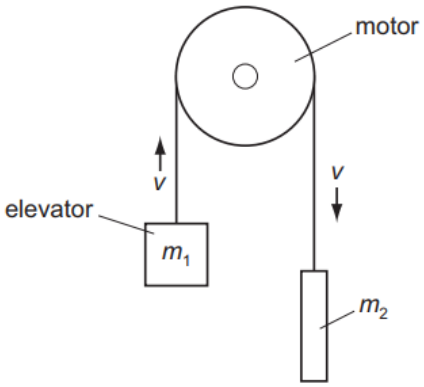


What is the efficiency of the turbine?

A $\frac{P_L}{P_O}$ **B** $\frac{P_I}{P_O}$ **C** $\frac{P_L}{P_I}$ **D** $\frac{P_O}{P_I}$

92. D

18 The diagram shows a lift system in which the elevator (mass m_1) is partly counterbalanced by a heavy weight (mass m_2).



At what rate does the motor provide energy to the system when the elevator is rising at a steady speed v? (g = acceleration of free fall)

A $\frac{1}{2}m_1v^2$

B $\frac{1}{2}(m_1 - m_2)v^2$

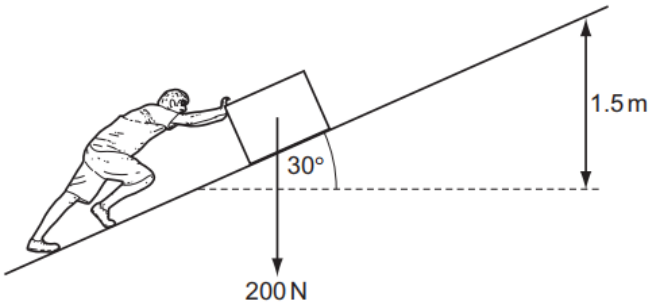
C m_1gv

D $(m_1 - m_2)gv$

W10/12

93. D

14 A box of weight 200 N is pushed so that it moves at a steady speed along a ramp, through a height of 1.5 m. The ramp makes an angle of 30° with the ground. The frictional force on the box is 150 N while the box is moving.



What is the work done by the person?

A 150 J **B** 300 J **C** 450 J **D** 750 J

94. D

15 A raindrop of mass m is falling vertically through the air with a steady speed v. The raindrop experiences a retarding force kv due to the air, where k is a constant. The acceleration of free fall is g.

Which expression gives the kinetic energy of the raindrop?

A $\frac{mg}{k}$ **B** $\frac{mg^2}{2k^2}$ **C** $\frac{m^3g^2}{k^2}$ **D** $\frac{m^3g^2}{2k^2}$

95. B

16 The kinetic energy of a vehicle of mass 1000 kg is 4.5×10^5 J. It is stopped by applying a constant braking force of 6000 N.

What is its stopping distance?

A 37 m **B** 75 m **C** 150 m **D** 300 m

96. C

17 What are units of work, energy and power?

	work	energy	power
A	J	N m	J
B	$J s^{-1}$	J	$J s^{-1}$
C	N m	N m	W
D	N m	W	W

S10/11

97. A

3 An ion is accelerated by a series of electrodes in a vacuum. A graph of the power supplied to the ion is plotted against time.

What is represented by the area under the graph between two times?

A the change in kinetic energy of the ion

B the average force on the ion

C the change in momentum of the ion

D the change in velocity of the ion

98. B

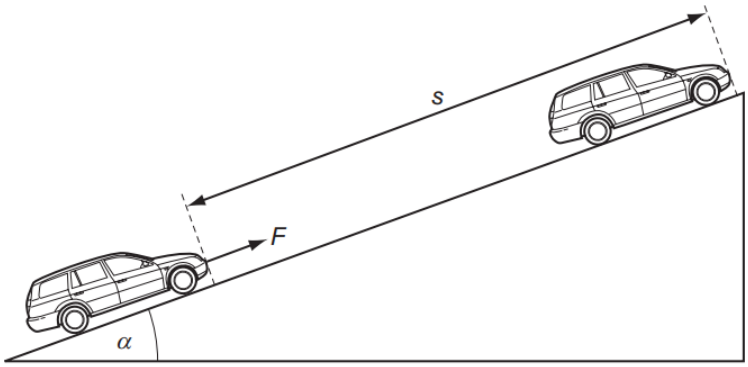
15 A force of 1000 N is needed to lift the hook of a crane at a steady velocity. The crane is then used to lift a load of mass 1000 kg at a velocity of $0.50 m s^{-1}$.

How much of the power developed by the motor of the crane is used in lifting the hook and the load? Assume that the acceleration of free fall *g* is equal to $10 m s^{-2}$.

A 5.0 kW **B** 5.5 kW **C** 20 kW **D** 22 kW

99. D

16 A constant force F, acting on a car of mass m, moves the car up the slope through a distance s at constant velocity v. The angle of the slope to the horizontal is α.



Which expression gives the efficiency of the process?

A $\frac{mgs\sin\alpha}{Fv}$ **B** $\frac{mv}{Fs}$ **C** $\frac{mv^2}{2Fs}$ **D** $\frac{mg\sin\alpha}{F}$

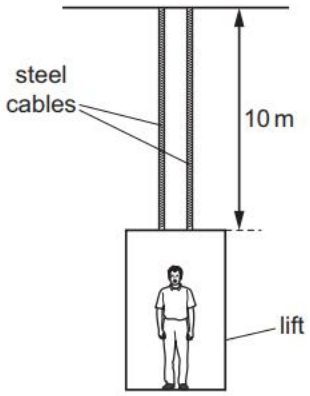
New Topic 6:

6. MATTER AND MATERIALS

S16/11

1. C

3 A lift is supported by two steel cables, each of length 10 m and diameter 0.5 cm.



NOT TO SCALE

The cables extend by 1 mm when a man of mass 80 kg steps into the lift.

What is the best estimate of the value of the Young modulus of the steel?

A $2 \times 10^{10}\,\text{N m}^{-2}$

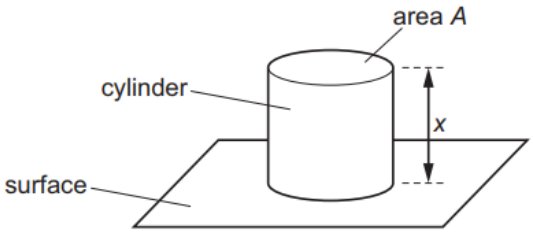
B $4 \times 10^{10}\,\text{N m}^{-2}$

C $2 \times 10^{11}\,\text{N m}^{-2}$

D $4 \times 10^{11}\,\text{N m}^{-2}$

2. B

13 A solid metal cylinder stands on a horizontal surface, as shown.



The cylinder has length x and cross-sectional area A. The cylinder exerts a pressure p on the surface. The acceleration of free fall is g.

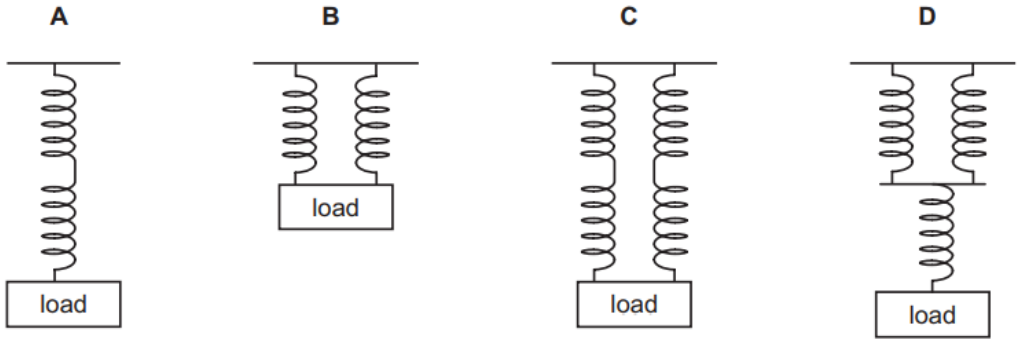
Which expression gives the density of the metal of the cylinder?

A $\frac{gx}{p}$ **B** $\frac{p}{gx}$ **C** $\frac{gx}{pA}$ **D** $\frac{pA}{gx}$

3. C

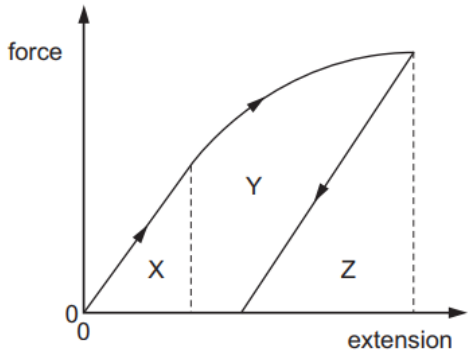
20 A number of identical springs are joined in four arrangements.

Which arrangement has the same spring constant as a single spring?



4. B

21 A sample of material is stretched by a tensile force to a point beyond its elastic limit. The tensile force is then reduced to zero. The graph of force against extension is shown below.



Which area represents the net work done on the sample?

A X **B** X + Y **C** Y + Z **D** Z

S16/12

5. A

13 In a large container in an oil refinery, three oils of different densities are mixed. No chemical activity occurs.

The mixture consists of

1200 kg of oil of density 1100 kg m^{-3},

1500 kg of oil of density 860 kg m^{-3},

4000 kg of oil of density 910 kg m^{-3}.

What is the density of the mixture?

A 927 kg m^{-3} **B** 957 kg m^{-3} **C** 1010 kg m^{-3} **D** 1080 kg m^{-3}

6. C

15 The density of air on the Earth decreases almost linearly with height from 1.22 kg m^{-3} at sea level to 0.74 kg m^{-3} at an altitude of 5000 m.

Atmospheric pressure at the Earth's surface on a particular day is 100 000 Pa. The value of g between the Earth's surface and an altitude of 5000 m can be considered to have a constant value of 9.7 m s^{-2}.

What will be the atmospheric pressure at an altitude of 5000 m?

A 36 000 Pa **B** 48 000 Pa **C** 52 000 Pa **D** 59 000 Pa

7. D

20 A spring balance consists of a spring of length 20.0 cm with a hook attached.

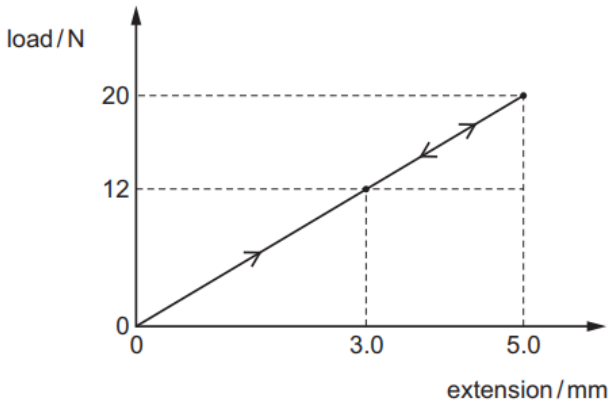
When a fish of mass 3.0 kg is suspended from the hook, the new length of the spring is 27.0 cm.

What is the spring constant of the spring?

A 4.2 N m^{-1} **B** 43 N m^{-1} **C** 110 N m^{-1} **D** 420 N m^{-1}

8. D

21 A metal wire is attached at one end to a fixed point and a load is hung from the other end so that the wire hangs vertically. The load is increased from zero to 20 N. This causes the wire to extend elastically by 5.0 mm. The load is then reduced to 12 N and the extension decreases to 3.0 mm.



How much strain energy is released during the unloading process?

A 0.8 × 10^{-2} J **B** 1.8 × 10^{-2} J **C** 2.4 × 10^{-2} J **D** 3.2 × 10^{-2} J

S16/13

9. C

15 For a change in depth Δh in a liquid of density ρ, the change in pressure Δp is given by $\Delta p = \Delta h \rho g$ where g is the acceleration of free fall.

What is the equation, or principle of physics, used in the derivation of this formula?

A atmospheric pressure decreases with height

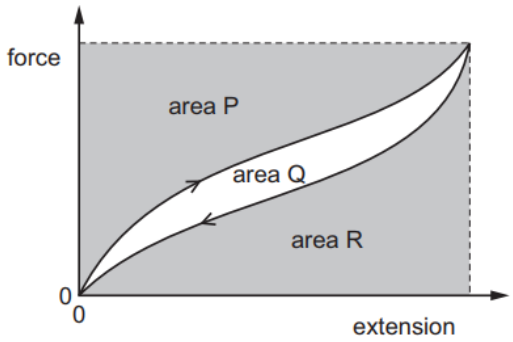
B change in gravitational potential energy = mass × $g\Delta h$

C $\rho = \frac{\text{mass}}{\text{volume}}$

D the density of a fluid increases with depth

10. C

20 The diagram shows the force-extension graph for a sample of material. The sample is stretched and then returns to its original length.



Which area represents the work done to stretch the sample?

A P + Q **B** P only **C** Q + R **D** R only

11. D

21 A metal wire of cross-sectional area 0.20 mm^2 hangs vertically from a fixed point. A load of 84 N is then attached to the lower end of the wire. The wire obeys Hooke's law and increases in length by 0.30%.

What is the Young modulus of the metal of the wire?

A 1.4×10^5 Pa

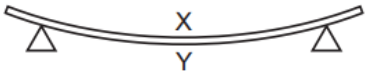
B 1.4×10^8 Pa

C 1.4×10^9 Pa

D 1.4×10^{11} Pa

12. C

22 The diagram shows a beam supported on two pivots.



Which statement describes the state of the top surface X and of the bottom surface Y?

A Both X and Y are in compression.

B Both X and Y are in tension.

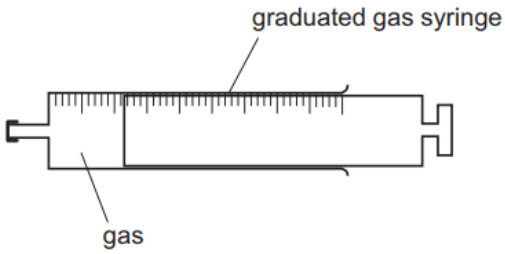
C X is in compression and Y is in tension.

D X is in tension and Y is in compression.

W15/11

13. B

15 A gas is contained inside a sealed syringe, as shown.



The volume of gas at room temperature is 2.0 cm^3.

Atmospheric pressure is 101 kPa.

What is the work done by the gas when it is heated and expands to a volume of 6.0 cm^3?

A 404 μJ **B** 404 mJ **C** 404 J **D** 404 kJ

14. D

18 A fixed amount of gas is reduced in volume at a constant temperature.

What is the reason for the increase in pressure of the gas?

A The average distance travelled between collisions by the gas molecules is increased.

B The average intermolecular attractive force between the gas molecules is decreased.

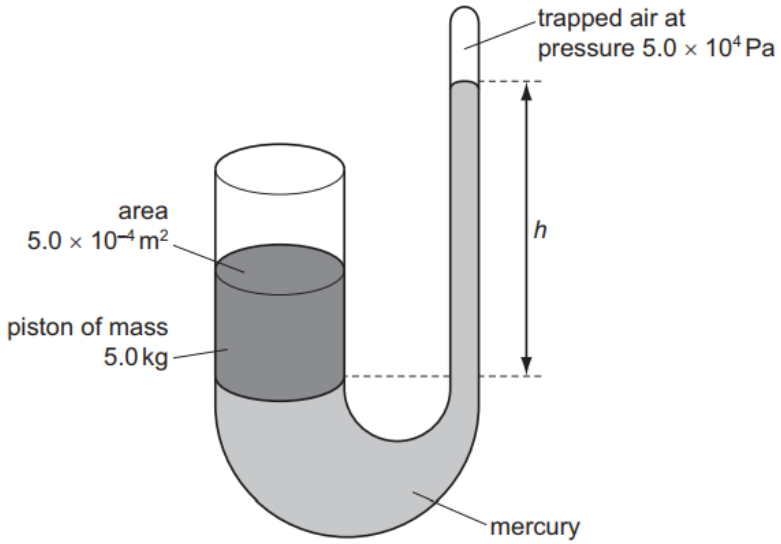
C The average speed of the gas molecules is increased.

D The frequency of the collisions of the gas molecules with the walls of the container is increased.

15. D

19 A U-tube closed at one end contains mercury. Air at a pressure of 5.0×10^4 Pa is trapped at the closed end. The other end is open to the atmosphere and is fitted with a piston of mass 5.0 kg and cross-sectional area 5.0×10^{-4} m^2.

The density of mercury is 13 600 kg m^{-3} and atmospheric pressure is 1.01×10^5 Pa.



What is the height *h* of the mercury column?

A 37 cm **B** 44 cm **C** 74 cm **D** 110 cm

16. B

20 A known tensile force acts on a wire. The wire does not exceed its elastic limit.

Which two measurements enable the strain of the wire to be calculated?

A the unstretched length of the wire and the cross-sectional area of the wire

B the unstretched length of the wire and the extension of the wire

C the Young modulus of the wire's material and the extension of the wire

D the Young modulus of the wire's material and the unstretched length of the wire

17. B

21 The Young modulus of steel is determined using a length of steel wire and is found to have the value *E*.

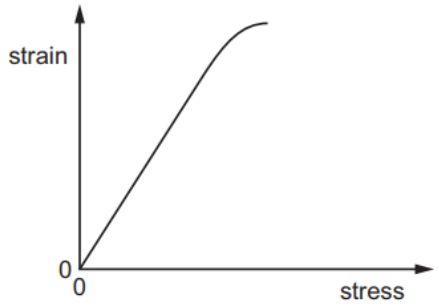
Another experiment is carried out using a wire of the same steel, but of half the length and half the diameter.

Which value is obtained for the Young modulus in the second experiment?

A $\frac{1}{2}E$ **B** E **C** $2E$ **D** $4E$

18. A

22 The graph shows the variation with stress of the strain of a material as it is extended elastically.



Why is the strain energy per unit volume of the material **not** the area under the graph?

A The axes are the wrong way round.

B The graph is not a straight line.

C The graph is strain-stress instead of extension-force.

D The material is polymeric.

19. B

23 A wire has a final length of 6.0 m after undergoing a strain of 200%.

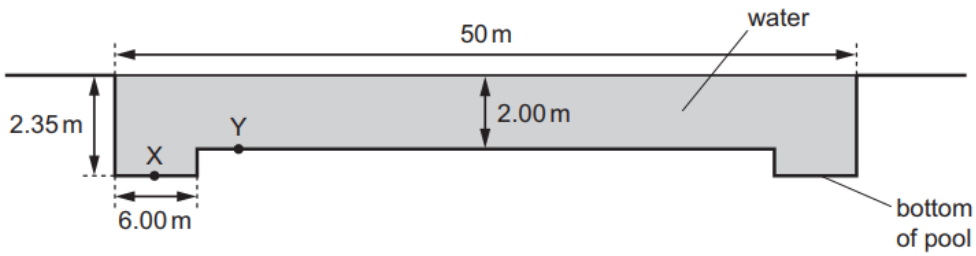
What is the original length of the wire?

A 1.5 m **B** 2.0 m **C** 3.0 m **D** 4.0 m

W15/12

20. B

20 The diagram shows the cross-section of an Olympic-size swimming pool filled with water. It is not drawn to scale. The density of the water is 1000 kg m^{-3}.



What is the difference in pressure between X and Y?

A 0.35 kPa **B** 3.4 kPa **C** 21.3 kPa **D** 58.9 kPa

21. D

21 A force acts on a wire to produce extension *e*. The same force then acts on a second wire of the same material, but of half the diameter and three times the length of the first wire. Both wires obey Hooke's law.

What is the extension of the second wire?

A 3*e* **B** 4*e* **C** 6*e* **D** 12*e*

22. D

22 Which statement about elastic and plastic deformation is correct?

A Elastic deformation and plastic deformation are proportional to the applied force.

B Elastic deformation and plastic deformation cause no change in volume.

C Elastic deformation causes heating of the material but plastic deformation does not.

D Elastic deformation is reversible but plastic deformation is not.

23. C

23 What is meant by the *ultimate tensile stress* of a ductile metal?

A It is the maximum stress at which the material deforms elastically.

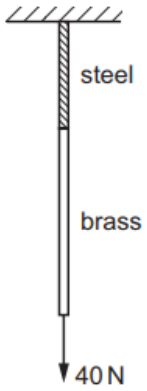
B It is the maximum stress at which the material obeys Hooke's law.

C It is the maximum stress that the material can support without breaking.

D It is the Young modulus multiplied by the maximum possible strain of a material.

24. B

24 A 0.80 m length of steel wire and a 1.4 m length of brass wire are joined together. The combined wires are suspended from a fixed support and a force of 40 N is applied, as shown.



The Young modulus of steel is 2.0×10^{11} Pa.

The Young modulus of brass is 1.0×10^{11} Pa.

Each wire has a cross-sectional area of 2.4×10^{-6} m^2.

The wires extend without reaching their elastic limits.

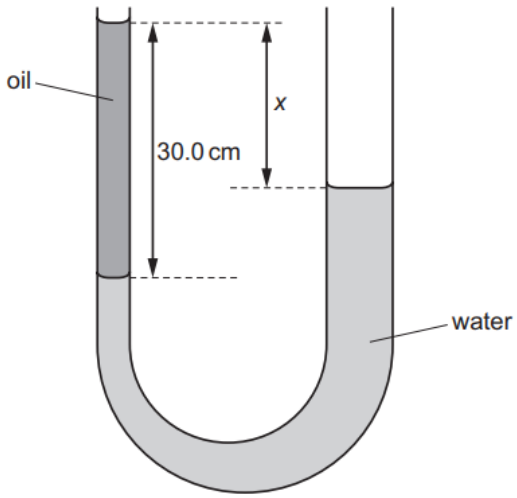
What is the total extension? Ignore the weights of the wires.

A 1.7×10^{-4} m **B** 3.0×10^{-4} m **C** 3.9×10^{-4} m **D** 9.0×10^{-4} m

W15/13

25. A

19 A U-tube has one arm of area of cross-section A and the other of cross-section $4A$. The tube contains water of density 1000 kg m^{-3} and oil of density 850 kg m^{-3}, as shown.



The column of oil on top of the water in the left-hand arm is of length 30.0 cm.

What is the difference in height x between the levels in the two arms of the tube?

A 4.5 cm **B** 6.2 cm **C** 23.8 cm **D** 25.5 cm

26. B

20 The Young modulus of a metal may be determined from the ratio $\frac{\text{stress}}{\text{strain}}$ when the metal is stretched elastically. This can be done by making measurements when loads are added to a wire.

Which measurements are needed to calculate the stress and strain of the wire in such an experiment?

	stress		strain	
A	wire diameter	initial and final positions of load	wire's original length	mass added
B	wire diameter	mass added	wire's original length	initial and final positions of load
C	wire's original length	initial and final positions of load	wire diameter	mass added
D	wire's original length	mass added	wire diameter	initial and final positions of load

27. C

21 A copper wire of length 3.6 m and diameter 1.22 mm is stretched elastically by a force of 37 N. The Young modulus of copper is 1.17×10^{11} Pa.

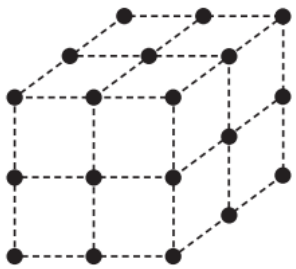
Which extension is caused by this force?

A 0.24 mm **B** 0.76 mm **C** 0.97 mm **D** 3.1 mm

S15/11

28. C

21 The diagram shows the arrangement of atoms in a particular crystal.



Each atom is at the corner of a cube.

The mass of each atom is 3.5×10^{-25} kg. The density of the crystal is 9.2×10^{3} kg m^{-3}.

What is the shortest distance between the centres of two adjacent atoms?

A 3.8×10^{-29} m

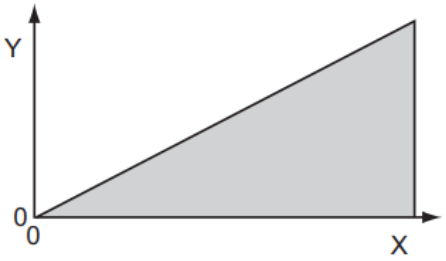
B 6.2×10^{-15} m

C 3.4×10^{-10} m

D 3.0×10^{-9} m

29. A

22 The graph shown was plotted in an experiment on a metal wire.



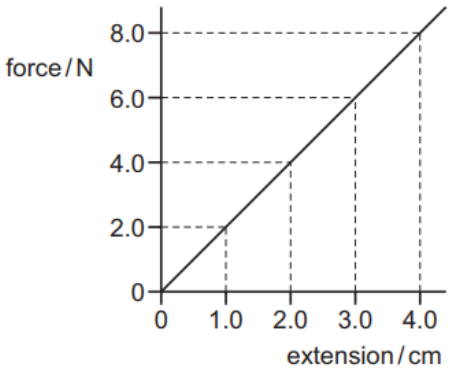
The shaded area represents the total strain energy stored in stretching the wire.

How should the axes be labelled?

	Y	X
A	force	extension
B	mass	extension
C	strain	energy
D	stress	strain

30. B

23 The variation with applied force of the extension of a spring is shown in the graph.



When there is no force applied to the spring, it has a length of 1.0 cm.

What is the **increase** in the strain energy stored in the spring when its **length** is increased from 2.0 cm to 3.0 cm?

A 0.020 J **B** 0.030 J **C** 0.040 J **D** 0.050 J

S15/12

31. B

20 The maximum pressure that granite rock can withstand is $2.0 \times 10^8\,\text{N m}^{-2}$. Above this pressure, the rock begins to flow like a liquid. The density of granite is $2.7 \times 10^3\,\text{kg m}^{-3}$.

What would be the height of a pure granite mountain whose base is just beginning to flow?

A $3.8 \times 10^3\,\text{m}$ **B** $7.6 \times 10^3\,\text{m}$ **C** $3.7 \times 10^4\,\text{m}$ **D** $7.4 \times 10^4\,\text{m}$

32. A

21 To determine the Young modulus of a wire, several measurements are taken.

In which row can the measurement **not** be taken **directly** with the stated apparatus?

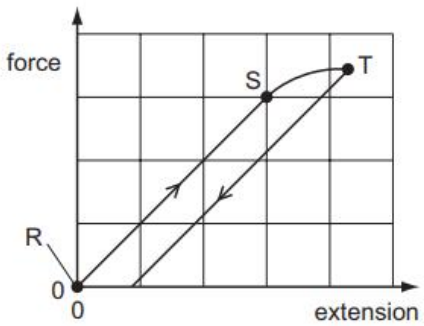
	measurement	apparatus
A	area of cross-section of wire	micrometer screw gauge
B	extension of wire	vernier scale
C	mass of load applied to wire	electronic balance
D	original length of wire	metre rule

33. B

22 A long, thin metal wire is suspended from a fixed support and hangs vertically. Masses are suspended from its lower end.

The load on the lower end is increased from zero and then decreased again back to zero.

The diagram shows the force-extension graph produced.



Where on the graph would the elastic limit be found?

A anywhere between point R and point S

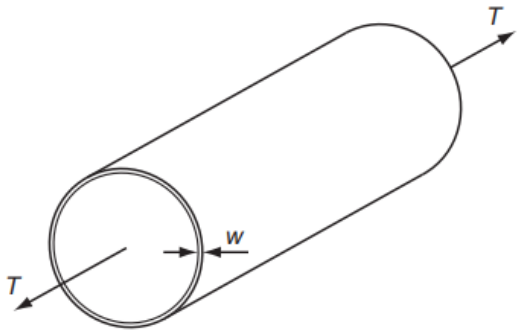
B just beyond point S

C exactly at point S

D exactly at point T

34. C

23 The diagram represents a steel tube with wall thickness *w* which is small in comparison with the diameter of the tube.



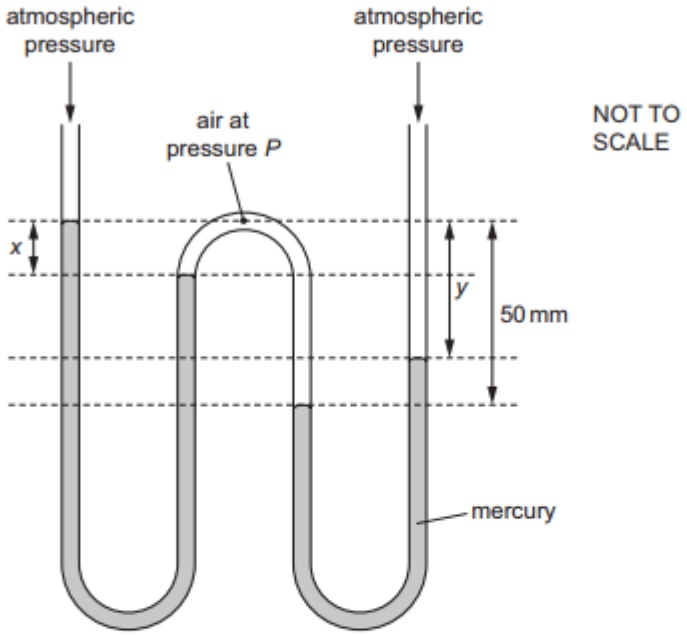
The tube is under tension, caused by a force *T*, parallel to the axis of the tube. To reduce the stress in the material of the tube, it is proposed to thicken the wall.

The tube diameter and the tension being constant, which wall thickness gives half the stress?

A $\frac{w}{2}$ **B** $\sqrt{2}\,w$ **C** $2w$ **D** $4w$

S15/13

21 A W-shaped tube contains two amounts of mercury, each open to the atmosphere. Air at pressure *P* is trapped in between them. The diagram shows two vertical distances *x* and *y*.



Atmospheric pressure is equal to the pressure that would be exerted by a column of mercury of height 760 mm. The pressure *P* is expressed in this way.

Which values of *x*, *y* and *P* are possible?

	x/mm	*y*/mm	*P*/mm of mercury
A	20	20	780
B	20	30	780
C	30	20	810
D	30	30	790

35.B

36. A

22 A steel bar of circular cross-section is under tension *T*, as shown.

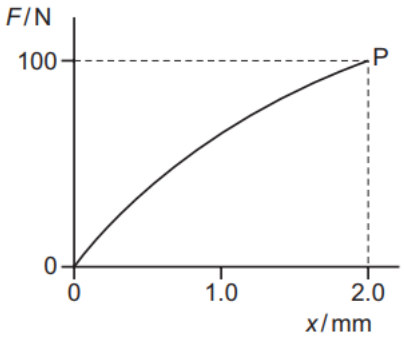
The diameter of the wide portion is double the diameter of the narrow portion.

What is the value of $\frac{\text{stress in the wide portion}}{\text{stress in the narrow portion}}$?

A 0.25 **B** 0.50 **C** 2.0 **D** 4.0

37. C

23 The graph shows the non-linear force-extension curve for a wire made from a new composite material.

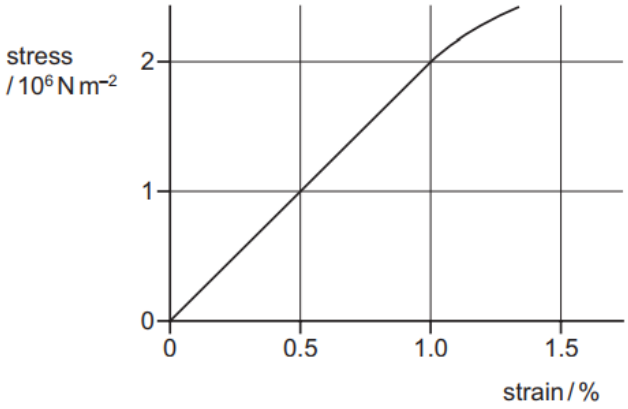


What could be the value of the strain energy stored in the wire when it is stretched elastically to point P?

A 0.09 J **B** 0.10 J **C** 0.11 J **D** 0.20 J

38. D

24 The diagram shows the stress-strain graph for bone.



What is the Young modulus of bone?

A $1 \times 10^6\,N\,m^{-2}$

B $2 \times 10^6\,N\,m^{-2}$

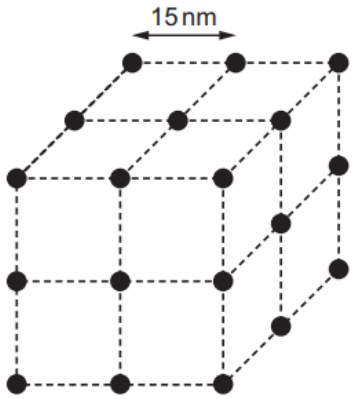
C $1 \times 10^8\,N\,m^{-2}$

D $2 \times 10^8\,N\,m^{-2}$

W14/11

39. B

19 The diagram shows the atoms of a substance with the atoms at the corners of a cube. The average separation of the atoms at a particular temperature is 15 nm.

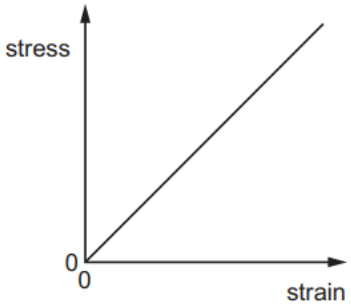


When the temperature changes so that the average separation becomes 17 nm, by which factor will the density of the substance change?

A 0.61 **B** 0.69 **C** 0.78 **D** 0.88

40. A

20 The stress-strain graph for a glass rod, up to the point at which it breaks, is shown below.



Which statement about the glass rod is correct?

A Hooke's law is obeyed for all values of stress up to the breaking point.

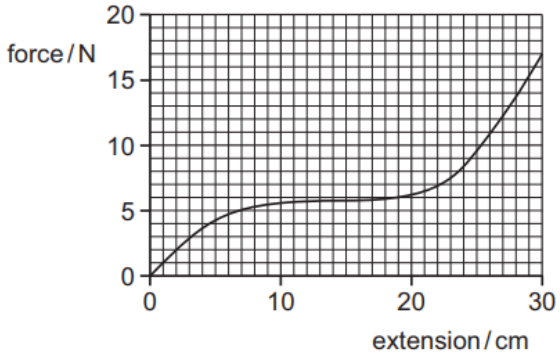
B The glass is ductile.

C The glass shows plastic deformation.

D When the cross-sectional area of the rod is doubled, the ultimate tensile stress of the rod is halved.

41. A

21 A rubber band is stretched by hanging weights on it and the force-extension graph is plotted from the results.



What is the best estimate of the strain energy stored in the rubber band when it is extended 30 cm?

A 1.8 J **B** 2.6 J **C** 5.1 J **D** 200 J

W14/13

42. A

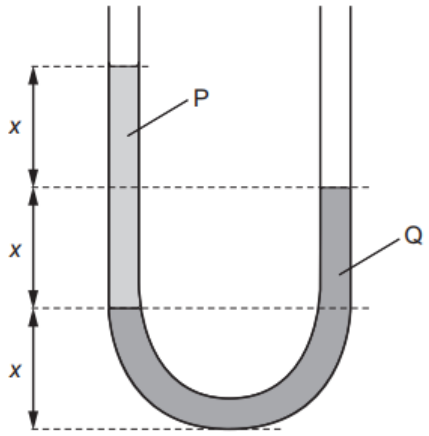
20 Atmospheric pressure at sea level has a value of 100 kPa.
The density of sea water is 1020 kg m^{-3}.

At which depth in the sea would the total pressure be 110 kPa?

A 1.0 m **B** 9.8 m **C** 10 m **D** 11 m

43. A

22 The diagram shows two liquids, labelled P and Q, which do **not** mix. The liquids are in equilibrium in an open U-tube.



What is the ratio $\frac{\text{density of P}}{\text{density of Q}}$?

A $\frac{1}{2}$ **B** $\frac{2}{3}$ **C** $\frac{3}{2}$ **D** 2

44. C

23 What is meant by the ultimate tensile stress of a material?

A the maximum force that can be applied to a bar of the material before it bends

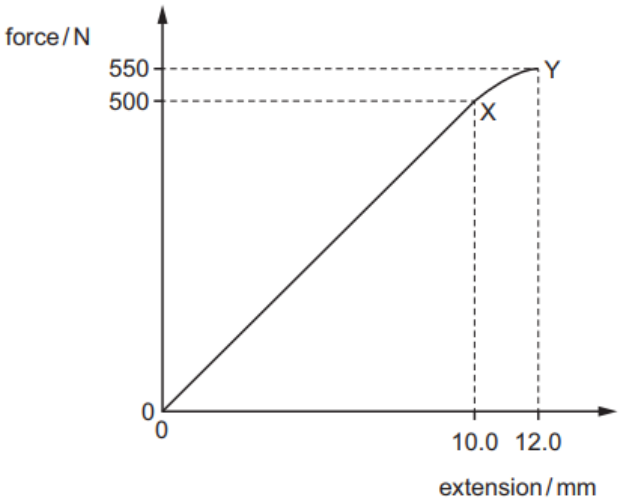
B the maximum inter-atomic force before the atomic bonds of the material break

C the maximum stretching force per unit cross-sectional area before the material breaks

D the maximum tensile force in a wire of the material before it breaks

45. B

24 The graph shows the behaviour of a sample of a metal when it is stretched until it starts to undergo plastic deformation.

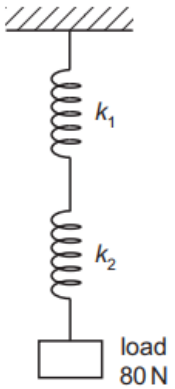


What is the total work done in stretching the sample from zero to 12.0 mm extension?
Simplify the calculation by treating the curve XY as a straight line.

A 3.30 J **B** 3.55 J **C** 3.60 J **D** 6.60 J

46. A

25 Two springs, one with spring constant $k_1 = 4\,\text{kN m}^{-1}$ and the other with spring constant $k_2 = 2\,\text{kN m}^{-1}$, are connected as shown.



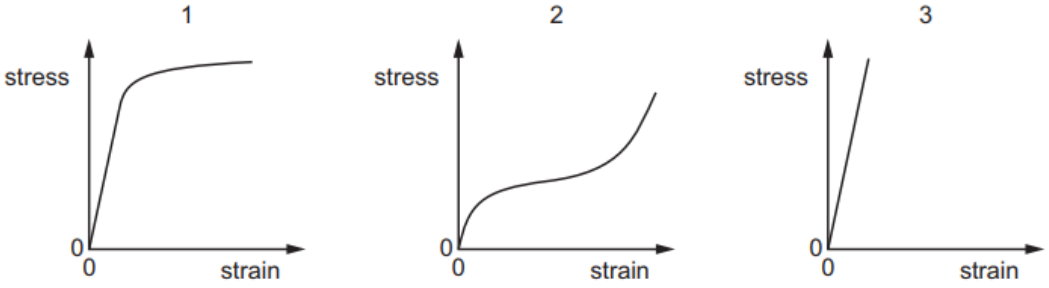
What is the total extension of the springs when supporting a load of 80 N?

A 1.3 cm **B** 4 cm **C** 6 cm **D** 60 cm

S14/11

47. B

20 The stress-strain graphs for three different materials are shown, not drawn to the same scales.



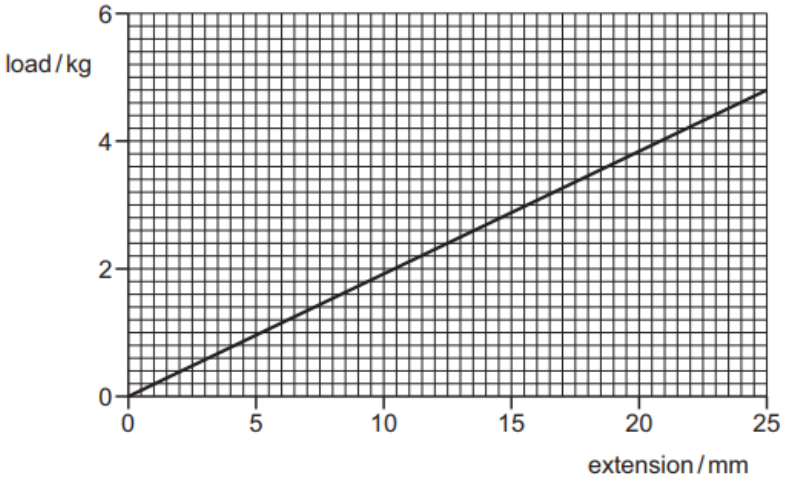
The three materials are copper, rubber and glass.

Which materials are represented by the graphs?

	1	2	3
A	copper	glass	rubber
B	copper	rubber	glass
C	glass	copper	rubber
D	glass	rubber	copper

48. C

21 The graph is a load-extension graph for a wire undergoing elastic deformation.



How much work is done on the wire to increase the extension from 10 mm to 20 mm?

A 0.028 J **B** 0.184 J **C** 0.28 J **D** 0.37 J

S14/12

49. B

18 Liquid Q has twice the density of liquid R.

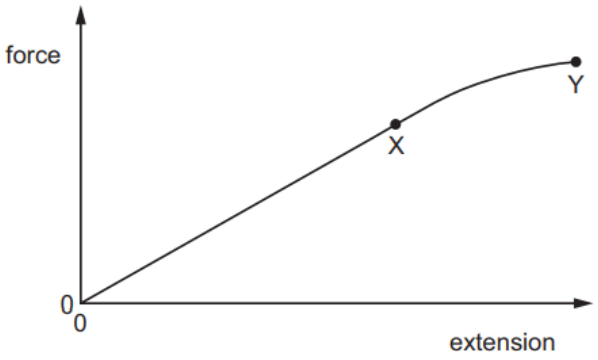
At depth *x* in liquid R, the pressure due to the liquid is 4 kPa.

At what depth in liquid Q is the pressure due to the liquid 7 kPa?

A $\frac{2x}{7}$ **B** $\frac{7x}{8}$ **C** $\frac{8x}{7}$ **D** $\frac{7x}{2}$

50. D

19 A sample of metal is subjected to a force which increases to a maximum value and then decreases back to zero. A force-extension graph for the sample is shown.



When the sample contracts it follows the same force-extension curve as when it was being stretched.

What is the behaviour of the metal between X and Y?

A both elastic and plastic

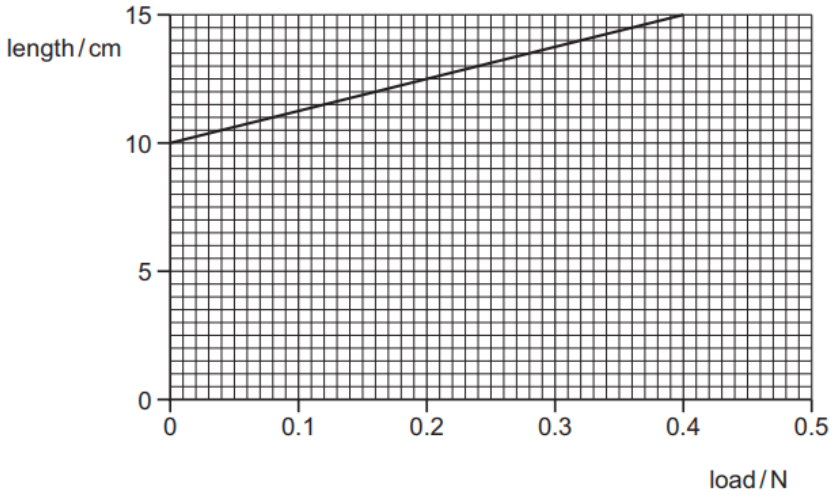
B not elastic and not plastic

C plastic but not elastic

D elastic but not plastic

51. A

20 The graph shows the length of a spring as it is stretched by an increasing load.

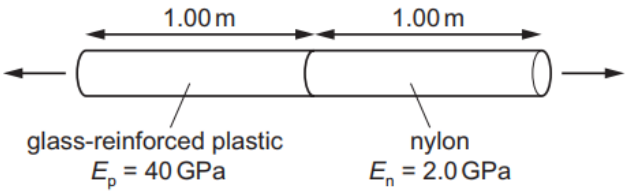


What is the spring constant?

A $8.0\,N\,m^{-1}$ **B** $2.7\,N\,m^{-1}$ **C** $0.13\,N\,m^{-1}$ **D** $0.080\,N\,m^{-1}$

52. C

21 A composite rod is made by attaching a glass-reinforced plastic rod and a nylon rod end to end, as shown.



The rods have the same cross-sectional area and each rod is 1.00 m in length. The Young modulus E_p of the plastic is 40 GPa and the Young modulus E_n of the nylon is 2.0 GPa.

The composite rod will break when its total extension reaches 3.0 mm.

What is the greatest tensile stress that can be applied to the composite rod before it breaks?

A 7.1×10^{-14} Pa

B 7.1×10^{-2} Pa

C 5.7×10^{6} Pa

D 5.7×10^{9} Pa

S14/13

53. D

22 The Mariana Trench in the Pacific Ocean has a depth of about 10 km.

Assuming that sea water is incompressible and has a density of about 1020 kg m^{-3}, what would be the approximate pressure at that depth?

A 10^5 Pa **B** 10^6 Pa **C** 10^7 Pa **D** 10^8 Pa

54. A

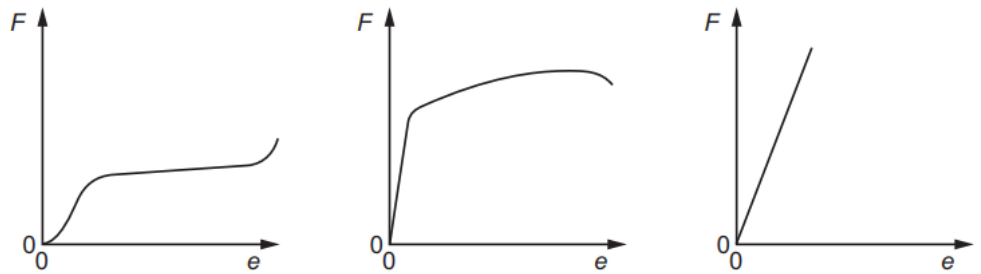
23 An elastic material with a Young modulus E is subjected to a tensile stress S. Hooke's Law is obeyed.

What is the expression for the elastic energy stored per unit volume of the material?

A $\frac{S^2}{2E}$ **B** $\frac{S^2}{E}$ **C** $\frac{E}{2S^2}$ **D** $\frac{2E}{S^2}$

55. D

24 Cylindrical samples of steel, glass and rubber are each subjected to a gradually increasing tensile force F. The extensions e are measured and graphs are plotted as shown below.



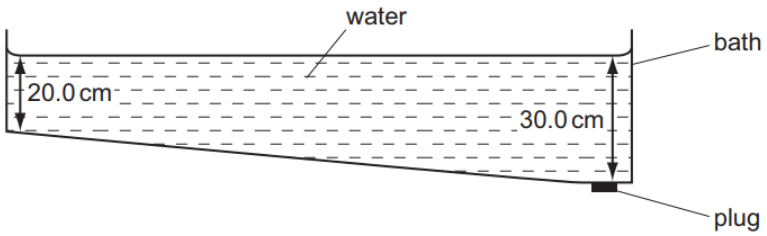
Which row correctly relates the graphs to the materials?

	steel	glass	rubber
A	X	Y	Z
B	X	Z	Y
C	Y	X	Z
D	Y	Z	X

W13/11

56. C

22 Water in a bath varies in depth from 20.0 cm at the shallow end to 30.0 cm at the end with the plug.



The density of the water is 1000 kg m^{-3}.

What is the pressure of the water acting on the plug?

A 1960 Pa **B** 2450 Pa **C** 2940 Pa **D** 4900 Pa

57. A

24 A steel spring has a spring constant of 150 N m^{-1}. When a 25 N weight is hung from the spring, it has a stretched length of 55 cm.

What was the original length of the spring?

A 0.38 m **B** 0.49 m **C** 0.61 m **D** 0.72 m

W13/13

58. B

20 Gold has a density of 19.3 g cm^{-3}.

The volume occupied by a single atom of gold may be considered to be a cube with sides of length 2.6×10^{-8} cm.

What is the mass of a gold atom?

A 3.4×10^{-25} g

B 3.4×10^{-22} g

C 1.3×10^{-17} g

D 1.3×10^{-14} g

59. C

22 A lift is supported by two steel cables each of length 20 m.

Each of the cables consists of 100 parallel steel wires, each wire of cross-sectional area 3.2×10^{-6} m^2. The Young modulus of steel is 2.1×10^{11} N m^{-2}.

Which distance does the lift move downward when a man of mass 70 kg steps into it?

A 0.010 mm **B** 0.020 mm **C** 0.10 mm **D** 0.20 mm

60. D

23 What is equal to the Young modulus of a material that is extended elastically within the limit of proportionality?

A area under the force-extension graph

B area under the stress-strain graph

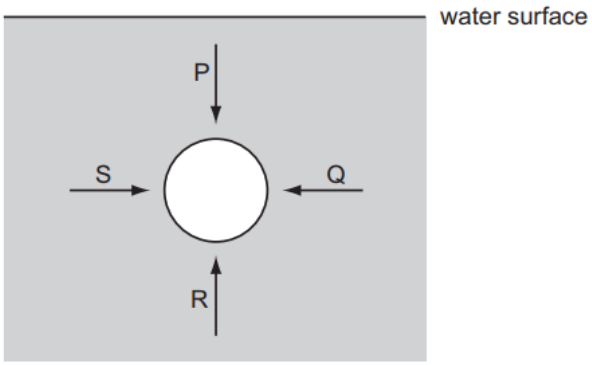
C gradient of the force-extension graph

D gradient of the stress-strain graph

S13/11

61. A

15 The diagram represents a sphere under water. P, Q, R and S are forces acting on the sphere, due to the pressure of the water.



Each force acts perpendicularly to the sphere's surface. P and R act in opposite directions vertically. Q and S act in opposite directions horizontally.

Which information about the magnitudes of the forces is correct?

A $P < R$ and $S = Q$

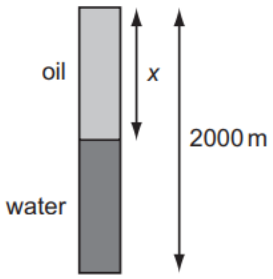
B $P > R$ and $S = Q$

C $P = R$ and $S = Q$ and $P \neq S$

D $P = R$ and $S = Q$ and $P = S$

62. D

21 A bore-hole of depth 2000 m contains both oil and water as shown. The pressure due to the liquids at the bottom of the bore-hole is 17.5 MPa. The density of the oil is 830 kg m^{-3} and the density of the water is 1000 kg m^{-3}.



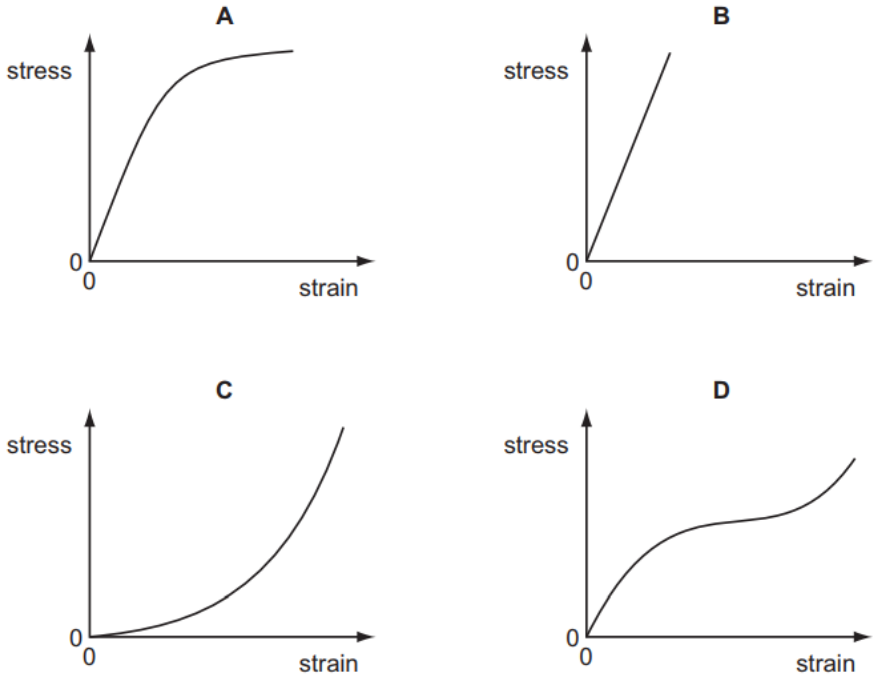
What is the depth *x* of the oil?

A 907 m **B** 1000 m **C** 1090 m **D** 1270 m

63. A

22 The stress-strain graphs for four different materials are shown below.

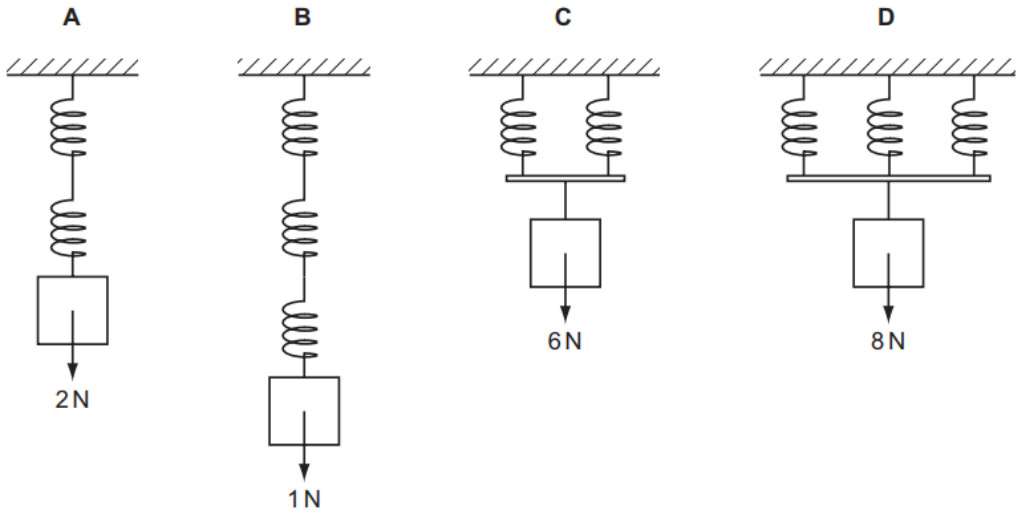
Which diagram shows the stress-strain graph for a ductile metal?



64. A

23 A number of identical springs, each having the same spring constant, are joined in four arrangements. A different load is applied to each arrangement.

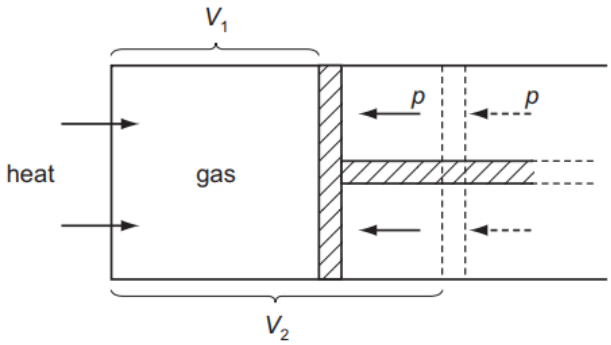
Which arrangement has the largest extension?



S13/12

65. A

18 A gas is enclosed inside a cylinder which is fitted with a frictionless piston.



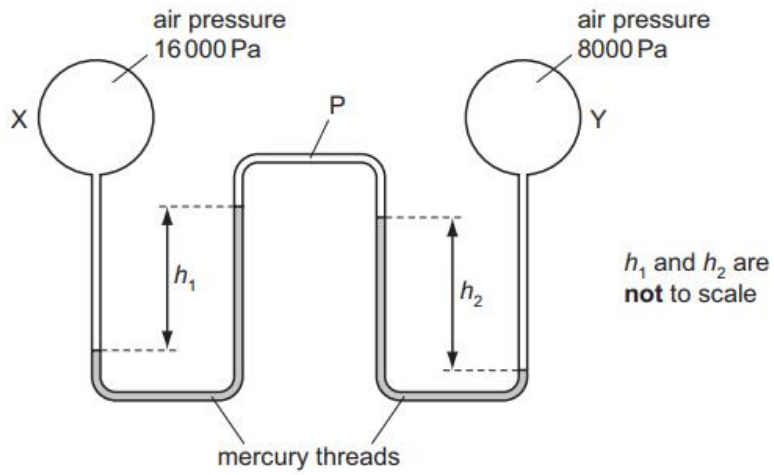
Initially, the gas has a volume V_1 and is in equilibrium with an external pressure p. The gas is then heated slowly so that it expands, pushing the piston back until the volume of the gas has increased to V_2.

How much work is done by the gas during this expansion?

A $p(V_2 - V_1)$ **B** $\frac{1}{2}p(V_2 - V_1)$ **C** $p(V_2 + V_1)$ **D** $\frac{1}{2}p(V_2 + V_1)$

66. D

20 Two bulbs X and Y containing air at different pressures are connected by a tube P which contains two mercury threads.



The density of mercury is 13 600 kg m^{-3}.

Which pair of values of h_1 and h_2 is possible?

	h_1 / cm	h_2 / cm
A	4.0	2.0
B	6.0	6.0
C	12.0	18.0
D	18.0	12.0

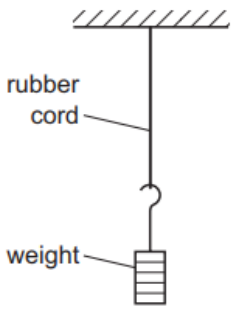
67. C

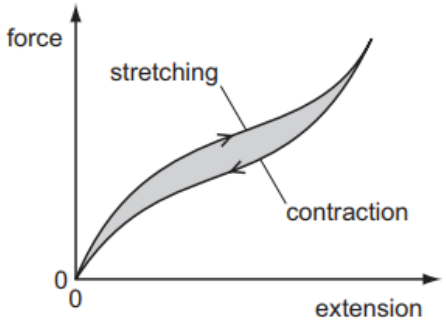
21 What is the unit of the Young modulus?

A Nm^{-1} **B** Nm **C** Nm^{-2} **D** Nm^2

68. B

22 A rubber cord hangs from a rigid support. A weight attached to its lower end is gradually increased from zero, and then gradually reduced to zero.





The force-extension curve for contraction is below the force-extension curve for stretching.

What does the shaded area between the curves represent?

A the amount of elastic energy stored in the rubber

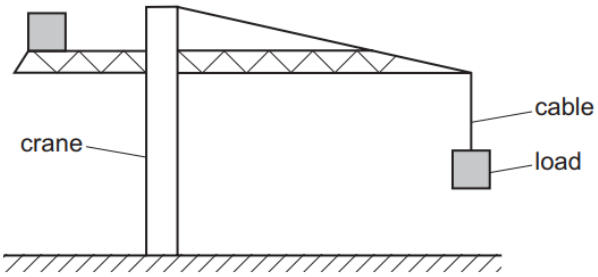
B the amount of thermal energy dissipated in the rubber

C the work done on the rubber cord during stretching

D the work done by the rubber cord during contraction

69. B

23 The diagram shows a large crane on a construction site lifting a cube-shaped load.



A model is made of the crane, its load and the cable supporting the load.

The material used for each part of the model is the same as that in the full-size crane, cable and load. The model is one tenth full-size in all linear dimensions.

What is the ratio $\frac{\text{stress in the cable on the full-size crane}}{\text{stress in the cable on the model crane}}$?

A 10^0 **B** 10^1 **C** 10^2 **D** 10^3

S13/13

70. A

18 The formula for hydrostatic pressure is $p = \rho gh$.

Which equation, or principle of physics, is used in the derivation of this formula?

A density = $\frac{\text{mass}}{\text{volume}}$

B potential energy = mgh

C atmospheric pressure decreases with height

D density increases with depth

71. A

18 The formula for hydrostatic pressure is $p = \rho gh$.

Which equation, or principle of physics, is used in the derivation of this formula?

A density = $\frac{\text{mass}}{\text{volume}}$

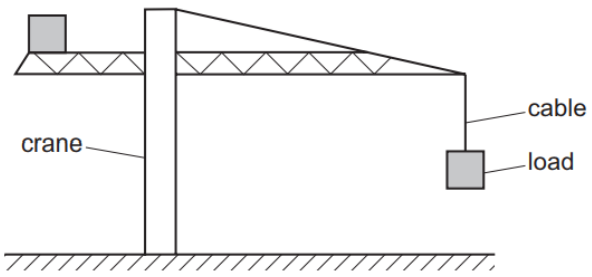
B potential energy = mgh

C atmospheric pressure decreases with height

D density increases with depth

72. C

19 The diagram shows a large crane on a construction site lifting a cube-shaped load.



A model is made of the crane, its load and the cable supporting the load.

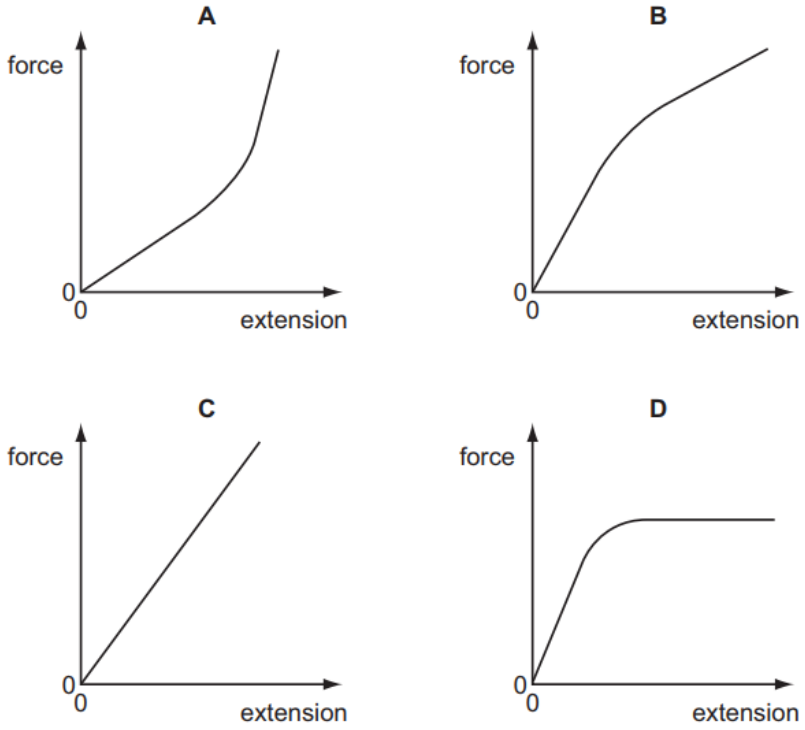
The material used for each part of the model is the same as that in the full-size crane, cable and load. The model is one tenth full-size in all linear dimensions.

What is the ratio $\frac{\text{extension of the cable on the full-size crane}}{\text{extension of the cable on the model crane}}$?

A 10^0 **B** 10^1 **C** 10^2 **D** 10^3

73. A

20 Which graph represents the force-extension relationship of a rubber band that is stretched almost to its breaking point?



74. D

21 A spring is stretched over a range within which elastic deformation occurs. Its spring constant is $3.0\,N\,cm^{-1}$.

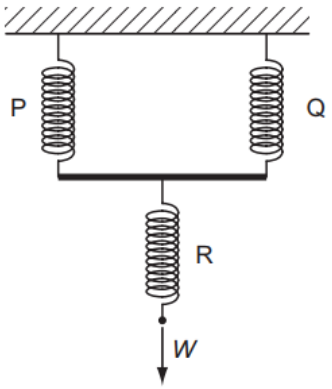
Which row, for the stated applied force, gives the correct extension and strain energy?

	force / N	extension / cm	strain energy / mJ
A	3.0	1.0	1.5
B	6.0	2.0	120
C	12.0	3.0	180
D	24.0	8.0	960

W12/11

75. A

23 Three springs are arranged vertically as shown.



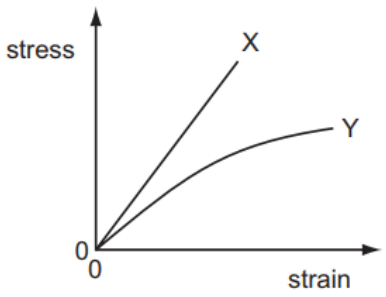
Springs P and Q are identical and have spring constant k. Spring R has spring constant $3k$.

What is the increase in the overall length of the arrangement when a force W is applied as shown?

A $\frac{5}{6}\frac{W}{k}$ **B** $\frac{4}{3}\frac{W}{k}$ **C** $\frac{7}{2}kW$ **D** $4kW$

76. B

24 The diagram shows the stress-strain graph for two wires X and Y of different materials up to their breaking points. Both wires have the same initial dimensions.



Which statement is **not** correct?

A Material X extends elastically.

B Material X extends more than material Y when loaded with the same force.

C Material X has a larger ultimate tensile stress.

D Material X is brittle.

77. B

25 A steel wire and a brass wire are joined end to end and are hung vertically with the steel wire attached to a point on the ceiling. The steel wire is twice as long as the brass wire and has half the diameter.

A large mass is hung from the end of the brass wire so that both wires are stretched elastically.

The Young modulus for steel is 2.0×10^{11} Pa and for brass is 1.0×10^{11} Pa.

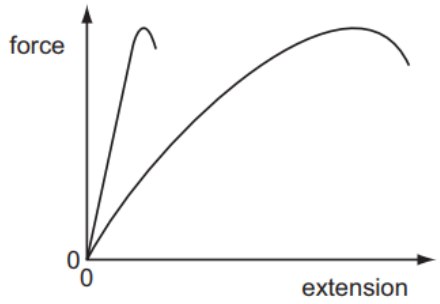
What is the ratio of the extension of the steel to the extension of the brass?

A 2 **B** 4 **C** 8 **D** 16

W12/12

78. D

26 The diagram shows the force-extension graphs for two materials, of the same dimensions, loaded to fracture.



What describes the behaviour of the materials?

A Both materials are brittle.

B Both materials obey Hooke's law.

C Both materials are plastic.

D Both materials have the same ultimate tensile stress.

79. B

27 Two wires, X and Y, are made from different metals and have different dimensions. The Young modulus of wire X is twice that of wire Y. The diameter of wire X is half that of wire Y.

Both wires are extended with equal strain and obey Hooke's law.

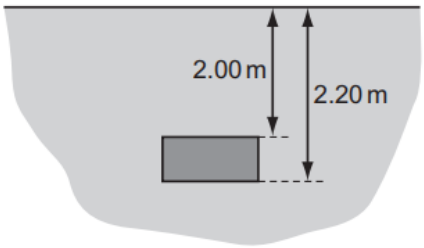
What is the ratio $\frac{\text{tension in wire X}}{\text{tension in wire Y}}$?

A $\frac{1}{8}$ **B** $\frac{1}{2}$ **C** 1 **D** 8

W12/13

80. B

23 The diagram shows a rectangular block of mass 8.2 kg immersed in sea water of density $1.10 \times 10^3\,kg\,m^{-3}$.



What is the difference in pressure between the top and bottom surfaces of the block?

A $2.2 \times 10^2\,Pa$

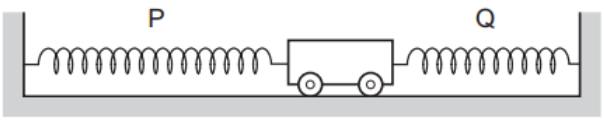
B $2.2 \times 10^3\,Pa$

C $1.8 \times 10^4\,Pa$

D $2.3 \times 10^4\,Pa$

81. B

24 A trolley is held at rest between two steel springs.



Each spring has an unstretched length of 0.10 m.

Spring P has spring constant $60\,N\,m^{-1}$.
Spring Q has spring constant $120\,N\,m^{-1}$.

Spring P has an extension of 0.40 m.

What is the extension of spring Q?

A 0.10 m **B** 0.20 m **C** 0.30 m **D** 0.80 m

82. C

25 A lift is supported by two steel cables, each of length 10 m and diameter 0.5 cm.

The lift drops 1 mm when a man of mass 80 kg steps into the lift.

What is the best estimate of the value of the Young modulus of the steel?

A $2 \times 10^{10}\,N\,m^{-2}$

B $4 \times 10^{10}\,N\,m^{-2}$

C $2 \times 10^{11}\,N\,m^{-2}$

D $4 \times 10^{11}\,N\,m^{-2}$

S12/11

83. C

23 Which property of a metal wire depends on its Young modulus?

A ductility

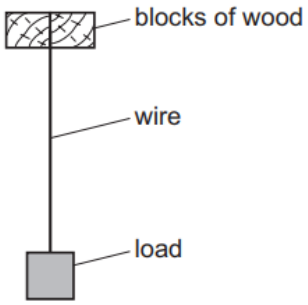
B elastic limit

C spring constant

D ultimate tensile stress

84. B

24 The diagram shows a wire of diameter *D* and length *L* that is firmly clamped at one end between two blocks of wood. A load is applied to the wire which causes it to extend by an amount *x*.



By how much would a wire of the same material, but of diameter 2*D* and length 3*L*, extend when the same load is applied?

A $\frac{2}{3}x$ **B** $\frac{3}{4}x$ **C** $\frac{4}{3}x$ **D** $\frac{3}{2}x$

85. B

25 What is represented by the gradient of a graph of force (vertical axis) against extension (horizontal axis)?

A elastic limit

B spring constant

C stress

D Young modulus

S12/12

86. D

20 A mass of gas enclosed in a cylinder by a piston is heated gently. At the same time, the piston is moved so that the pressure remains constant.

As a result of this, what will **not** occur?

A The average velocity of the molecules will increase.

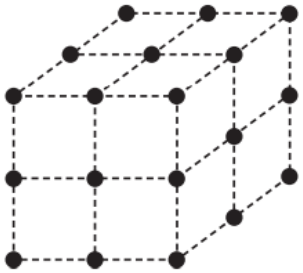
B The mean separation of the molecules will increase.

C The molecules will travel greater distances between collisions.

D The number of collisions per second of the molecules on the piston will increase.

87. C

22 The diagram shows the arrangement of atoms in a particular crystal.



Each atom is at the corner of a cube.

The mass of each atom is 3.5×10^{-25} kg. The density of the crystal is 9.2×10^{3} kg m^{-3}.

What is the shortest distance between the centres of two adjacent atoms?

A 3.8×10^{-29} m

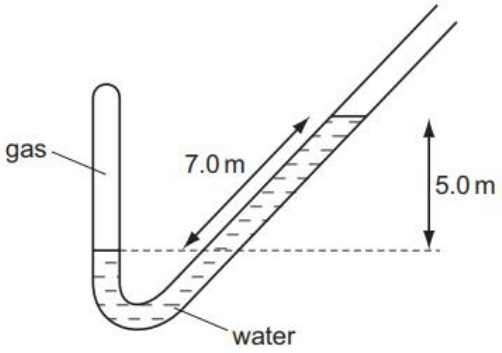
B 6.2×10^{-15} m

C 3.4×10^{-10} m

D 3.0×10^{-9} m

88. C

23 A pipe is closed at one end and contains gas, trapped by a column of water.



The atmospheric pressure is 1.0×10^5 Pa. The density of water is 1000 kg m^{-3}.

What is the pressure of the gas? (Use g = 10 m s^{-2}.)

A 0.3×10^5 Pa

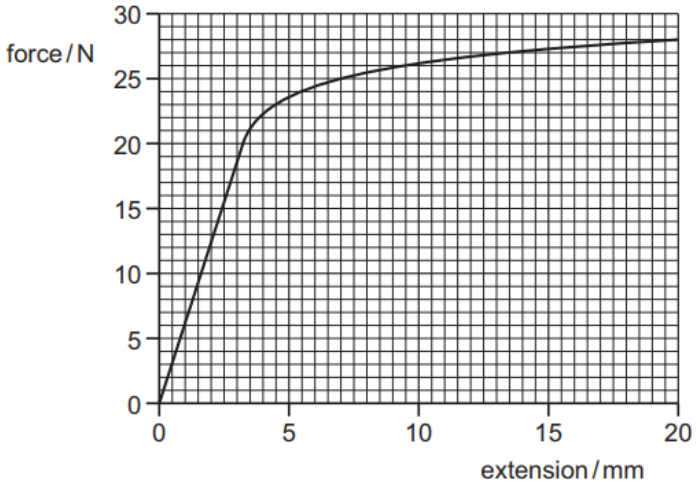
B 0.5×10^5 Pa

C 1.5×10^5 Pa

D 1.7×10^5 Pa

89. B

24 The graph is a force-extension graph for a wire that is being stretched.



How much work needs to be done by the tensile force, to two significant figures, to cause an extension of 7.0 mm?

A 0.088 J **B** 0.12 J **C** 0.53 J **D** 120 J

90. C

25 A wire stretches 8 mm under a load of 60 N.

A second wire of the same material, with half the diameter and a quarter of the original length of the first wire, is stretched by the same load.

Assuming that Hooke's law is obeyed, what is the extension of this wire?

A 1 mm **B** 4 mm **C** 8 mm **D** 16 mm

W11/11

91. C

21 Why does the pressure increase when a sealed container of gas is heated?

A The gas molecules collide more often with each other.

B The gas molecules expand when they are heated.

C The gas molecules travel faster and hit the walls of the container more often.

D There are more gas molecules present to collide with the walls of the container.

92. B

23 The Young modulus of steel is determined using a length of steel wire and is found to have the value E.

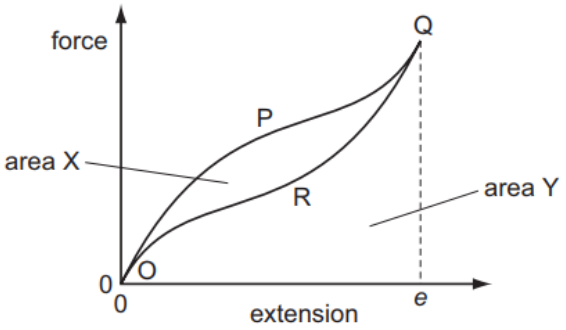
Another experiment is carried out using a wire of the same steel, but of half the length and half the diameter.

What value is obtained for the Young modulus in the second experiment?

A $\frac{1}{2}E$ **B** E **C** $2E$ **D** $4E$

93. B

24 A rubber band is stretched and then relaxed to its original length. The diagram shows the force-extension graph for this process.



As the force is increased, the curve follows the path OPQ to extension *e*. As the force is reduced, the curve follows the path QRO to return to zero extension.

The area labelled X is between the curves OPQ and QRO. The area labelled Y is bounded by the curve QRO and the horizontal axis.

Which statement about the process is correct?

A Area X is the energy which heats the band as it is stretched to *e*.

B (Area X + area Y) is the minimum energy required to stretch the band to *e*.

C Area X is the elastic potential energy stored in the band when it is stretched to *e*.

D (Area Y – area X) is the net work done on the band during the process.

94. C

25 When describing the behaviour of a spring, the spring constant is used.

Different loads are used to extend the spring by different amounts.

To find the spring constant, which quantities are required?

A the elastic limit and the loads

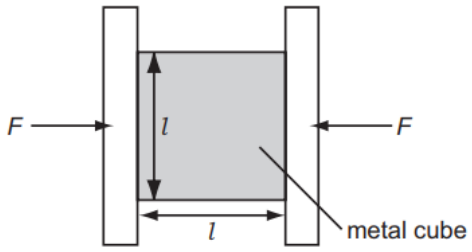
B the elastic limit, extensions and the length of the spring

C the loads and the extensions of the spring

D the loads and the length of the spring

95. B

26 A metal cube of side l is placed in a vice and compressed elastically by two opposing forces F.



How will Δl, the amount of compression, relate to l?

A $\Delta l \propto \frac{1}{l^2}$ **B** $\Delta l \propto \frac{1}{l}$ **C** $\Delta l \propto l$ **D** $\Delta l \propto l^2$

W11/12

96. A

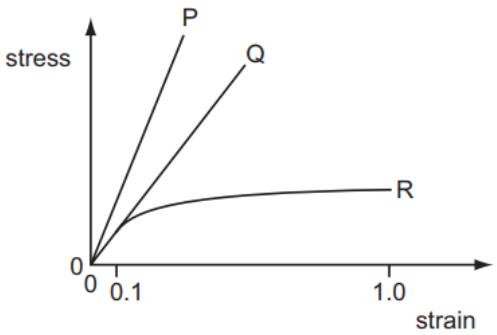
20 A horizontal plate of area 0.036 m^2 is beneath the surface of a liquid of density 930 kg m^{-3}. The force on the plate due to the pressure of the liquid is 290 N.

What is the depth of the plate beneath the surface of the liquid?

A 0.88 m **B** 1.13 m **C** 8.7 m **D** 9.1 m

97. C

21 The graph shows the relationship between stress and strain for three wires of the same linear dimensions but made from different materials.



Which statements are correct?

1 The extension of P is approximately twice that of Q for the same stress.

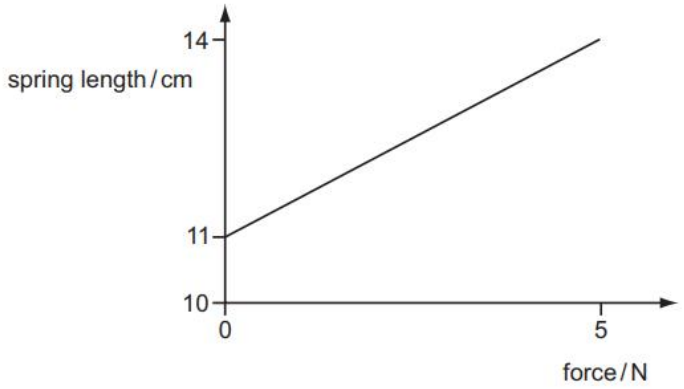
2 The ratio of the Young modulus for P to that of Q is approximately two.

3 For strain less than 0.1, R obeys Hooke's law.

A 1, 2 and 3 **B** 1 and 3 only **C** 2 and 3 only **D** 2 only

98. A

22 The graph shows the effect of applying a force of up to 5 N to a spring.



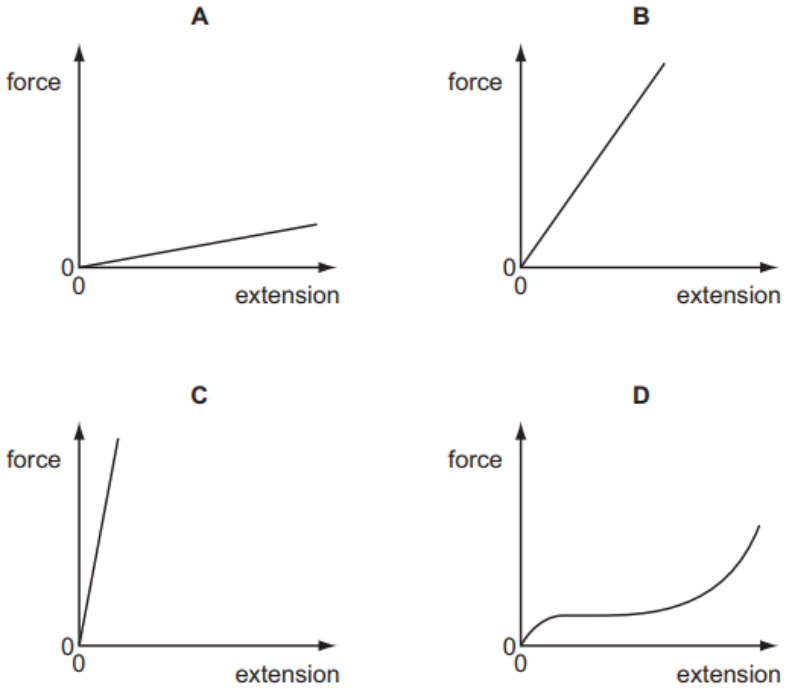
What is the total increase in length produced by a 7 N force, assuming the spring obeys Hooke's law?

A 4.2 cm **B** 5.6 cm **C** 15.2 cm **D** 19.6 cm

99. B

23 The following force-extension graphs are drawn to the same scale.

Which graph represents the deformed object with the greatest amount of elastic potential energy?



100. D

24 A wave that can be polarised must be

A longitudinal.

B progressive.

C stationary.

D transverse.

S11/11

101. D

19 1.5 m^3 of water is mixed with 0.50 m^3 of alcohol. The density of water is 1000 kg m^{-3} and the density of alcohol is 800 kg m^{-3}.

What is the density of the mixture with volume 2.0 m^3?

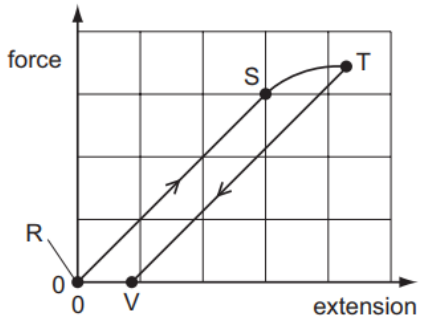
A 850 kg m^{-3} **B** 900 kg m^{-3} **C** 940 kg m^{-3} **D** 950 kg m^{-3}

102. B

20 A long, thin metal wire is suspended from a fixed support and hangs vertically. Masses are suspended from its lower end.

The load on the lower end is increased from zero and then decreased again back to zero.

The diagram shows the force-extension graph produced.



Where on the graph would the elastic limit be found?

A anywhere between point R and point S

B beyond point S but before point T

C exactly at point S

D exactly at point T

103. A

21 The Young modulus E can be determined from measurements made when a wire is stretched.

Which quantities would be measured in order to determine E?

A	mass of stretching load	original length of wire	diameter of wire	extension of wire
B	mass of stretching load	new length of wire	cross-sectional area of wire	diameter of wire
C	mass of wire	original length of wire	cross-sectional area of wire	new length of wire
D	mass of wire	new length of wire	diameter of wire	extension of wire

S11/12

104. C

21 Two solid substances P and Q have atoms of mass M_P and M_Q respectively. They have n_P and n_Q atoms per unit volume.

The density of P is greater than the density of Q.

What **must** be correct?

A $M_P > M_Q$

B $n_P > n_Q$

C $M_P n_P > M_Q n_Q$

D $\frac{M_P}{n_P} > \frac{M_Q}{n_Q}$

105. C

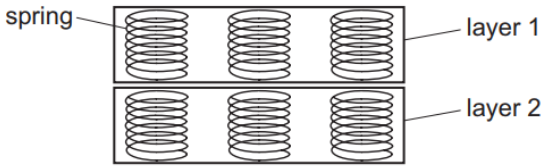
23 The behaviour of a wire under tensile stress may be described in terms of the Young modulus E of the material of the wire and of the force per unit extension k of the wire.

For a wire of length L and cross-sectional area A, what is the relation between E and k?

A $E = \frac{A}{kL}$ **B** $E = \frac{kA}{L}$ **C** $E = \frac{kL}{A}$ **D** $E = \frac{L}{kA}$

106. B

24 The diagram shows the structure of part of a mattress.



The manufacturer wants to design a softer mattress (one which will compress more for the same load).

Which change will **not** have the desired effect?

A using more layers of springs

B using more springs per unit area

C using springs with a smaller spring constant

D using springs made from wire with a smaller Young modulus

W10/11

107. D

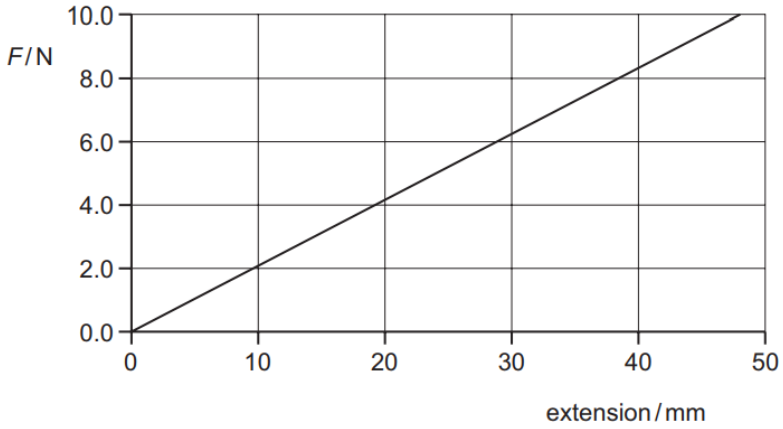
19 The Mariana Trench in the Pacific Ocean has a depth of about 10 km.

Assuming that sea water is incompressible and has a density of about 1020 kg m^{-3}, what would be the approximate pressure at that depth?

A 10^5 Pa **B** 10^6 Pa **C** 10^7 Pa **D** 10^8 Pa

108. A

21 The graph shows how force depends on extension for a certain spring.



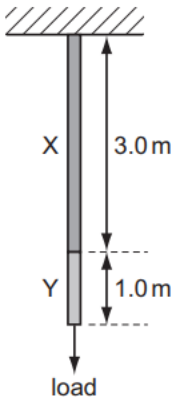
What is the energy stored in the spring when the extension is 30 mm?

A 0.095 J **B** 0.19 J **C** 0.25 J **D** 0.95 J

109. B

22 A wire consists of a 3.0 m length of metal X joined to a 1.0 m length of metal Y.

The cross-sectional area of the wire is uniform.



A load hung from the wire causes metal X to stretch by 1.5 mm and metal Y to stretch by 1.0 mm.

The same load is then hung from a second wire of the same cross-section, consisting of 1.0 m of metal X and 3.0 m of metal Y.

What is the total extension of this second wire?

A 2.5 mm **B** 3.5 mm **C** 4.8 mm **D** 5.0 mm

W10/12

110. D

20 The pressure at sea level is approximately 100 000 Pa. The density of sea water is 1030 kg m^{-3}.

What is the approximate pressure 80 m below the surface of the sea?

A 100 000 Pa **B** 180 000 Pa **C** 800 000 Pa **D** 900 000 Pa

111. A

21 Two wires P and Q are made from the same material.

Wire P is initially twice the diameter and twice the length of wire Q. The same force, applied to each wire, causes the wires to extend elastically.

What is the ratio of the extension in P to that in Q?

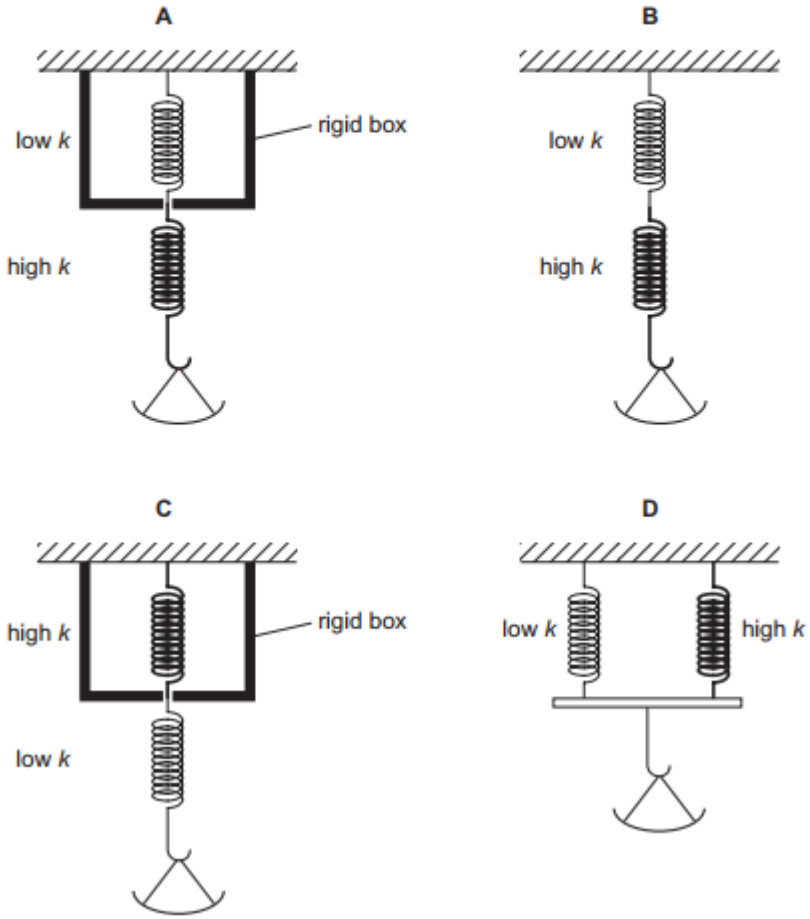
A $\frac{1}{2}$ **B** 1 **C** 2 **D** 4

112. A

22 To determine the mass of food in a pan, a scale is used that has high sensitivity for small masses but low sensitivity for large masses.

To do this, two springs are used, each with a different spring constant *k*. One of the springs has a low spring constant and the other has a high spring constant.

Which arrangement of springs would be suitable?



S10/11

113. A

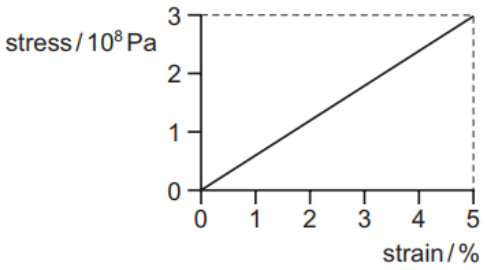
17 Atmospheric pressure at sea level has a value of 100 kPa.
The density of sea water is 1020 kg m^{-3}.

At what depth in the sea would the total pressure be 110 kPa?

A 1.0 m **B** 9.8 m **C** 10 m **D** 11 m

114. D

19 In stress-strain experiments on metal wires, the stress axis is often marked in units of 10^8 Pa and the strain axis is marked as a percentage. This is shown for a particular wire in the diagram.

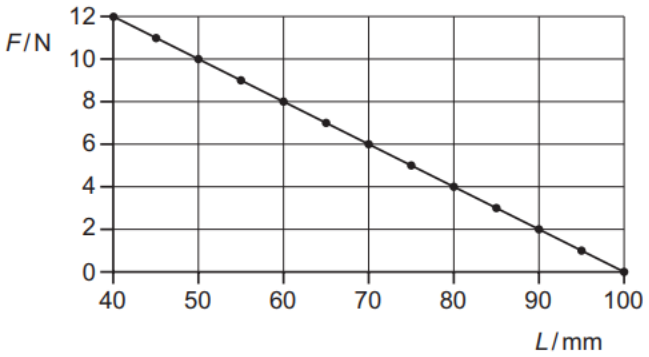


What is the value of the Young modulus for the material of the wire?

A 6.0×10^7 Pa **B** 7.5×10^8 Pa **C** 1.5×10^9 Pa **D** 6.0×10^9 Pa

115. D

20 A spring is compressed by a force. The graph shows the compressing force F plotted against the length L of the spring.

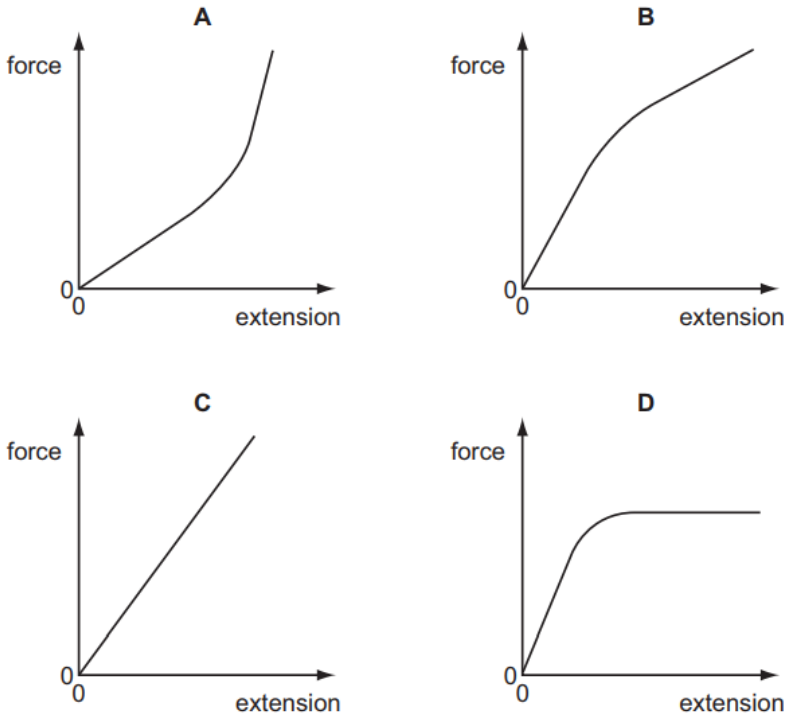


What is the spring constant of this spring?

A $0.2\,N\,m^{-1}$ **B** $5\,N\,m^{-1}$ **C** $100\,N\,m^{-1}$ **D** $200\,N\,m^{-1}$

116. A

21 Which graph represents the force-extension relationship of a rubber band that is stretched almost to its breaking point?



New Topic 7:

7. WAVES

S16/11

1. A

22 Two sound waves have frequencies of 250 Hz and 300 Hz. The speed of sound is 340 m s^{-1}.

What is the difference between the wavelengths of the two waves?

A 0.23 m **B** 1.1 m **C** 1.4 m **D** 6.8 m

2. B

23 Which electromagnetic waves have the wavelengths of 10^{-2} m, 10^{-5} m, 10^{-10} m and 10^{-13} m?

	10^{-2} m	10^{-5} m	10^{-10} m	10^{-13} m
A	infra-red	microwaves	visible light	X-rays
B	microwaves	infra-red	X-rays	gamma rays
C	microwaves	visible light	ultraviolet	gamma rays
D	radio waves	microwaves	ultraviolet	X-rays

3. A

24 Which statement concerning a stationary wave is correct?

A All the particles between two successive nodes oscillate in phase.

B The amplitude of the stationary wave is equal to the amplitude of one of the waves creating it.

C The wavelength of the stationary wave is equal to the separation of two adjacent nodes.

D There is no displacement of a particle at an antinode at any time.

4. D

25 Continuous water waves are diffracted through a gap in a barrier in a ripple tank.

Which change will cause the diffraction of the waves to increase?

A increasing the frequency of the waves

B increasing the width of the gap

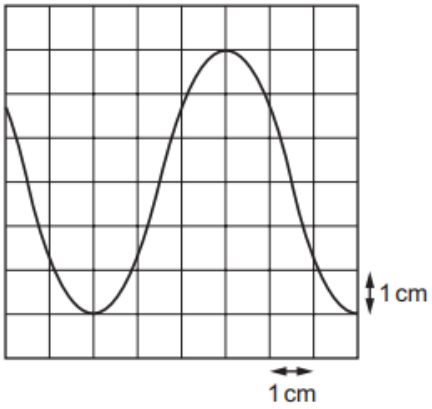
C reducing the wavelength of the waves

D reducing the width of the gap

S16/12

5. A

22 A microphone connected to the Y-plates of a cathode-ray oscilloscope (c.r.o.) is placed in front of a loudspeaker. The trace on the screen of the c.r.o. is shown.



The time-base setting is 0.5 ms cm^{-1} and the Y-plate sensitivity is 0.2 mV cm^{-1}.

What is the frequency of the sound from the loudspeaker and what is the amplitude of the trace on the c.r.o.?

	frequency /Hz	amplitude /mV
A	330	0.6
B	330	1.2
C	670	0.6
D	670	1.2

6. B

23 A source of sound of frequency 1000 Hz moves away from a stationary observer at a speed of 30.0 m s^{-1}. The speed of sound is 330 m s^{-1}.

What is the frequency of the sound heard by the observer?

A 909 Hz **B** 917 Hz **C** 1090 Hz **D** 1100 Hz

7. C

24 Each of the principal radiations of the electromagnetic spectrum has a range of wavelengths.

Which wavelength is correctly linked to its radiation?

	wavelength / m	radiation
A	10^{-9}	gamma ray
B	10^{-5}	microwave
C	10^{-8}	ultraviolet
D	10^{-14}	X-ray

8. C

25 A stationary wave is set up on a stretched string.

The diagram shows the string at two instants of time when it has maximum displacement.

The oscillations of point P on the string have amplitude *A*.

What is the distance moved by P from the position shown in the diagram after half a time period of the wave?

A 0 **B** *A* **C** 2*A* **D** 4*A*

9. D

26 Which statement is an example of the diffraction of light?

A the addition of the amplitudes of two beams of light which are in phase

B the change in direction of a beam of light when passing from air into water

C the separation of a beam of white light into a spectrum of colours using a prism

D the spreading of a beam of light as it passes through a small hole

S16/13

10. B

23 A beam of red laser light has length 1.0 m.

What is the order of magnitude of the number of wavelengths of the red light in 1.0 m?

A 10^4 **B** 10^6 **C** 10^8 **D** 10^{10}

11. B

24 When a car travelling with constant velocity passes a stationary observer, the observer hears a change in the frequency of the sound emitted by the car.

Which statement is correct?

A The change in frequency is greater as the car moves away than as it approaches.

B The greater the speed of the car, the greater the change in observed frequency.

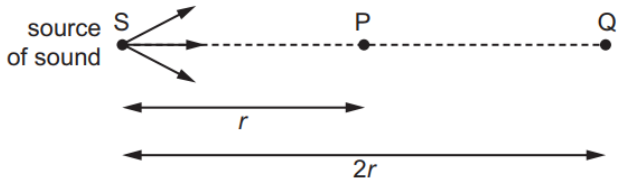
C The observed frequency is lower as the car moves towards the observer and higher as the car moves away from the observer.

D The volume of the sound heard by the observer does not change as the car approaches.

12. D

25 The intensity I of sound is inversely proportional to the square of the distance x from the source of the sound. This can be represented as

$$I \propto \frac{1}{x^2}.$$



Air molecules at point P, a distance r from the source S, oscillate with amplitude 8.0 μm.

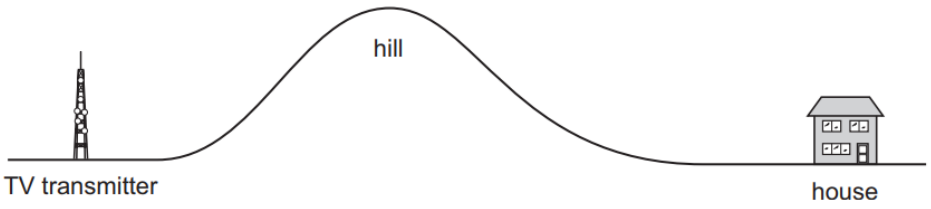
Point Q is situated a distance $2r$ from S.

What is the amplitude of oscillation of air molecules at Q?

A 1.4 μm **B** 2.0 μm **C** 2.8 μm **D** 4.0 μm

13. B

26 A hill separates a television (TV) transmitter from a house. The transmitter cannot be seen from the house. However, the house has good TV reception.



By which wave effect at the hill could the TV signal reach the house?

A coherence

B diffraction

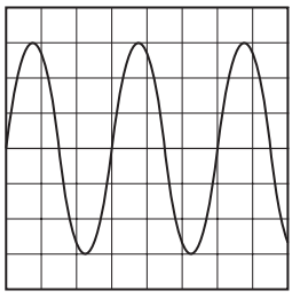
C interference

D reflection

W15/11

14. C

24 A sound wave is displayed on the screen of a cathode-ray oscilloscope, as shown.



The time-base setting is 0.50 ms per division.

What is the frequency of the sound wave?

A 250 Hz **B** 500 Hz **C** 670 Hz **D** 1300 Hz

15. A

25 Part of a car was damaged by heating when, on a sunny day, the car was left in front of a curved mirrored building which focussed reflected sunlight onto the car.

Which statement about sunlight correctly explains this observation?

A Sunlight contains infra-red radiation.

B Sunlight contains ultraviolet radiation.

C Sunlight is a longitudinal progressive wave which carries energy.

D Sunlight is a transverse standing wave which carries energy.

16. D

27 Ships have been damaged by water waves with large amplitudes. These waves could have been formed by adding the displacements of smaller waves.

Which term describes this phenomenon?

A diffraction

B polarisation

C refraction

D superposition

W15/12

17. D

25 Which of the following wave motions may be used to demonstrate the phenomenon of polarisation?

A a sound wave from a thunderclap

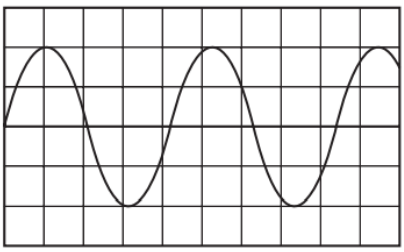
B a surface wave in a water ripple tank

C a stationary wave in an organ pipe

D a stationary wave on a stretched wire

18. D

26 The diagram shows the screen of a cathode-ray oscilloscope (c.r.o.) displaying a wave.



The time-base of the c.r.o. is set at 10 ms / div.

What is the frequency of the wave?

A 0.24 Hz **B** 4.2 Hz **C** 12 Hz **D** 24 Hz

19. A

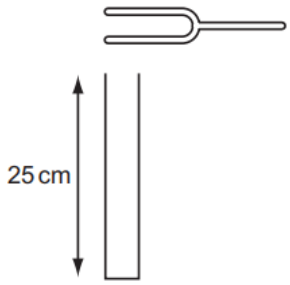
27 P is a source emitting infra-red radiation and Q is a source emitting ultra-violet radiation. The figures in the table are suggested values for the wavelengths emitted by P and Q.

Which row is correct?

	wavelength emitted by P / m	wavelength emitted by Q / m
A	5×10^{-5}	5×10^{-8}
B	5×10^{-5}	5×10^{-10}
C	5×10^{-7}	5×10^{-8}
D	5×10^{-7}	5×10^{-10}

20. D

28 The diagram shows a tuning fork above a tube of air of length 25 cm.



A stationary wave is set up in the tube with the same frequency as the tuning fork. The lower end of the tube is sealed. This is the minimum length of tube with the lower end sealed that creates a stationary wave.

Which other lengths of tubes, sealed at their lower end, will also create a stationary wave?

A 37.5 cm and 50 cm

B 50 cm and 75 cm

C 75 cm and 100 cm

D 75 cm and 125 cm

21. C

30 To produce a stationary wave, two waves must travel in opposite directions through the same space.

Which statement about the properties of the two waves must also be true?

A The waves must have equal frequency, but a different speed and wavelength.

B The waves must have equal speed, but a different wavelength and frequency.

C The waves must have equal speed, frequency and wavelength.

D The waves must have equal wavelength, but a different speed and frequency.

W15/13

22. C

22 When all the other features of a wave are constant, which relationship is correct?

A Amplitude is directly proportional to velocity.

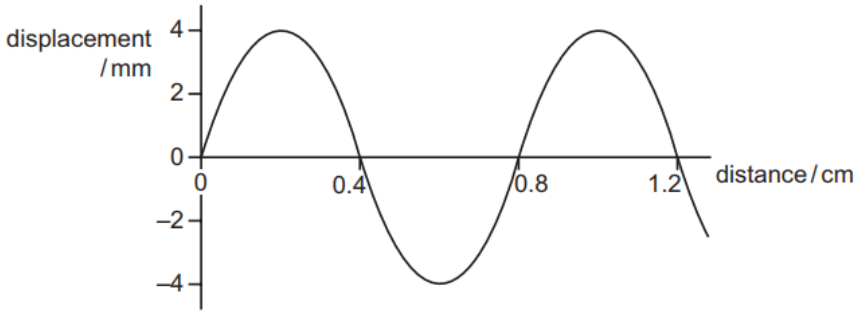
B Intensity is directly proportional to amplitude.

C Velocity is directly proportional to wavelength.

D Wavelength is directly proportional to frequency.

23. C

23 A vibrating rod makes a water wave in a ripple tank. The graph shows the displacement of the wave at one instant as it travels away from the rod. The wave speed is 2.0 cm s^{-1}.



What is the frequency of the wave?

A 0.8 Hz **B** 1.6 Hz **C** 2.5 Hz **D** 5.0 Hz

24. D

24 Polarisation is a phenomenon associated with a certain type of wave.

Which condition **must** be fulfilled if a wave is to be polarised?

A It must be a light wave.

B It must be a longitudinal wave.

C It must be a radio wave.

D It must be a transverse wave.

25. B

26 The following statements describe the diffraction of waves passing through a narrow slit.

Which statement is **not** correct?

A Both transverse and longitudinal waves can be diffracted.

B Diffraction can only be seen with light when the light is monochromatic.

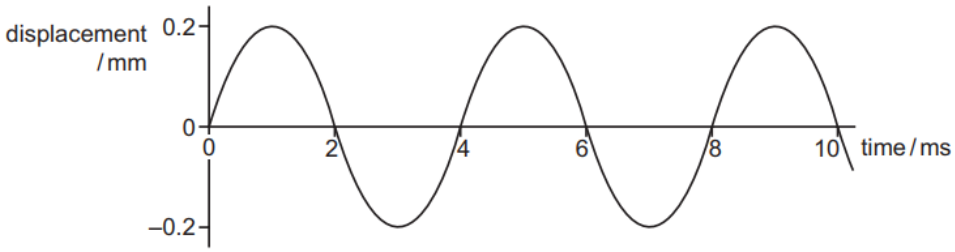
C Red light diffracts through a greater angle than blue light.

D The angle of diffraction increases when the width of the slit decreases.

S15/11

26. D

24 A sound wave moves with a speed of $320\,m\,s^{-1}$ through air. The variation with time of the displacement of an air particle due to this wave is shown in the graph.



Which statement about the sound wave is correct?

A The frequency of the wave is 500 Hz.

B The graph shows that sound is a transverse wave.

C The intensity of the wave will be doubled if its amplitude is increased to 0.4 mm.

D The wavelength of the sound wave is 1.28 m.

27. B

25 A wave of frequency 15 Hz travels at $24\,m\,s^{-1}$ through a medium.

What is the phase difference between two points 2 m apart?

A There is no phase difference.

B They are out of phase by a quarter of a cycle.

C They are out of phase by half a cycle.

D They are out of phase by 0.8 of a cycle.

28. D

26 A wave of amplitude *a* has an intensity of $3.0\,W\,m^{-2}$.

What is the intensity of a wave of the same frequency that has an amplitude $2a$?

A $4.2\,W\,m^{-2}$ **B** $6.0\,W\,m^{-2}$ **C** $9.0\,W\,m^{-2}$ **D** $12\,W\,m^{-2}$

29. A

27 An electromagnetic wave has a wavelength that is numerically of the same order of magnitude as the diameter of a nucleus.

In which region of the electromagnetic spectrum does the wave occur?

A gamma ray

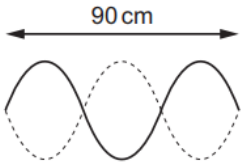
B X-ray

C visible light

D infra-red

30. B

28 The diagram shows a stationary wave on a string at two instants of maximum vertical displacement.



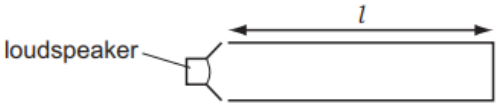
The frequency of the wave is 12 Hz.

What is the speed of the wave?

A $3.6\,m\,s^{-1}$ **B** $7.2\,m\,s^{-1}$ **C** $360\,m\,s^{-1}$ **D** $720\,m\,s^{-1}$

31. D

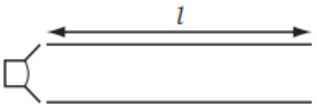
29 A loudspeaker emitting sound of frequency *f* is placed at the open end of a pipe of length *l* which is closed at the other end. A standing wave is set up in the pipe.



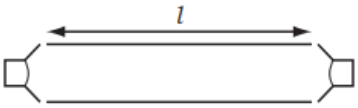
A series of pipes are then set up with either one or two loudspeakers of frequency *f*. The pairs of loudspeakers vibrate in phase with each other.

Which pipe contains a standing wave?

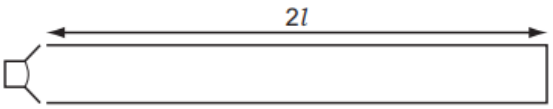
A



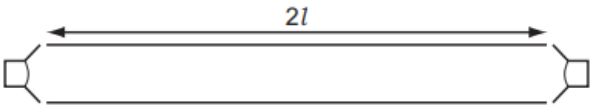
B



C



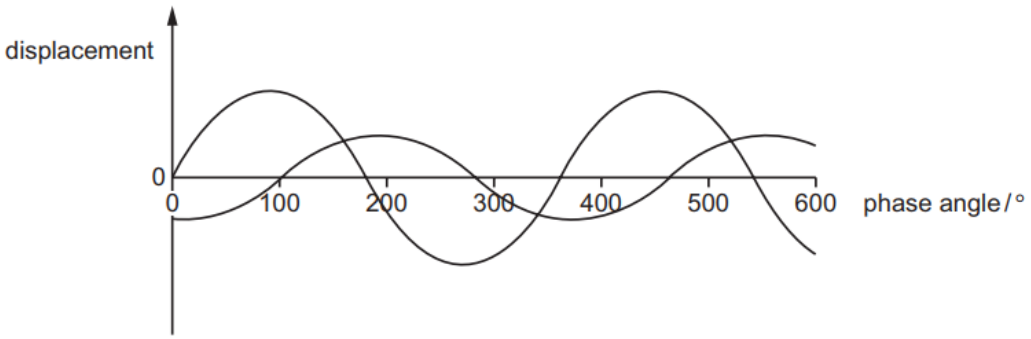
D



S15/12

32. C

24 Two light waves of the same frequency are represented by the diagram.



What could be the phase difference between the two waves?

A 150° **B** 220° **C** 260° **D** 330°

33. B

25 A sound wave has a speed of 330 m s^{-1} and a frequency of 50 Hz.

What is a possible distance between two points on the wave that have a phase difference of 60°?

A 0.03 m **B** 1.1 m **C** 2.2 m **D** 6.6 m

34. C

26 What is **not** an **essential** condition for an observable interference pattern to occur between the waves from two sources?

A The frequencies of the two sources must be equal.

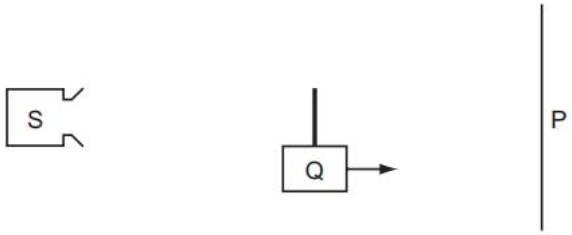
B The sources must be coherent.

C The sources must emit waves of equal amplitude.

D The waves from the two sources must overlap.

35. B

27 Source S emits microwaves with a constant amplitude. The microwaves hit a metal screen P and are reflected. A stationary wave is formed between S and P. The wavelength of the microwaves is much smaller than the distance between S and P.



A detector Q is moved at a slow, constant speed from S to P.

What happens to the amplitude of the signal detected by Q?

A decreases steadily

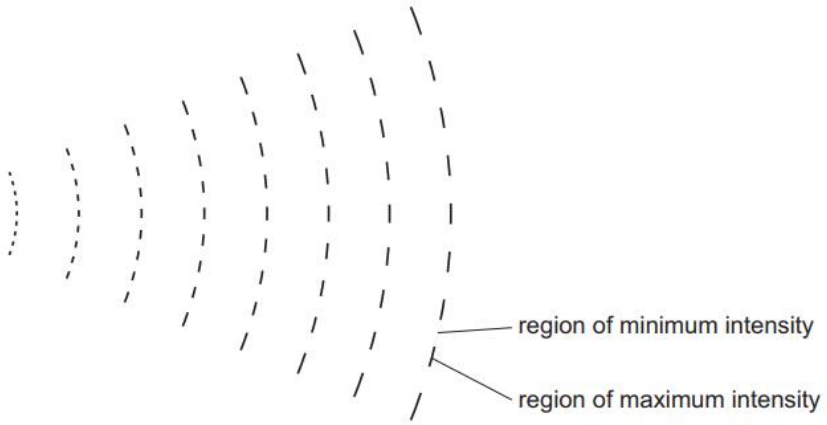
B increases and decreases regularly

C increases steadily

D remains constant

36. B

28 A pattern of waves was observed without being able to view the source of the waves. The pattern is represented in the diagram.



What can cause this pattern?

A coherence only

B diffraction and interference

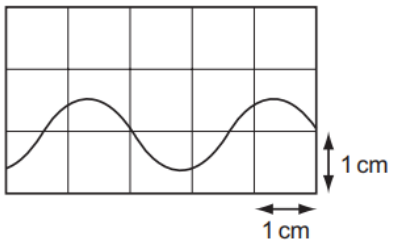
C diffraction only

D interference only

S15/13

37. C

25 A cathode-ray oscilloscope (c.r.o.) is used to display the trace from a sound wave. The time-base is set at $5\,\mu s\,mm^{-1}$.

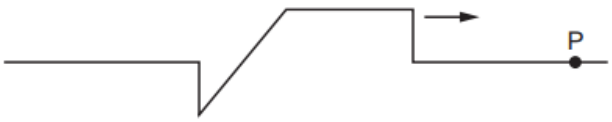


What is the frequency of the sound wave?

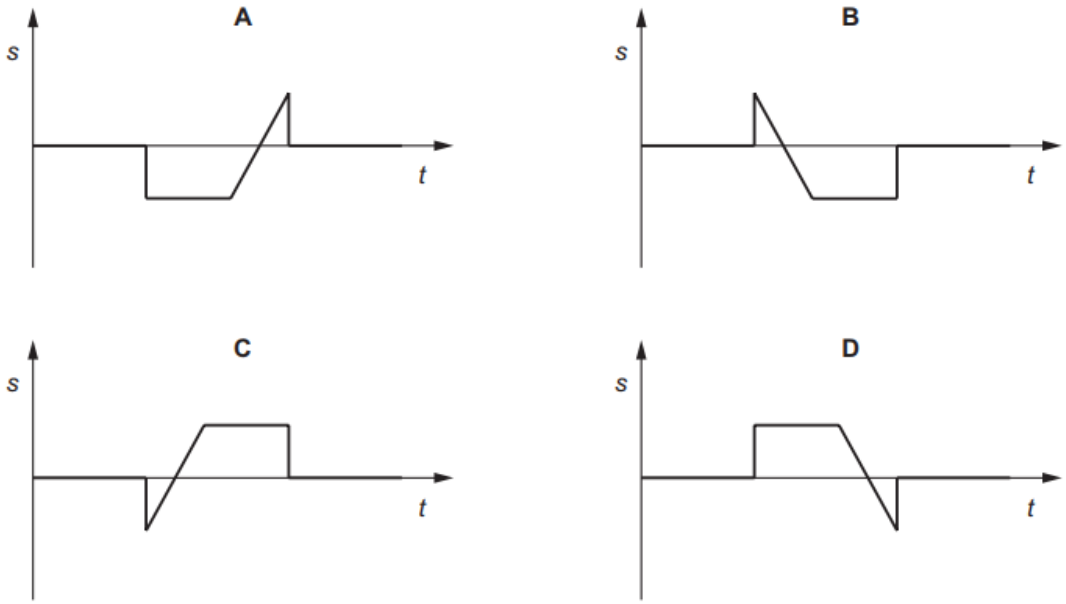
A 6.7 Hz **B** 67 Hz **C** 6.7 kHz **D** 67 kHz

38. D

26 A wave pulse moves along a stretched rope in the direction shown.



Which diagram correctly shows the variation with time *t* of the displacement *s* of the particle P in the rope?



39. D

27 The table contains statements about stationary and progressive waves.

Which row is correct?

	stationary wave	progressive wave
A	all particles vibrate with the same amplitude	all particles vibrate with the same amplitude
B	energy is transferred along the wave	energy is transferred along the wave
C	particles in adjacent loops vibrate in antiphase	particles vibrate in phase with their immediate neighbours
D	particles one wavelength apart vibrate in phase	particles one wavelength apart vibrate in phase

40. D

28 Which electromagnetic wave would cause the most significant diffraction effect for an atomic lattice of spacing around 10^{-10} m?

A infra-red

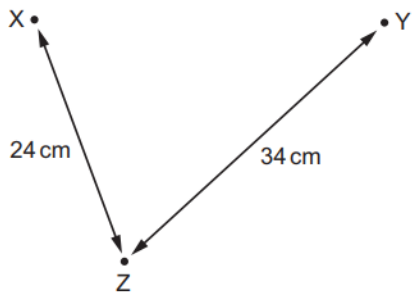
B microwave

C ultraviolet

D X-ray

41. C

29 Wave generators at points X and Y produce water waves of the same wavelength. At point Z, the waves from X have the same amplitude as the waves from Y. Distances XZ and YZ are as shown.



When the wave generators operate in phase, the amplitude of oscillation at Z is zero.

What could be the wavelength of the waves?

A 2 cm **B** 3 cm **C** 4 cm **D** 6 cm

W14/11

42. B

22 Which statement about electromagnetic radiation is correct?

A Waves of wavelength 5×10^{-9} m are high-energy gamma rays.

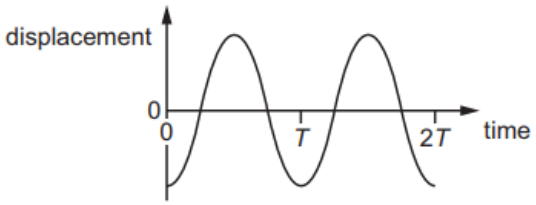
B Waves of wavelength 3×10^{-8} m are ultra-violet waves.

C Waves of wavelength 5×10^{-7} m are infra-red waves.

D Waves of wavelength 9×10^{-7} m are light waves.

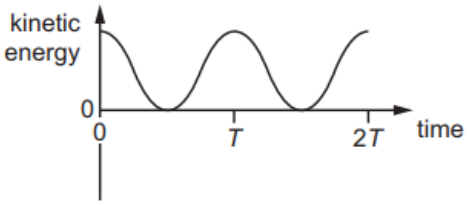
43. D

23 When sound travels through air, the air particles vibrate. A graph of displacement against time for a single air particle is shown.

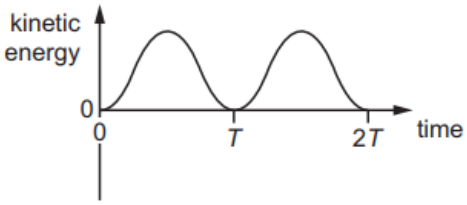


Which graph best shows how the kinetic energy of the air particle varies with time?

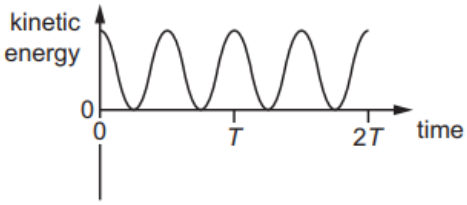
A



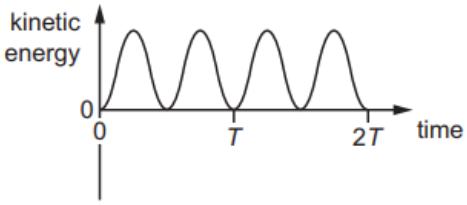
B



C



D



44. D

24 Which statement describes a situation when polarisation could **not** occur?

A Light waves are reflected.

B Light waves are scattered.

C Microwaves pass through a metal grid.

D Sound waves pass through a metal grid.

45. D

25 A stationary sound wave is produced in a tube.

Which statement describes the wave speed?

A It is the distance between two adjacent nodes divided by the period of the wave.

B It is the speed at which energy is transferred from one antinode to an adjacent antinode.

C It is the speed of a particle at an antinode.

D It is the speed of one of the progressive waves that are producing the stationary wave.

W14/13

46. A

26 Which statement about waves is correct?

A All electromagnetic waves travel at the same speed in a vacuum.

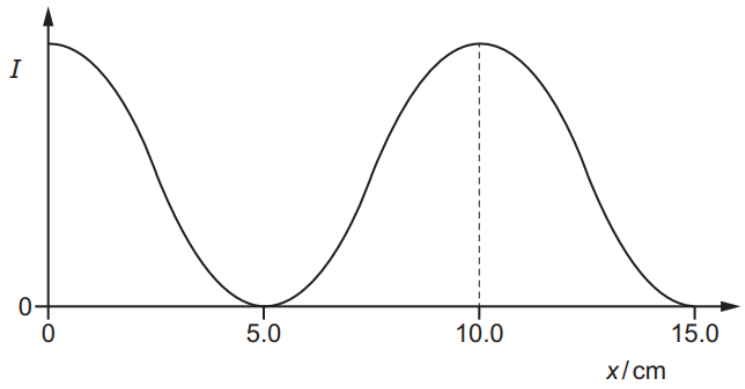
B Longitudinal waves can be polarised.

C The amplitude of a wave is directly proportional to the energy transferred by the wave.

D The frequency of infra-red light is greater than the frequency of ultra-violet light.

47. A

27 The variation with distance x of the intensity I along a stationary sound wave in air is shown by the following graph.



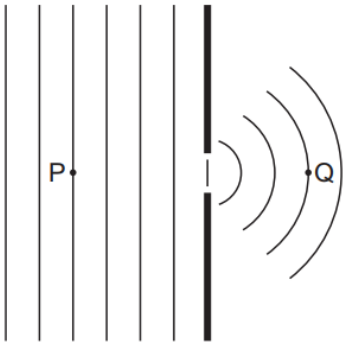
The speed of sound in air is $340\,m\,s^{-1}$.

What is the frequency of the sound wave?

A 1700 Hz **B** 2270 Hz **C** 3400 Hz **D** 6800 Hz

48. C

28 Plane wavefronts in a ripple tank pass through a gap as shown.



Which property of the wave will be different at Q compared with P?

A velocity

B frequency

C amplitude

D wavelength

49. C

29 An organ pipe of length l is open at both ends. Notes are produced by the pipe when stationary waves are set up.

The speed of sound in the air column is v.

What is the lowest (fundamental) frequency of the note produced by the pipe?

A $\frac{2v}{l}$ **B** $\frac{v}{l}$ **C** $\frac{v}{2l}$ **D** $\frac{v}{4l}$

S13/11

50. C

24 A light wave of amplitude A is incident normally on a surface of area S. The power per unit area reaching the surface is P.

The amplitude of the light wave is increased to $2A$. The light is then focussed on to a smaller area $\frac{1}{3}S$.

What is the power per unit area on this smaller area?

A $36P$

B $18P$

C $12P$

D $6P$

51. A

25 A wave has a speed of 340 m s^{-1} and a period of 0.28 ms.

What is its wavelength?

A 0.095 m **B** 95 m **C** 1.2×10^3 m **D** 1.2×10^6 m

52. C

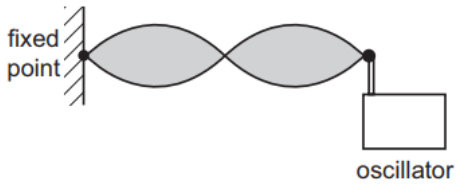
26 Which line in the table summarises the change in wave characteristics on going from infra-red to ultraviolet in the electromagnetic spectrum?

	frequency	speed in a vacuum
A	decreases	decreases
B	decreases	remains constant
C	increases	remains constant
D	increases	increases

53.NIL

54. (1)C

28 The speed of a transverse wave on a stretched string can be changed by adjusting the tension of the string. A stationary wave pattern is set up on a stretched string using an oscillator set at a frequency of 650 Hz.



How must the wave be changed to maintain the same stationary wave pattern if the applied frequency is increased to 750 Hz?

A Decrease the speed of the wave on the string.

B Decrease the wavelength of the wave on the string.

C Increase the speed of the wave on the string.

D Increase the wavelength of the wave on the string.

54.(2) B

29 Noise reduction headphones actively produce their own sound waves in order to cancel out external sound waves.

A microphone in the headphones receives waves of one frequency. A loudspeaker in the headphones then produces a wave of that frequency but of a different phase.

What is the phase difference between the external sound wave and the wave produced by the loudspeaker in the headphones?

A 90° **B** 180° **C** 270° **D** 360°

S13/12

55. D

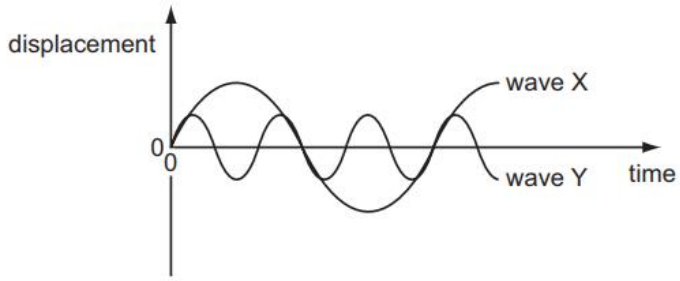
24 The order of magnitude of the frequency of the shortest wavelength of visible light waves can be expressed as 10^x Hz.

What is the value of x?

A 12 **B** 13 **C** 14 **D** 15

56. D

25 The diagram shows two waves X and Y.



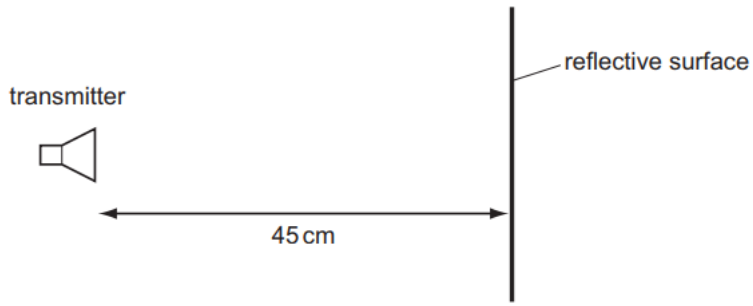
Wave X has amplitude 8 cm and frequency 100 Hz.

What are the amplitude and the frequency of wave Y?

	amplitude / cm	frequency / Hz
A	2	33
B	2	300
C	4	33
D	4	300

57. C

27 A transmitter of electromagnetic waves is placed 45 cm from a reflective surface.



The emitted waves have a frequency of 1.00 GHz. A stationary wave is produced with a node at the transmitter and a node at the surface.

How many antinodes are in the space between the transmitter and the surface?

A 1 **B** 2 **C** 3 **D** 4

S13/13

58. A

22 Which statement about different types of electromagnetic wave is correct?

A The frequency of infra-red waves is less than the frequency of blue light.

B The frequency of radio waves is greater than the frequency of gamma rays.

C The wavelength of red light is less than the wavelength of ultraviolet waves.

D The wavelength of X-rays is greater than the wavelength of microwaves.

59. C

23 Orange light has a wavelength of 600 nm.

What is the frequency of this light?

A 180 GHz **B** 180 Hz **C** 500 THz **D** 500 kHz

60. C

24 Electromagnetic waves of wavelength λ and frequency f travel at speed c in a vacuum.

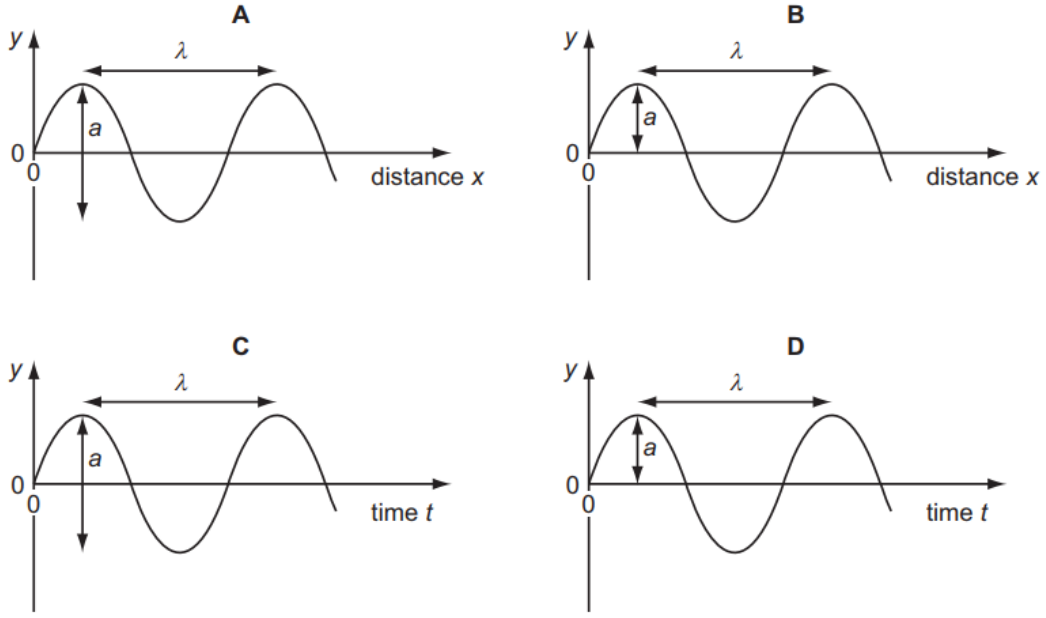
What describes the wavelength and speed of electromagnetic waves of frequency $f/2$?

	wavelength	speed in a vacuum
A	$\lambda/2$	$c/2$
B	$\lambda/2$	c
C	2λ	c
D	2λ	$2c$

61. B

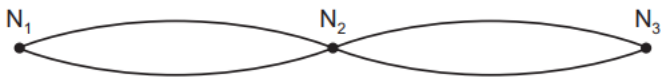
26 A sound wave has displacement *y* at distance *x* from its source at time *t*.

Which graph correctly shows the amplitude *a* and the wavelength λ of the wave?



62. D

28 The diagram shows a standing wave on a string. The standing wave has three nodes N_1, N_2 and N_3.



Which statement is correct?

A All points on the string vibrate in phase.

B All points on the string vibrate with the same amplitude.

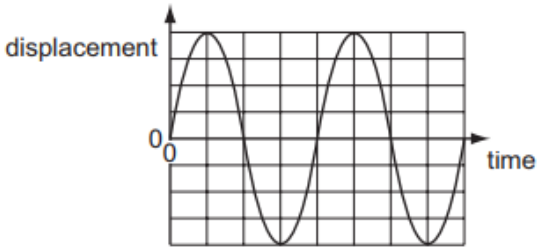
C Points equidistant from N_2 vibrate with the same frequency and in phase.

D Points equidistant from N_2 vibrate with the same frequency and the same amplitude.

W12/11

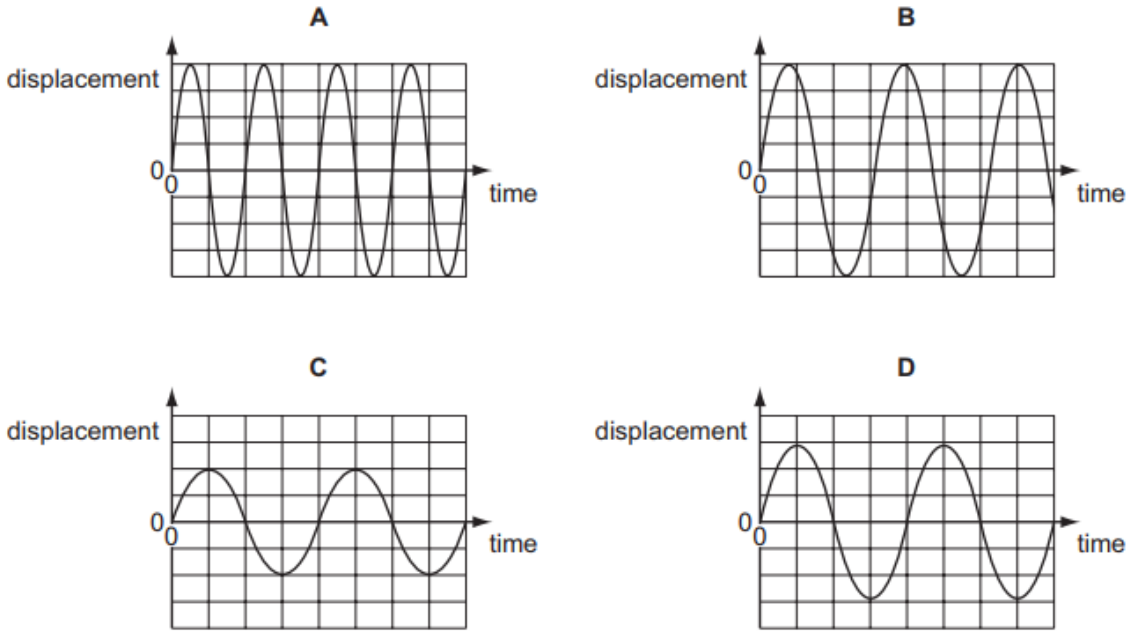
63. D

26 The diagram shows a graph of displacement against time for a sound wave.



The intensity of the sound is halved.

Which graph shows the displacement of this sound wave?



64. A

27 What do **not** travel at the speed of light in a vacuum?

A electrons

B microwaves

C radio waves

D X-rays

65. B

28 A musical organ produces notes by blowing air into a set of pipes that are open at one end and closed at the other.

What is the lowest frequency of sound produced by a pipe of length 10 m?
(The speed of sound in the pipe is 320 m s^{-1}.)

A 4 Hz **B** 8 Hz **C** 16 Hz **D** 32 Hz

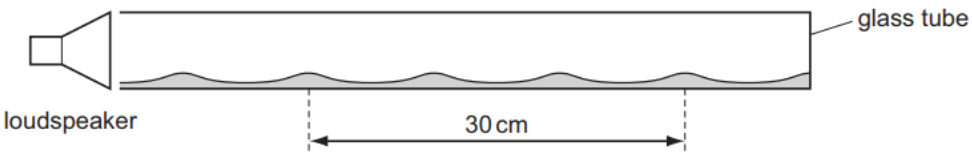
W12/12

66. A

29 A horizontal glass tube, closed at one end, has a layer of dust laid inside it on its lower side. Sound is emitted from a loudspeaker that is placed near the open end of the tube.

The frequency of the sound is varied and, at one frequency, a stationary wave is formed inside the tube so that the dust forms small heaps.

The distance between four heaps of dust is 30 cm.



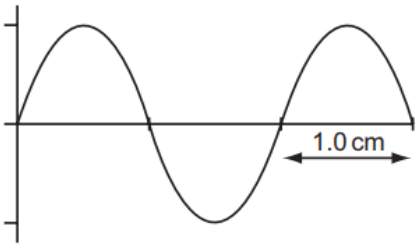
The speed of sound in the tube is 330 m s^{-1}.

What is the frequency of the sound emitted by the loudspeaker?

A 1650 Hz **B** 2200 Hz **C** 3300 Hz **D** 6600 Hz

67. A

31 The diagram shows a cathode-ray oscilloscope display of an electromagnetic wave.



The time base setting is 0.20 μs cm^{-1}.

Which statement is correct?

A The frequency of the wave is 2.5 MHz and it lies in the radio wave region of the electromagnetic spectrum.

B The frequency of the wave is 2.5 MHz and it lies in the microwave region of the electromagnetic spectrum.

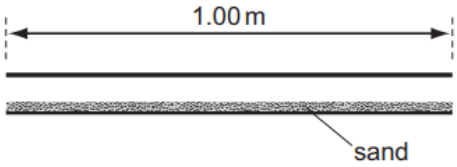
C The frequency of the wave is 5.0 MHz and it lies in the radio wave region of the electromagnetic spectrum.

D The frequency of the wave is 5.0 MHz and it lies in the microwave region of the electromagnetic spectrum.

W12/13

68. B

26 The diagram shows an air-filled pipe open at both ends. The length of the pipe is 1.00 m and the lower surface of the inside of the pipe is covered with a layer of fine sand.



When a source of sound of a single frequency is put near one end of the pipe, the air in the pipe is found to resonate and a pattern in the sand shows that a standing wave containing three nodes is formed within the pipe.

The speed of sound in air is 330 m s^{-1}.

What is the frequency of the sound?

A 330 Hz **B** 495 Hz **C** 990 Hz **D** 1320 Hz

69. B

27 A stationary sound wave is formed in a measuring cylinder by blowing across the top, as shown.

Which statement is correct?

A The fundamental frequency of the stationary wave decreases when some water is added to the cylinder.

B The stationary wave in the cylinder is caused by the superposition of two waves moving in opposite directions.

C The stationary wave in the cylinder is polarised.

D The stationary wave will have an antinode at the bottom of the cylinder.

70. A

28 Diffraction can be observed when a wave passes an obstruction. The diffraction effect is greatest when the wavelength and the obstruction are similar in size.

For waves travelling through air, what is the combination of wave and obstruction that could best demonstrate diffraction?

A microwaves passing a steel post

B radio waves passing a copper wire

C sound waves passing a human hair

D visible light waves passing a gate post

71. B

29 A health inspector is measuring the intensity of a sound. Near a loudspeaker, his meter records an intensity I. This corresponds to an amplitude A of the sound wave. At another position, the meter gives an intensity reading of $2I$.

What is the corresponding amplitude of the sound wave?

A $\frac{A}{\sqrt{2}}$ **B** $\sqrt{2}A$ **C** $2A$ **D** $4A$

S12/11

72. C

26 Two waves E and G are shown. The waves have the same speed.

Which statement is correct?

A Wave E has a greater amplitude than wave G.

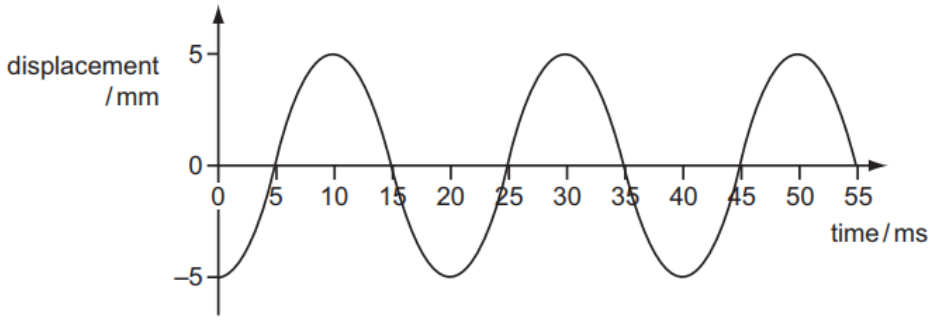
B Wave E has a greater intensity than wave G.

C Wave E has a smaller frequency than wave G.

D Wave E has a smaller wavelength than wave G.

73. B

27 The diagram shows a displacement-time graph for a progressive wave.



What are the amplitude and frequency of the wave?

	amplitude / mm	frequency / Hz
A	5	40
B	5	50
C	10	40
D	10	50

74. C

29 To produce a stationary wave, two waves must travel in opposite directions through the same space.

Which statement about the properties of the two waves must also be true?

A The waves must have equal frequency, but a different speed and wavelength.

B The waves must have equal speed, but a different wavelength and frequency.

C The waves must have equal speed, frequency and wavelength.

D The waves must have equal wavelength, but a different speed and frequency.

S14/11

75. D

22 Which statement about longitudinal waves is correct?

A Longitudinal waves include radio waves travelling through air.

B Particles in a longitudinal wave vibrate at right-angles to the direction of transfer of wave energy.

C Some types of longitudinal wave can be polarised.

D Stationary waves can be produced by the superposition of longitudinal waves.

76. B

23 The order of magnitude of the frequency of the longest-wavelength ultraviolet waves can be expressed as 10^x Hz.

What is the value of x?

A 13 **B** 15 **C** 17 **D** 19

77. D

24 The speed v of waves in deep water is given by the equation

$$v^2 = \frac{g\lambda}{2\pi}$$

where λ is the wavelength of the waves and g is the acceleration of free fall.

A student measures the wavelength λ and the frequency f of a number of these waves.

Which graph should he plot to give a straight line through the origin?

A f^2 against λ

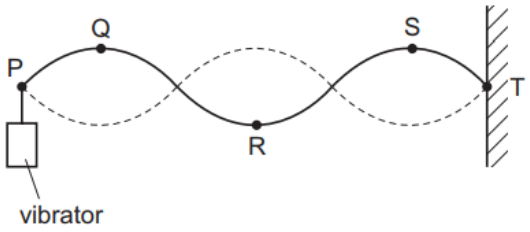
B f against λ^2

C f against $\frac{1}{\lambda}$

D f^2 against $\frac{1}{\lambda}$

78. B

25 A stationary wave on a stretched string is set up between two points P and T.



Which statement about the wave is correct?

A Point R is at a node.

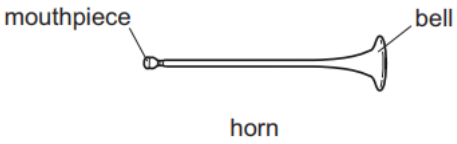
B Points Q and S vibrate in phase.

C The distance between P and T is three wavelengths.

D The wave shown has the lowest possible frequency.

79. D

27 The basic principle of note production in a horn is to set up a stationary wave in an air column.



For any note produced by the horn, a node is formed at the mouthpiece and an antinode is formed at the bell. The frequency of the lowest note is 75 Hz.

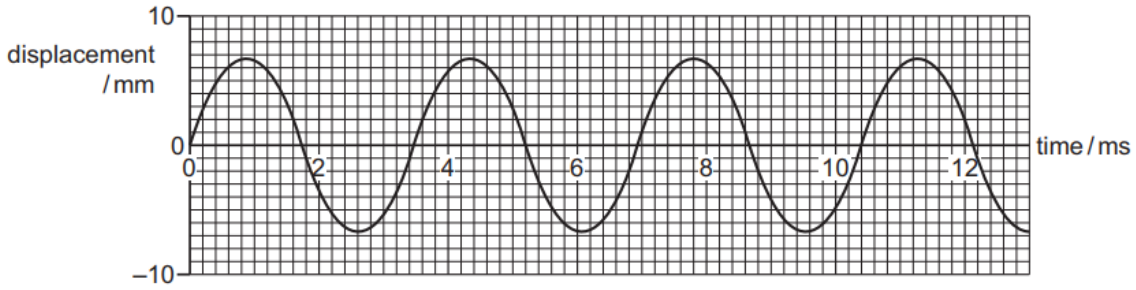
What are the frequencies of the next two higher notes for this air column?

	first higher note / Hz	second higher note / Hz
A	113	150
B	150	225
C	150	300
D	225	375

S14/12

80. C

22 What, to two significant figures, are the period, the frequency and the amplitude of the wave represented by the graph?

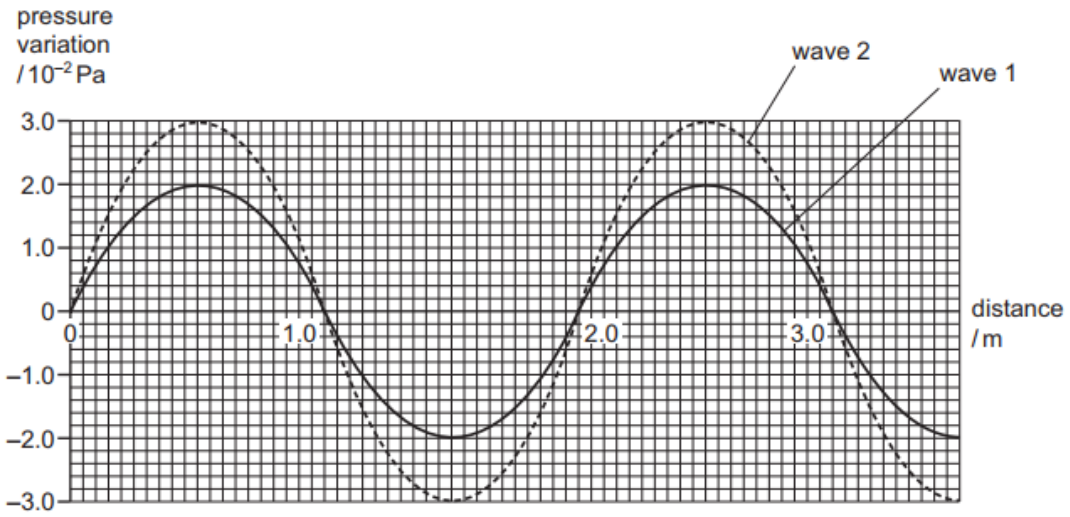


	period / s	frequency / Hz	amplitude / m
A	0.0027	370	0.0067
B	0.0031	320	0.013
C	0.0035	290	0.0067
D	0.0042	240	0.013

81. C

23 A sound wave consists of a series of moving pressure variations from the normal, constant air pressure.

The graph shows these pressure variations for two waves at one instant in time.



Wave 1 has an intensity of $1.6 \times 10^{-6}\,W m^{-2}$.

What is the intensity of wave 2?

A $2.4 \times 10^{-6}\,W m^{-2}$

B $3.0 \times 10^{-6}\,W m^{-2}$

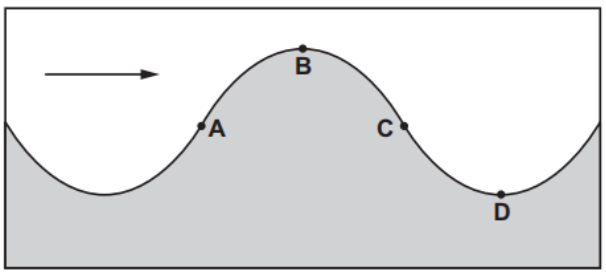
C $3.6 \times 10^{-6}\,W m^{-2}$

D $4.5 \times 10^{-6}\,W m^{-2}$

82. B

24 The diagram shows a vertical cross-section through a water wave moving from left to right.

At which point is the water moving upwards with maximum speed?



83. B

25 The principle of superposition states that a certain quantity is added when two or more waves meet at a point.

What is this quantity?

A amplitude

B displacement

C intensity

D wavelength

S14/13

84. C

25 A cathode-ray oscilloscope (c.r.o.) displays a waveform corresponding to a sound wave.

In order to determine the frequency of the sound wave, which part of the displayed waveform must be measured and which c.r.o. setting must be known?

	on-screen measurement	c.r.o. setting
A	amplitude	time-base
B	amplitude	Y-gain
C	wavelength	time-base
D	wavelength	Y-gain

85. C

26 What is the approximate range of frequencies of infra-red radiation?

A 1×10^3 Hz to 1×10^9 Hz

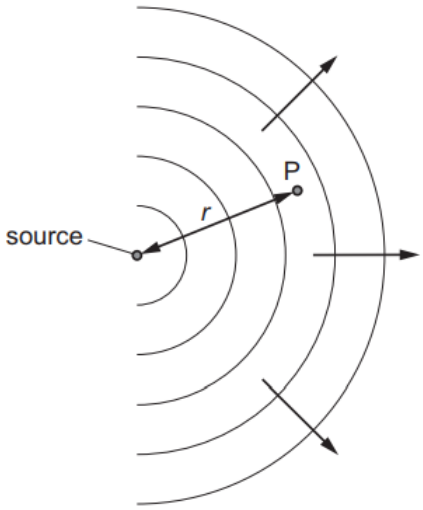
B 1×10^9 Hz to 1×10^{11} Hz

C 1×10^{11} Hz to 1×10^{14} Hz

D 1×10^{14} Hz to 1×10^{17} Hz

86. B

27 A small source emits spherical waves.



The wave intensity I at any point P, a distance r from the source, is inversely proportional to r^2.

What is the relationship between the wave amplitude a and the distance r?

A $a^2 \propto \frac{1}{r}$ **B** $a \propto \frac{1}{r}$ **C** $a \propto \frac{1}{r^2}$ **D** $a \propto \frac{1}{r^4}$

87. A

28 A student attempts to show the interference of light using two identical green LEDs.

Which statement explains why the experiement will **not** succeed?

A The light waves from the sources are not coherent.

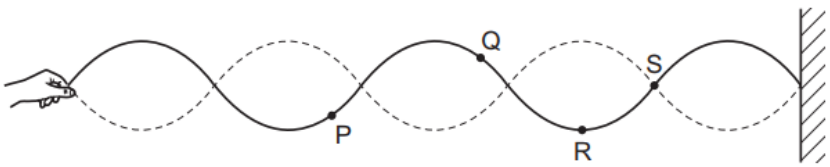
B The light waves from the sources do not have the same amplitude.

C The light waves from the sources have a range of wavelengths.

D The light waves from the sources are not monochromatic.

88. B

29 A stationary wave is set up on a stretched string, as shown.



Which statement about the points on the string is correct?

A Point Q vibrates with the largest amplitude.

B Points P and R vibrate in phase.

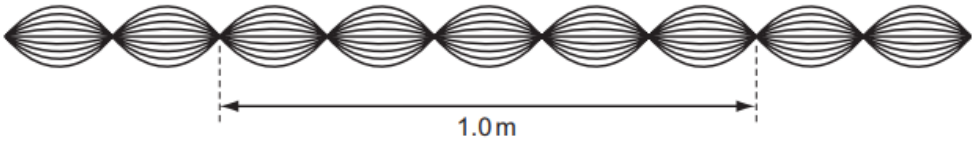
C Point S is an antinode.

D The horizontal distance between R and S is half the wavelength.

W13/11

89. D

25 The diagram shows a sketch of a wave pattern, over a short period of time.



Which description of this wave is correct?

A The wave is longitudinal, has a wavelength of 20 cm and is stationary.

B The wave is transverse, has a wavelength of 20 cm and is stationary.

C The wave is transverse, has a wavelength of 40 cm and is progressive.

D The wave is transverse, has a wavelength of 40 cm and is stationary.

90. C

26 Which statement about a light wave and a sound wave is correct?

A Both can be polarised.

B Both can travel through free space.

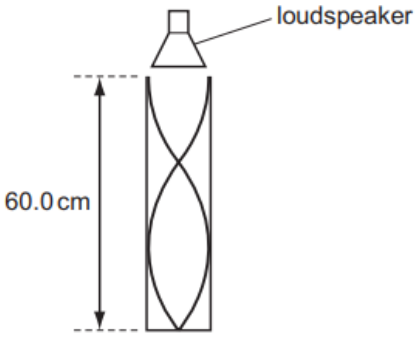
C Both have a frequency inversely proportional to their wavelength.

D Both have an intensity proportional to their amplitude.

91. A

27 The sound from a loudspeaker placed above a tube causes resonance of the air in the tube.

A stationary wave is formed with two nodes and two antinodes as shown.



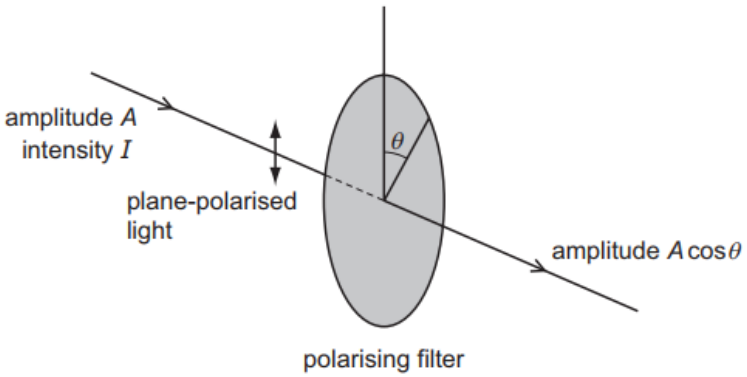
The speed of sound in air is 330 m s^{-1}.

What is the frequency of the sound?

A 413 Hz **B** 550 Hz **C** 830 Hz **D** 1650 Hz

92. A

30 When plane-polarised light of amplitude A is passed through a polarising filter as shown, the amplitude of the light emerging is $A\cos\theta$.



The intensity of the initial beam is I.

What is the intensity of the emerging light when θ is 60.0°?

A $0.250\,I$ **B** $0.500\,I$ **C** $0.750\,I$ **D** $0.866\,I$

W13/13

93. C

24 Electromagnetic waves from an unknown source in space were found to be significantly diffracted when passing through gaps of the order of 10^{-5} m.

Which type of wave are they most likely to be?

A radio waves

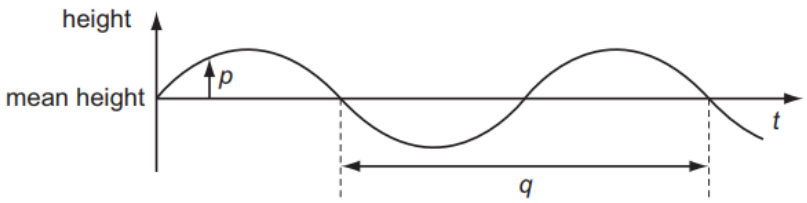
B microwaves

C infra-red waves

D ultraviolet waves

94. A

25 The graph shows how the height of the water surface at a point in a harbour varies with time *t* as waves pass the point.



What are *p* and *q*?

	p	*q*
A	displacement	period
B	displacement	wavelength
C	amplitude	period
D	amplitude	wavelength

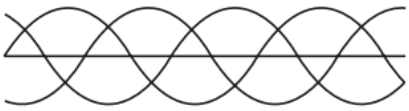
95. A

26 The three waves shown in each diagram have the same amplitude and frequency but differ in phase.

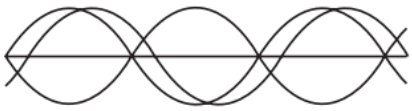
They are added together to give a resultant wave.

In which case is the resultant wave zero?

A

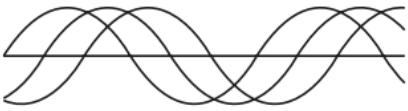


B



C

D



96. D

27 A stationary sound wave has a series of nodes. The distance between the first and the sixth node is 30.0 cm.

What is the wavelength of the sound wave?

A 5.0 cm **B** 6.0 cm **C** 10.0 cm **D** 12.0 cm

97. B

28 What is meant by diffraction?

A Addition of two coherent waves to produce a stationary wave pattern.

B Bending of waves round an obstacle.

C Change of direction when waves cross the boundary between one medium and another.

D Splitting of white light into colours.

S13/11

98. C

24 A light wave of amplitude A is incident normally on a surface of area S. The power per unit area reaching the surface is P.

The amplitude of the light wave is increased to $2A$. The light is then focussed on to a smaller area $\frac{1}{3}S$.

What is the power per unit area on this smaller area?

A $36P$

B $18P$

C $12P$

D $6P$

99. A

25 A wave has a speed of $340\,\text{m}\,\text{s}^{-1}$ and a period of 0.28 ms.

What is its wavelength?

A 0.095 m **B** 95 m **C** 1.2×10^{3} m **D** 1.2×10^{6} m

100. C

26 Which line in the table summarises the change in wave characteristics on going from infra-red to ultraviolet in the electromagnetic spectrum?

	frequency	speed in a vacuum
A	decreases	decreases
B	decreases	remains constant
C	increases	remains constant
D	increases	increases

101. A

27 Light of wavelength 600 nm is incident on a pair of slits. Fringes with a spacing of 4.0 mm are formed on a screen.

What will be the fringe spacing when the wavelength of the light is changed to 400 nm and the separation of the slits is doubled?

A 1.3 mm

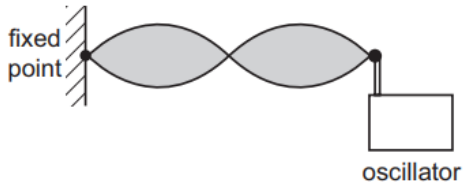
B 3.0 mm

C 5.3 mm

D 12 mm

102. C

28 The speed of a transverse wave on a stretched string can be changed by adjusting the tension of the string. A stationary wave pattern is set up on a stretched string using an oscillator set at a frequency of 650 Hz.



How must the wave be changed to maintain the same stationary wave pattern if the applied frequency is increased to 750 Hz?

A Decrease the speed of the wave on the string.

B Decrease the wavelength of the wave on the string.

C Increase the speed of the wave on the string.

D Increase the wavelength of the wave on the string.

S13/12

103. D

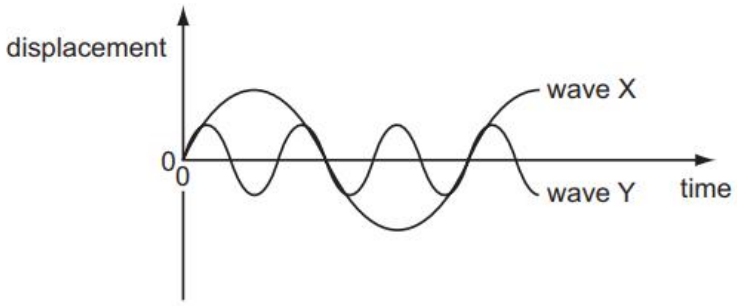
24 The order of magnitude of the frequency of the shortest wavelength of visible light waves can be expressed as 10^x Hz.

What is the value of x?

A 12 **B** 13 **C** 14 **D** 15

104. D

25 The diagram shows two waves X and Y.



Wave X has amplitude 8 cm and frequency 100 Hz.

What are the amplitude and the frequency of wave Y?

	amplitude / cm	frequency / Hz
A	2	33
B	2	300
C	4	33
D	4	300

105. B

26 What is correct for all transverse waves?

A They are all electromagnetic.

B They can all be polarised.

C They can all travel through a vacuum.

D They all involve the oscillation of atoms.

S13/13

106. A

22 Which statement about different types of electromagnetic wave is correct?

A The frequency of infra-red waves is less than the frequency of blue light.

B The frequency of radio waves is greater than the frequency of gamma rays.

C The wavelength of red light is less than the wavelength of ultraviolet waves.

D The wavelength of X-rays is greater than the wavelength of microwaves.

107. C

23 Orange light has a wavelength of 600 nm.

What is the frequency of this light?

A 180 GHz **B** 180 Hz **C** 500 THz **D** 500 kHz

108. C

24 Electromagnetic waves of wavelength λ and frequency f travel at speed c in a vacuum.

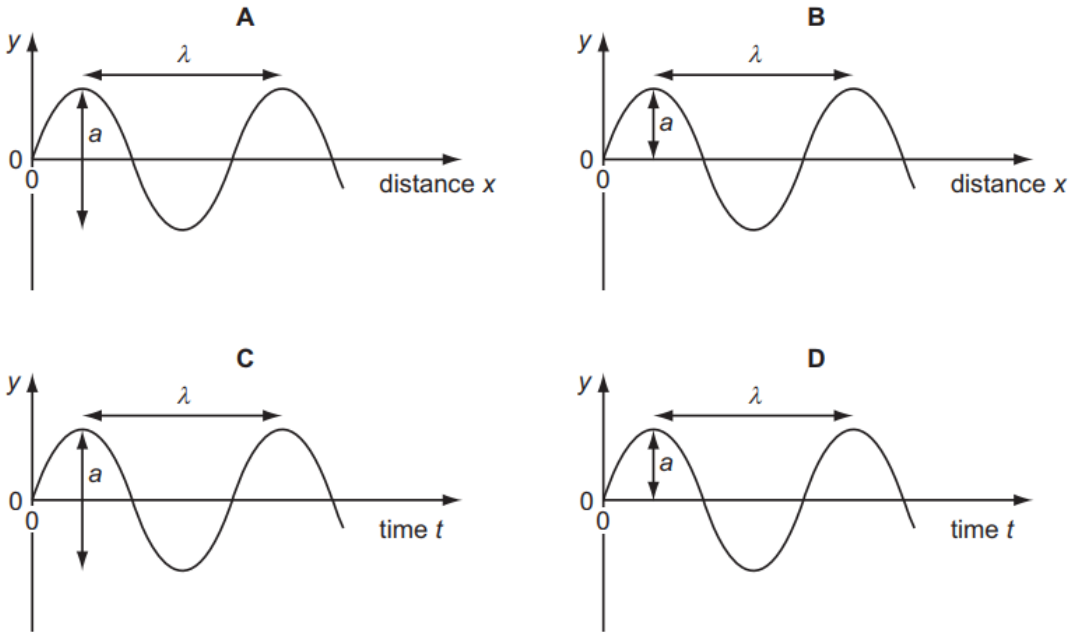
What describes the wavelength and speed of electromagnetic waves of frequency $f/2$?

	wavelength	speed in a vacuum
A	$\lambda/2$	$c/2$
B	$\lambda/2$	c
C	2λ	c
D	2λ	$2c$

109. B

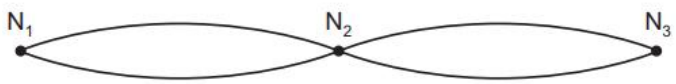
26 A sound wave has displacement y at distance x from its source at time t.

Which graph correctly shows the amplitude a and the wavelength λ of the wave?



110. D

28 The diagram shows a standing wave on a string. The standing wave has three nodes N_1, N_2 and N_3.



Which statement is correct?

A All points on the string vibrate in phase.

B All points on the string vibrate with the same amplitude.

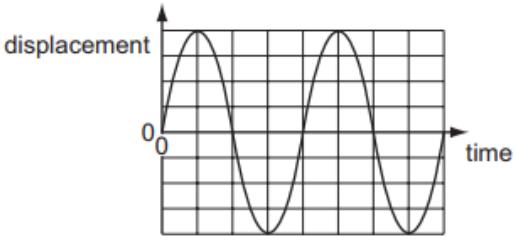
C Points equidistant from N_2 vibrate with the same frequency and in phase.

D Points equidistant from N_2 vibrate with the same frequency and the same amplitude.

W12/11

111. D

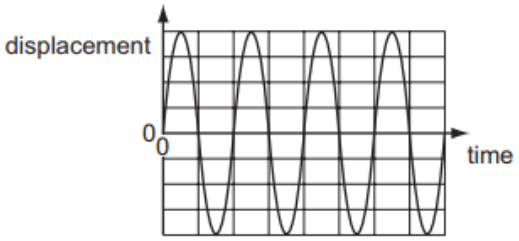
26 The diagram shows a graph of displacement against time for a sound wave.



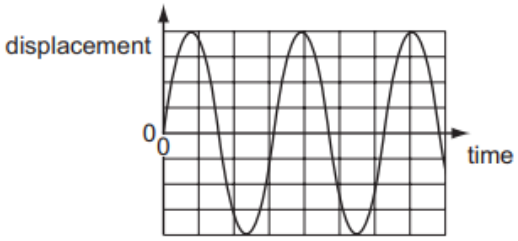
The intensity of the sound is halved.

Which graph shows the displacement of this sound wave?

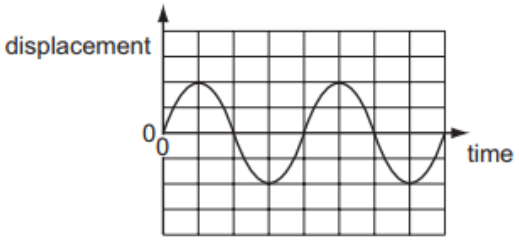
A



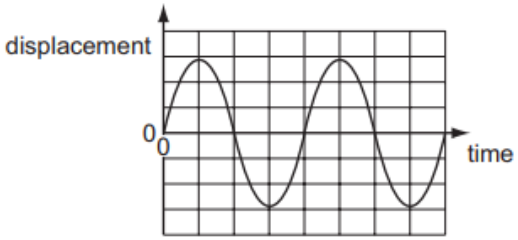
B



C



D



112. A

27 What do **not** travel at the speed of light in a vacuum?

A electrons

B microwaves

C radio waves

D X-rays

113. B

28 A musical organ produces notes by blowing air into a set of pipes that are open at one end and closed at the other.

What is the lowest frequency of sound produced by a pipe of length 10 m?
(The speed of sound in the pipe is 320 m s^{-1}.)

A 4 Hz **B** 8 Hz **C** 16 Hz **D** 32 Hz

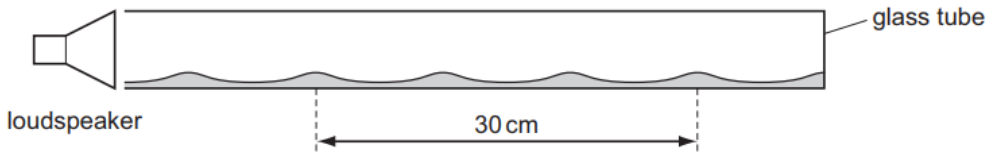
W12/12

114. A

29 A horizontal glass tube, closed at one end, has a layer of dust laid inside it on its lower side. Sound is emitted from a loudspeaker that is placed near the open end of the tube.

The frequency of the sound is varied and, at one frequency, a stationary wave is formed inside the tube so that the dust forms small heaps.

The distance between four heaps of dust is 30 cm.



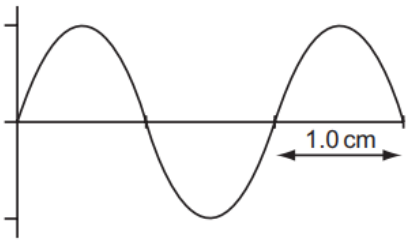
The speed of sound in the tube is 330 m s^{-1}.

What is the frequency of the sound emitted by the loudspeaker?

A 1650 Hz **B** 2200 Hz **C** 3300 Hz **D** 6600 Hz

115. A

31 The diagram shows a cathode-ray oscilloscope display of an electromagnetic wave.



The time base setting is 0.20 μs cm^{-1}.

Which statement is correct?

A The frequency of the wave is 2.5 MHz and it lies in the radio wave region of the electromagnetic spectrum.

B The frequency of the wave is 2.5 MHz and it lies in the microwave region of the electromagnetic spectrum.

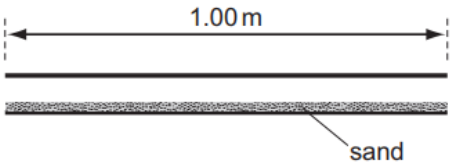
C The frequency of the wave is 5.0 MHz and it lies in the radio wave region of the electromagnetic spectrum.

D The frequency of the wave is 5.0 MHz and it lies in the microwave region of the electromagnetic spectrum.

W12/13

116. B

26 The diagram shows an air-filled pipe open at both ends. The length of the pipe is 1.00 m and the lower surface of the inside of the pipe is covered with a layer of fine sand.



When a source of sound of a single frequency is put near one end of the pipe, the air in the pipe is found to resonate and a pattern in the sand shows that a standing wave containing three nodes is formed within the pipe.

The speed of sound in air is 330 m s^{-1}.

What is the frequency of the sound?

A 330 Hz **B** 495 Hz **C** 990 Hz **D** 1320 Hz

117. B

27 A stationary sound wave is formed in a measuring cylinder by blowing across the top, as shown.

Which statement is correct?

A The fundamental frequency of the stationary wave decreases when some water is added to the cylinder.

B The stationary wave in the cylinder is caused by the superposition of two waves moving in opposite directions.

C The stationary wave in the cylinder is polarised.

D The stationary wave will have an antinode at the bottom of the cylinder.

118. A

28 Diffraction can be observed when a wave passes an obstruction. The diffraction effect is greatest when the wavelength and the obstruction are similar in size.

For waves travelling through air, what is the combination of wave and obstruction that could best demonstrate diffraction?

A microwaves passing a steel post

B radio waves passing a copper wire

C sound waves passing a human hair

D visible light waves passing a gate post

119. B

29 A health inspector is measuring the intensity of a sound. Near a loudspeaker, his meter records an intensity I. This corresponds to an amplitude A of the sound wave. At another position, the meter gives an intensity reading of $2I$.

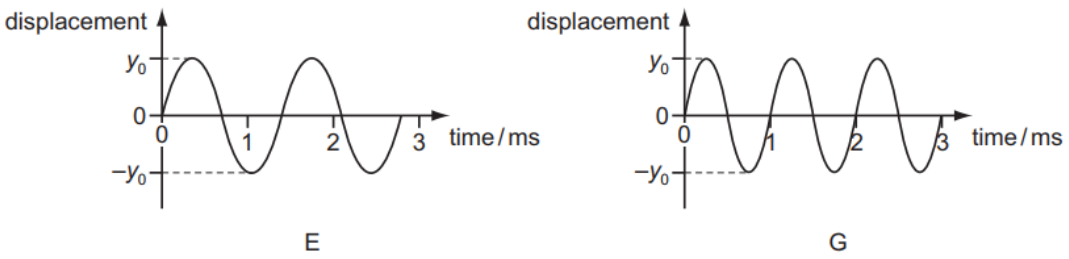
What is the corresponding amplitude of the sound wave?

A $\frac{A}{\sqrt{2}}$ **B** $\sqrt{2}A$ **C** $2A$ **D** $4A$

S12/11

120. C

26 Two waves E and G are shown. The waves have the same speed.



Which statement is correct?

A Wave E has a greater amplitude than wave G.

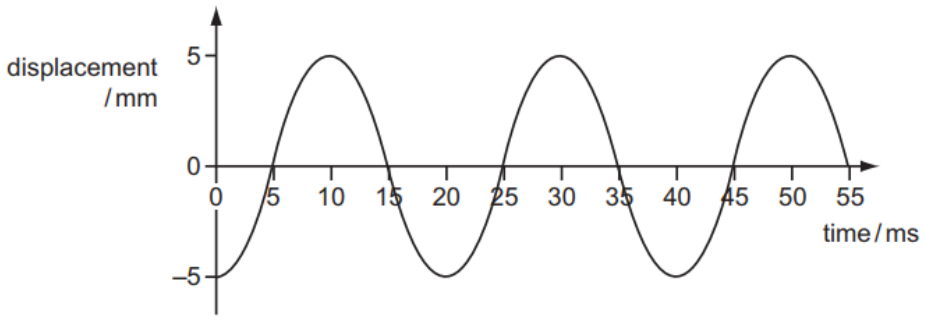
B Wave E has a greater intensity than wave G.

C Wave E has a smaller frequency than wave G.

D Wave E has a smaller wavelength than wave G.

121. B

27 The diagram shows a displacement-time graph for a progressive wave.



What are the amplitude and frequency of the wave?

	amplitude / mm	frequency / Hz
A	5	40
B	5	50
C	10	40
D	10	50

122. C

29 To produce a stationary wave, two waves must travel in opposite directions through the same space.

Which statement about the properties of the two waves must also be true?

A The waves must have equal frequency, but a different speed and wavelength.

B The waves must have equal speed, but a different wavelength and frequency.

C The waves must have equal speed, frequency and wavelength.

D The waves must have equal wavelength, but a different speed and frequency.

S12/12

123. D

26 A surveyor's device emits a laser pulse.

What is the time taken for the pulse to travel from the device to a wall 150 m away, where it is reflected, and then return to the device?

A 0.05 ns **B** 0.10 ns **C** 0.50 μs **D** 1.0 μs

124. C

27 The period of an electromagnetic wave is 1.0 ns.

What are the frequency and wavelength of the wave?

	frequency / Hz	wavelength / m
A	1.0	3.0×10^{8}
B	1.0×10^{6}	300
C	1.0×10^{9}	0.30
D	1.0×10^{12}	3.0×10^{-4}

125. D

28 X and Y are two points on the surface of water in a ripple tank. A source of waves of constant frequency begins to generate waves which then travel past X and Y, causing them to oscillate.

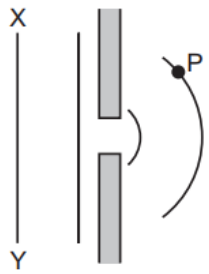
What is the phase difference between X and Y?

A 45° **B** 135° **C** 180° **D** 270°

126. C

29 A monochromatic plane wave of speed c and wavelength λ is diffracted at a small aperture.

The diagram illustrates successive wavefronts.



After what time will some portion of the wavefront XY reach point P?

A $\frac{3\lambda}{2c}$ **B** $\frac{2\lambda}{c}$ **C** $\frac{3\lambda}{c}$ **D** $\frac{4\lambda}{c}$

127. B

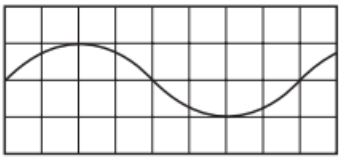
30 A standing sound wave is set up between a loudspeaker and a wall.

A microphone is connected to a cathode-ray oscilloscope (c.r.o.) and is moved along a line directly between the loudspeaker and the wall. The amplitude of the trace on the c.r.o. rises to a maximum at a position X, falls to a minimum and then rises once again to a maximum at a position Y.

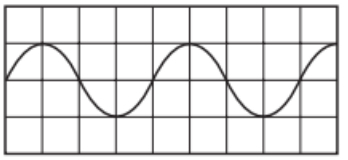
The distance between X and Y is 33 cm. The speed of sound in air is 330 m s^{-1}.

Which diagram represents the c.r.o. trace of the sound received at X?

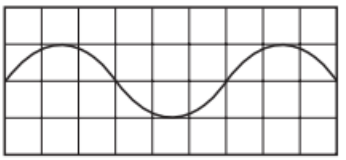
A



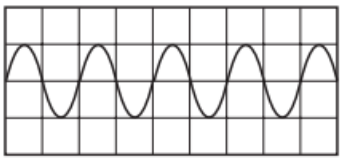
B



C



D



W11/11

128. A

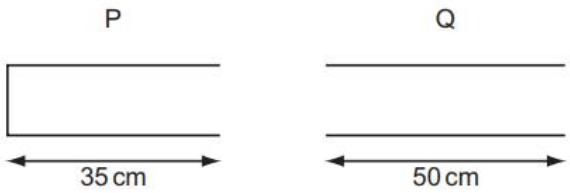
27 P is a source emitting infra-red radiation and Q is a source emitting ultra-violet radiation. The figures in the table are suggested values for the wavelengths emitted by P and Q.

Which row is correct?

	wavelength emitted by P / m	wavelength emitted by Q / m
A	5×10^{-5}	5×10^{-8}
B	5×10^{-5}	5×10^{-10}
C	5×10^{-7}	5×10^{-8}
D	5×10^{-7}	5×10^{-10}

129. A

29 Travelling waves of wavelength 20 cm are created in the air columns in a closed pipe P and an open pipe Q. The lengths of the pipes are shown.



In which pipe or pipes are stationary waves formed?

A P and Q

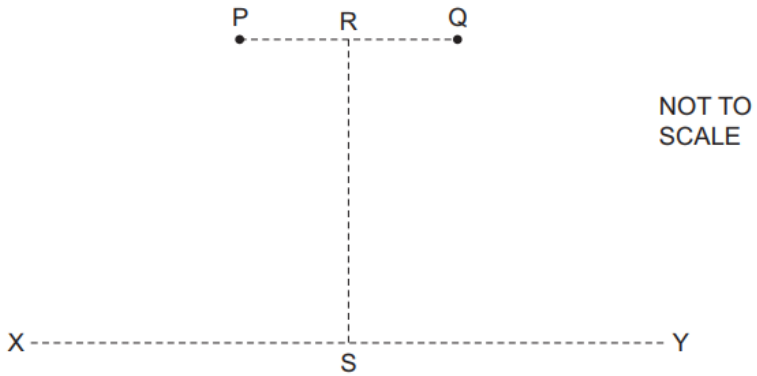
B P only

C Q only

D neither P nor Q

130. C

30 Coherent waves are produced at P and at Q and travel outwards in all directions. The line RS is halfway between P and Q and perpendicular to the line joining P and Q. The distance RS is much greater than the distance PQ.



Along which line, or lines, is an interference pattern observed?

A both RS and XY

B RS only

C XY only

D neither RS nor XY

W11/12

131. B

25 Which statement about electromagnetic radiation is correct?

A Waves of wavelength 5×10^{-9} m are high-energy gamma rays.

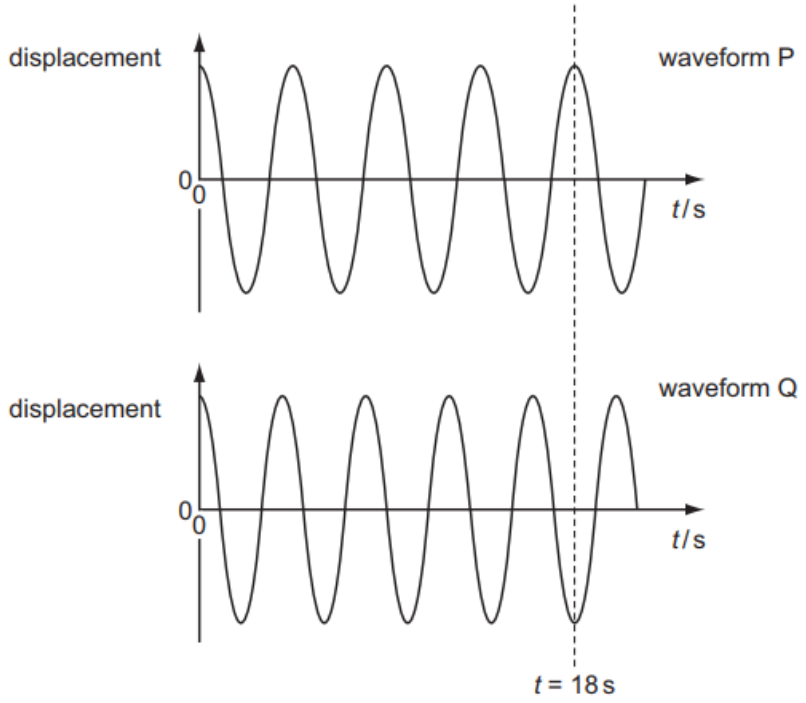
B Waves of wavelength 3×10^{-8} m are ultra-violet waves.

C Waves of wavelength 5×10^{-7} m are infra-red waves.

D Waves of wavelength 9×10^{-7} m are light waves.

132. B

26 The diagram shows two sinusoidal waveforms.



At time $t = 0$ the waves are in phase. At the dotted line, $t = 18$ s.

At which time is the phase difference between the two oscillations ⅛ of a cycle?

A 4.0 s **B** 4.5 s **C** 8.0 s **D** 9.0 s

133. B

27 A sound wave is set up in a long tube, closed at one end. The length of the tube is adjusted until the sound from the tube is loudest.

What is the nature of the sound wave in the tube?

A longitudinal and progressive

B longitudinal and stationary

C transverse and progressive

D transverse and stationary

134. A

28 Two light sources produce visible interference fringes only in certain circumstances.

Which condition enables visible interference fringes to be formed?

A using a white light source

B using incoherent sources

C using one light source which is polarised at right angles to light from the other source

D using sources from which the light does not overlap

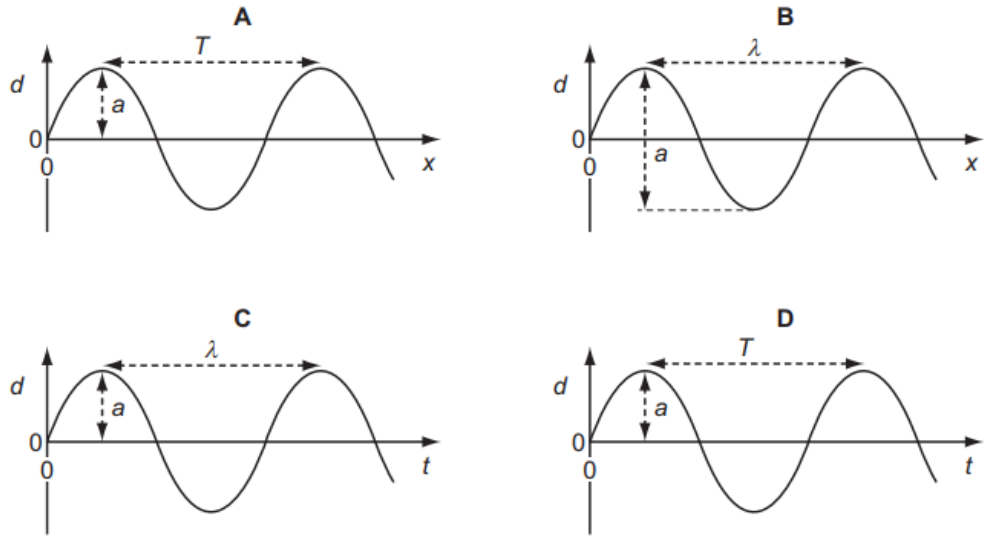
S11/11

135. D

22 The four graphs represent a progressive wave on a stretched string. Graphs **A** and **B** show how the displacement *d* varies with distance *x* along the string at one instant. Graphs **C** and **D** show how the displacement *d* varies with time *t* at a particular value of *x*.

The labels on the graphs are intended to show the wavelength λ, the period *T* and the amplitude *a* of the wave, but only one graph is correctly labelled.

Which graph is correctly labelled?



136. B

23 Which statement about sound waves in air at constant temperature is correct?

A Amplitude is inversely proportional to velocity.

B Frequency is inversely proportional to wavelength.

C Velocity is proportional to wavelength.

D Wavelength is proportional to amplitude.

137. A

24 A source of sound of constant power P is situated in an open space. The intensity I of sound at distance r from this source is given by

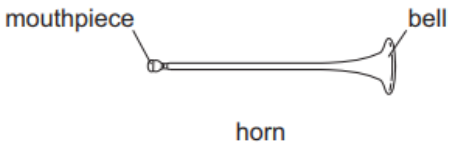
$$I = \frac{P}{4\pi r^2}.$$

How does the amplitude a of the vibrating air molecules vary with the distance r from the source?

A $a \propto \frac{1}{r}$ **B** $a \propto \frac{1}{r^2}$ **C** $a \propto r$ **D** $a \propto r^2$

138. D

25 The basic principle of note production in a horn is to set up a stationary wave in an air column.



horn

For the lowest note produced by a horn, a node is formed at the mouthpiece and the antinode is formed at the bell. The frequency of this note is 75 Hz.

What are the frequencies of the next two higher notes for this air column?

	first higher note /Hz	second higher note /Hz
A	113	150
B	150	225
C	150	300
D	225	375

139. B

26 Which electromagnetic wave phenomenon is needed to explain the spectrum produced when white light falls on a diffraction grating?

A coherence

B interference

C polarisation

D refraction

S11/12

140. C

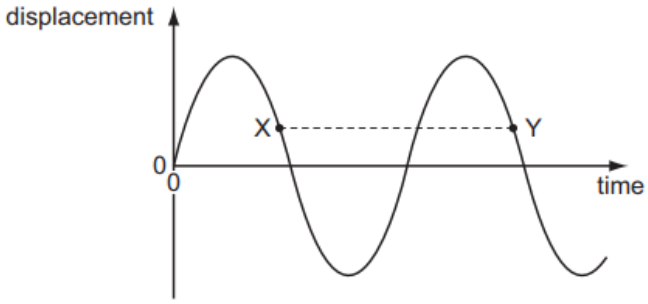
25 In which order of magnitude are the frequencies of electromagnetic waves in the visible spectrum?

A 10^{12} Hz **B** 10^{13} Hz **C** 10^{14} Hz **D** 10^{15} Hz

141. B

26 A transverse progressive wave is set up on a string.

The graph shows the variation with time of displacement for a point on this string.



The separation XY on the graph represents the .....1..... of the wave.

X and Y have equal .....2..... .

Which words correctly complete gaps 1 and 2?

	1	2
A	time period	amplitudes
B	time period	displacements
C	wavelength	amplitudes
D	wavelength	displacements

142. C

28 In which situation does diffraction occur?

A A wave bounces back from a surface.

B A wave passes from one medium into another.

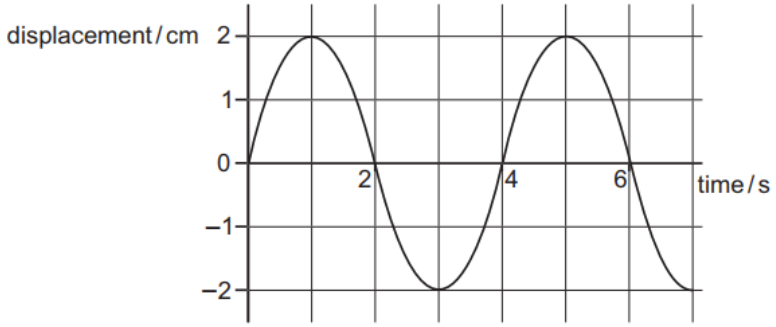
C A wave passes through an aperture.

D Waves from two identical sources are superposed.

W10/11

143. A

23 The graph shows how the displacement of a particle in a wave varies with time.



Which statement is correct?

A The wave has an amplitude of 2 cm and could be either transverse or longitudinal.

B The wave has an amplitude of 2 cm and must be transverse.

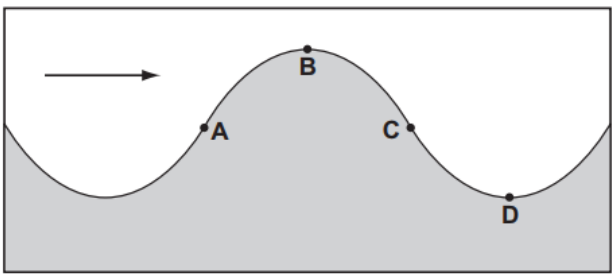
C The wave has an amplitude of 4 cm and could be either transverse or longitudinal.

D The wave has an amplitude of 4 cm and must be transverse.

144. C

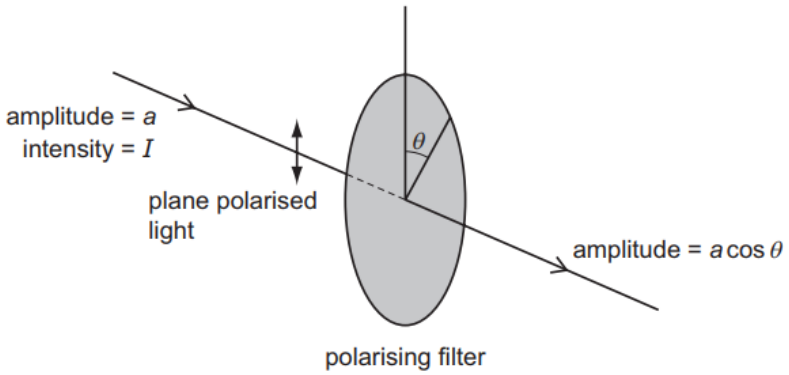
24 The diagram shows a vertical cross-section through a water wave moving from left to right.

At which point is the water moving upwards with maximum speed?



145. A

25 When plane-polarised light of amplitude a is passed through a polarising filter as shown, the amplitude of the light emerging is $a\cos\theta$.



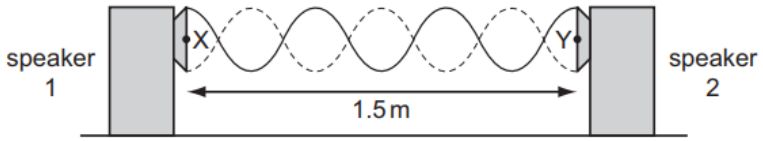
The intensity of the initial beam is I.

What is the intensity of the emerging light when θ is 60.0°?

A $0.250\,I$ **B** $0.500\,I$ **C** $0.750\,I$ **D** $0.866\,I$

146. A

26 A stationary wave is produced by two loudspeakers emitting sound of the same frequency.



When a microphone is moved between X and Y, a distance of 1.5 m, six nodes and seven antinodes are detected.

What is the wavelength of the sound?

A 0.50 m **B** 0.43 m **C** 0.25 m **D** 0.21 m

147. D

27 Which electromagnetic wave would cause the most significant diffraction effect for an atomic lattice of spacing around 10^{-10} m?

A infra-red

B microwave

C ultraviolet

D X-ray

W10/12

148. C

23 The amplitude of a wave is A and its intensity is I.

Which amplitude is necessary for the intensity to be doubled to $2I$?

A A^2 **B** $\sqrt{A}$ **C** $\sqrt{2}\,A$ **D** $2A$

149. C

24 Which value is a possible wavelength for radiation in the ultra-violet region of the electromagnetic spectrum?

A 3×10^{-2} m **B** 3×10^{-5} m **C** 3×10^{-8} m **D** 3×10^{-10} m

150. D

25 The diagram shows two tubes.

The tubes are identical except tube X is closed at its lower end while tube Y is open at its lower end. Both tubes have open upper ends.

A tuning fork placed above tube X causes resonance of the air at frequency f. No resonance is found at any **lower** frequency than f with tube X.

Which tuning fork will produce resonance when placed just above tube Y?

A a fork of frequency $\frac{f}{2}$

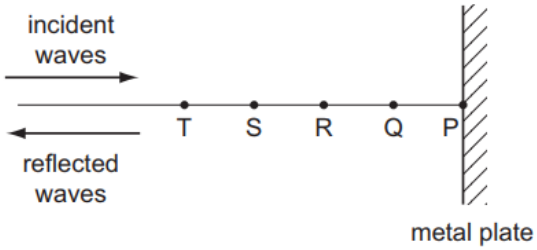
B a fork of frequency $\frac{2f}{3}$

C a fork of frequency $\frac{3f}{2}$

D a fork of frequency $2f$

151. C

26 A microwave transmitter emits waves towards a metal plate. The waves strike the plate and are reflected back along their original path.



A microwave detector is moved along the line PT.

Points P, Q, R, S and T are the positions where minima of intensity are observed. These points are found to be 15 mm apart.

What is the frequency of the microwaves?

A 5.0 GHz **B** 6.7 GHz **C** 10 GHz **D** 20 GHz

S10/11

152. C

22 Electromagnetic waves from an unknown source in space were found to be significantly diffracted when passing through gaps of the order of 10^{-5} m.

Which type of wave are they most likely to be?

A radio waves

B microwaves

C infra-red waves

D ultraviolet waves

153. A

24 Diagram 1 shows a ripple tank experiment in which plane waves are diffracted through a narrow slit in a metal sheet.

Diagram 2 shows the same tank with a slit of greater width.

In each case, the pattern of the waves incident on the slit and the emergent pattern are shown.

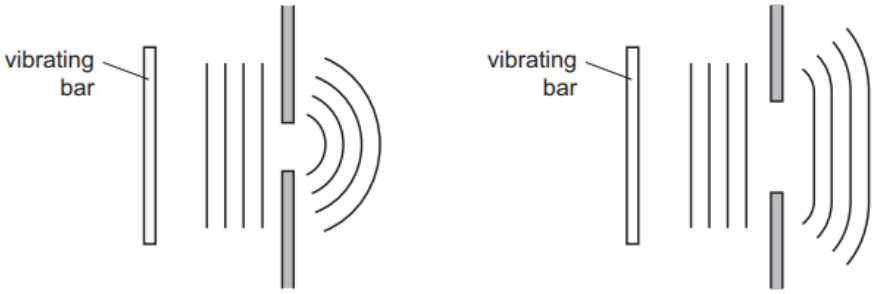


diagram 1 diagram 2

Which action would cause the waves in diagram 1 to be diffracted less and so produce an emergent pattern closer to that shown in diagram 2?

A increasing the frequency of vibration of the bar

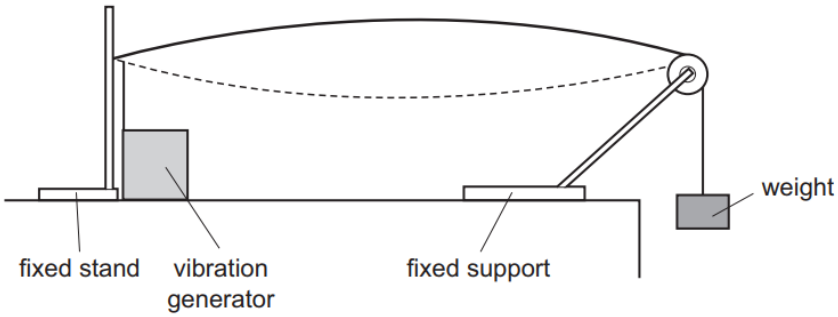
B increasing the speed of the waves by making the water in the tank deeper

C reducing the amplitude of vibration of the bar

D reducing the length of the vibrating bar

154. C

25 The diagram shows a steel wire clamped at one end and tensioned at the other by a weight hung over a pulley.



A vibration generator is attached to the wire near the clamped end. A stationary wave with one loop is produced. The frequency of the vibration generator is *f*.

Which frequency should be used to produce a stationary wave with two loops?

A $\frac{f}{4}$ **B** $\frac{f}{2}$ **C** $2f$ **D** $4f$

New Topic 8:

8. DOUBLE SLIT AND DIFFRACTION GRATING

S16/11

1. D

26 A parallel beam of light of wavelength 450 nm is incident normally on a diffraction grating which has 300 lines / mm.

What is the total number of intensity maxima observed?

A 7 **B** 8 **C** 14 **D** 15

2. D

27 Fringes of separation x are observed on a screen 1.00 m from a double slit that is illuminated by yellow light of wavelength 600 nm.

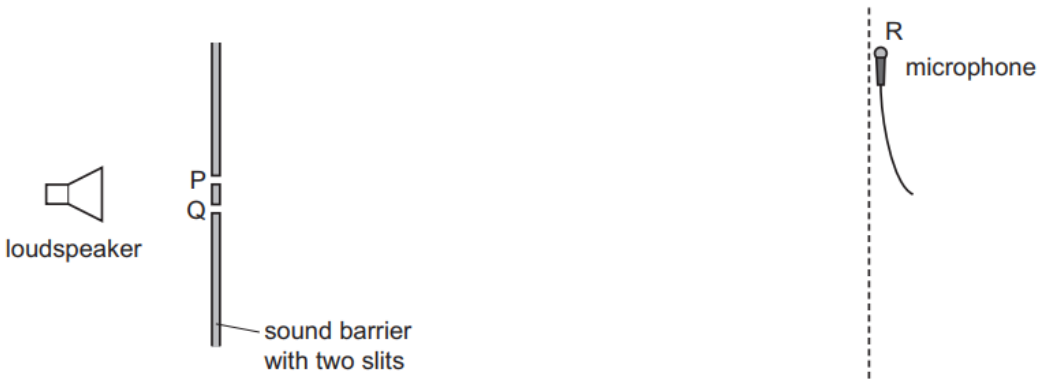
At which distance from the slits would fringes of the same separation x be observed when using blue light of wavelength 400 nm?

A 0.33 m **B** 0.67 m **C** 0.75 m **D** 1.50 m

S16/12

3. D

27 Sound waves of wavelength λ are emitted by a loudspeaker and pass through two slits P and Q. Two sound waves from the slits meet at R.



What is the condition for an intensity maximum (loud sound) to be detected by a microphone at R?

A The amplitudes of the two waves at R must be the same.

B The distance PQ must be smaller than the wavelength λ.

C The two waves from the slits must have travelled the same distance to R.

D The two waves must be in phase at R.

4. C

28 Coherent light passes through a double slit, producing bright and dark fringes on a screen placed parallel to the plane of the double slit. The intensity of the light from each of the slits is initially the same.

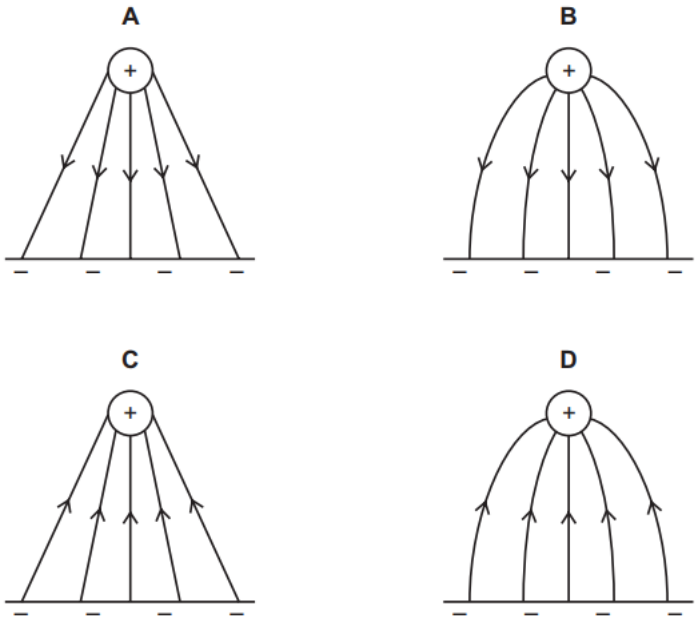
The intensity of the light passing through one of the slits in the double slit is now increased. The frequency of the light remains constant.

What is the effect on the appearance of the fringes on the screen?

	separation of fringes	maximum intensity of dark fringes
A	decreases	no change
B	increases	greater
C	no change	greater
D	no change	no change

5. B

29 Which diagram shows the pattern of the electric field between a positively charged metal sphere and a negatively charged metal plate?

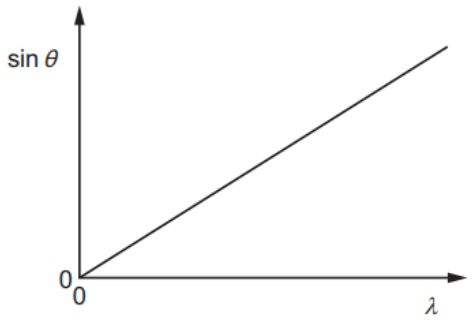


S16/13

6. A

27 A diffraction grating with N lines per metre is used to deflect light of various wavelengths λ.

The graph shows a relation between the deflection angle θ and λ for different wavelengths in the n^{th} order interference pattern.



What is the gradient of the graph?

A Nn **B** $\frac{N}{n}$ **C** $\frac{n}{N}$ **D** $\frac{1}{Nn}$

7. D

28 Which wave phenomenon is **not** needed to explain the pattern of observable fringes produced by a double slit experiment?

A coherence

B diffraction

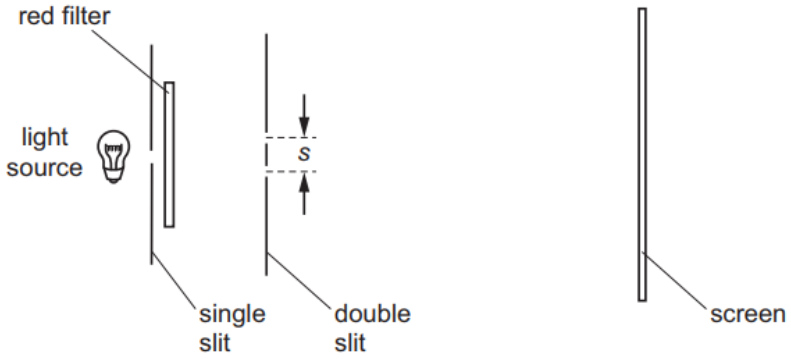
C interference

D reflection

W15/11

8. A

26 A student sets up an experiment to investigate double-slit interference of light but finds that the interference fringes observed on the screen are too close to each other to be distinguished.



Which change would help the student to distinguish the fringes?

A decrease the distance *s* between the two slits

B increase the width of each slit

C move the screen closer to the light source

D use a blue filter instead of a red filter

9. A

28 Water waves of wavelength λ are diffracted as they pass through a gap of width d in a barrier.

Which combination of wavelength and gap width would produce the greatest angle of diffraction?

	gap width	wavelength
A	$\frac{1}{2}d$	2λ
B	$\frac{1}{2}d$	$\frac{1}{2}\lambda$
C	$2d$	2λ
D	$2d$	$\frac{1}{2}\lambda$

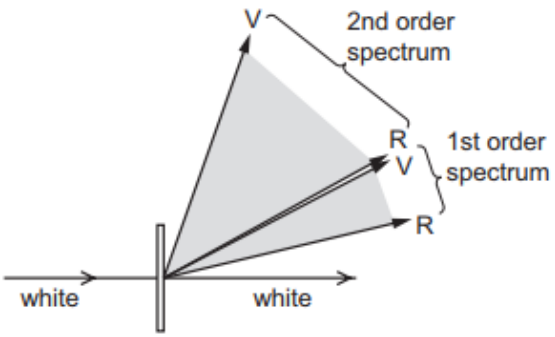
W15/12

10. C

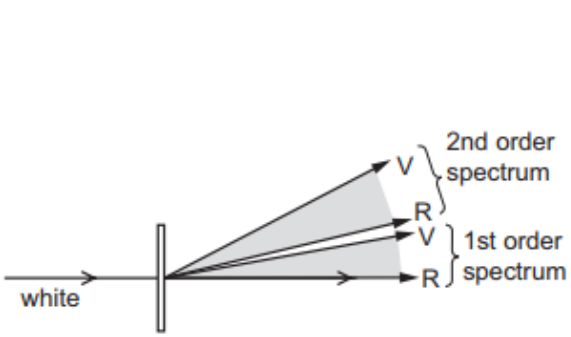
29 White light consists of many wavelengths. The wavelength of red light R is approximately twice the wavelength of violet light V. When white light is incident normally on a diffraction grating, several spectra can be formed.

Which diagram shows the possible distributions of light in the first order and the second order spectra?

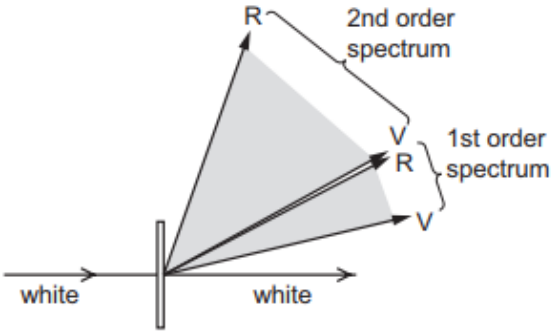
A



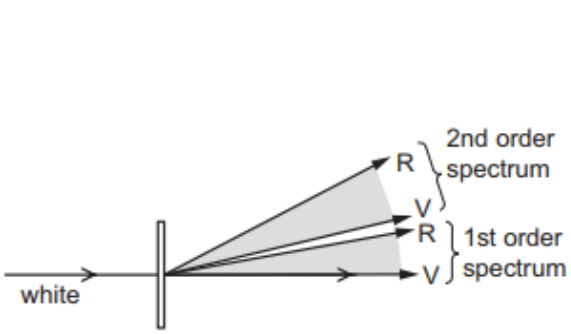
B



C



D



W15/13

11. B

25 Monochromatic light passes through two narrow slits and produces an interference pattern on a screen some distance away. The interference fringes are very close together.

Which change would **increase** the distance between the fringes?

A Increase the brightness of the light source.

B Increase the distance between the slits and the screen.

C Increase the distance between the two slits.

D Increase the frequency of the light used.

12. B

27 Monochromatic light is directed onto a pair of slits. Interference fringes that are 2.0 mm apart are observed on a distant screen.

The frequency of the light used is then doubled and the slit separation is halved.

How far apart are the new interference fringes?

A 0.50 mm **B** 2.0 mm **C** 4.0 mm **D** 8.0 mm

13. C

28 A diffraction grating has N lines per unit length and is placed at 90° to monochromatic light of wavelength λ.

What is the expression for θ, the angle to the normal to the grating at which the third order diffraction peak is observed?

A $\sin\theta = \frac{1}{3N\lambda}$ **B** $\sin\theta = \frac{N\lambda}{3}$ **C** $\sin\theta = 3N\lambda$ **D** $\sin\theta = \frac{3\lambda}{N}$

S15/11

14. B

30 In a double-slit experiment the distance between the fringes, on a screen, was too small to measure.

What would increase the distance between the fringes?

A increasing the distance between the light source and the slits

B increasing the distance between the slits and the screen

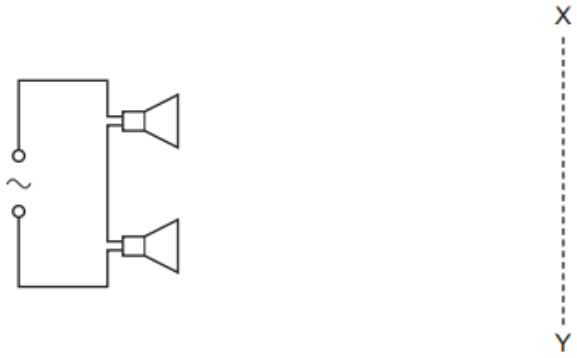
C increasing the distance between the slits

D increasing the frequency of the light source

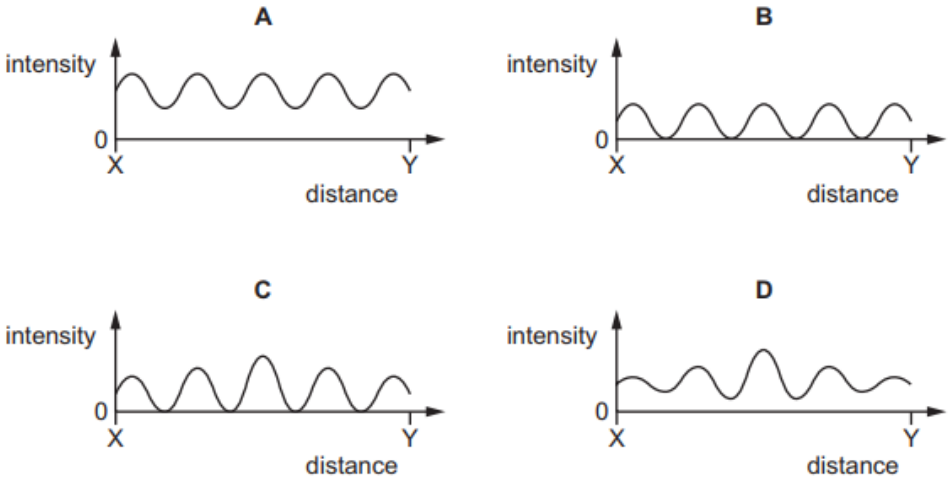
W14/11

15. D

26 Two identical loudspeakers are connected in series to an a.c. supply, as shown.

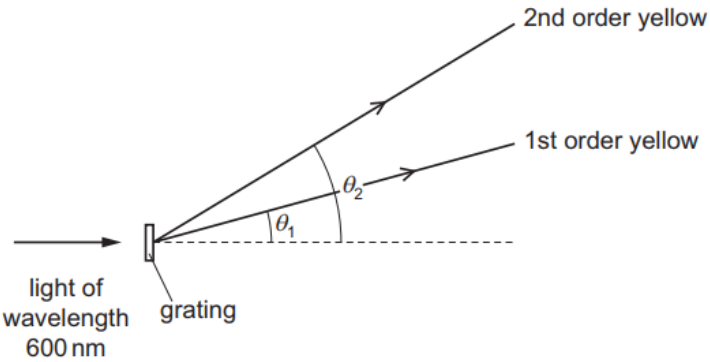


Which graph best shows the variation of the intensity of the sound with distance along the line XY?



16. B

27 A diffraction grating experiment is set up using yellow light of wavelength 600 nm. The grating has a slit separation of 2.00 μm.



What is the angular separation ($\theta_2 - \theta_1$) between the first and second order maxima of the yellow light?

A 17.5° **B** 19.4° **C** 36.9° **D** 54.3°

W14/13

17. D

30 Interference fringes are produced on a screen by double-slit interference using light of wavelength 600 nm. The fringe separation is 4.0 mm and the separation of the slits is 0.60 mm.

What is the distance between the double slit and the screen?

A 0.25 m **B** 0.40 m **C** 2.5 m **D** 4.0 m

S14/11

18. B

26 A parallel beam of white light passes through a diffraction grating. Orange light of wavelength 600 nm in the fourth order diffraction maximum coincides with blue light in the fifth order diffraction maximum.

What is the wavelength of the blue light?

A 450 nm **B** 480 nm **C** 500 nm **D** 750 nm

S14/12

19. D

26 Light passes through a diffraction grating ruled at 1000 lines per cm and the same wavelength of light also passes through two narrow slits 0.5 mm apart. Both situations produce intensity maxima and minima on a screen.

Which statement about the separation of the maxima on the screen and the sharpness of the maxima is correct?

A The diffraction grating maxima are less widely spaced and are less sharp than the two-slit maxima.

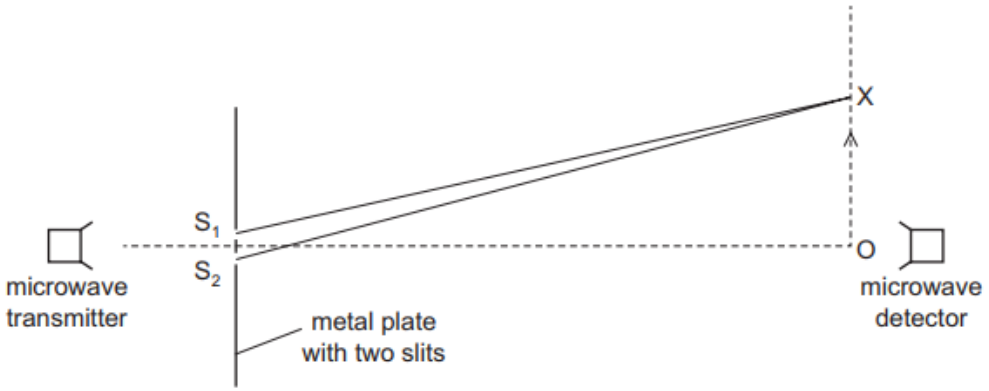
B The diffraction grating maxima are less widely spaced and are sharper than the two-slit maxima.

C The diffraction grating maxima are more widely spaced and are less sharp than the two-slit maxima.

D The diffraction grating maxima are more widely spaced and are sharper than the two-slit maxima.

20. D

27 The diagram shows an experiment which has been set up to demonstrate two-source interference. Microwaves of wavelength λ pass through two slits S_1 and S_2.



The detector is moved from point O in the direction of the arrow. The signal detected decreases until the detector reaches point X, and then starts to increase again as the detector moves beyond X.

Which equation correctly determines the position of X?

A $OX = \lambda$

B $OX = \lambda/2$

C $S_2X - S_1X = \lambda$

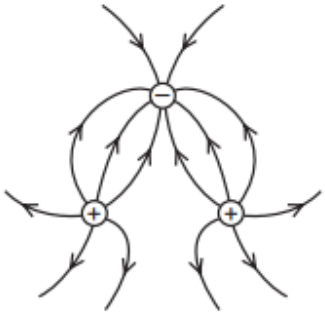
D $S_2X - S_1X = \lambda/2$

21. A

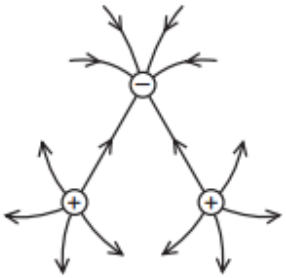
28 Two positive charges and one negative charge, all of equal magnitude, are set at the corners of an equilateral triangle.

Which diagram best represents the electric field surrounding the charges?

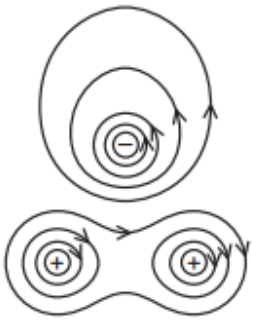
A



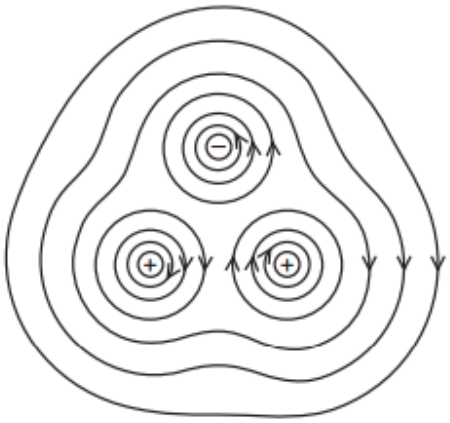
B



C



D



S14/13

22. B

30 Monochromatic light is incident on a diffraction grating and a diffraction pattern is observed.

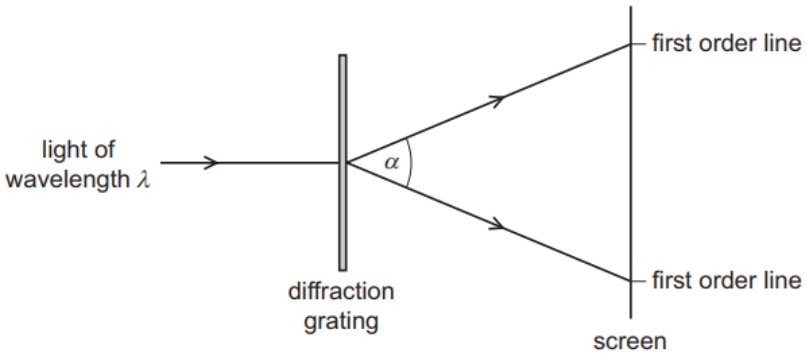
Which line of the table gives the effect of replacing the grating with one that has more lines per metre?

	number of orders of diffraction visible	angle between first and second orders of diffraction
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

W13/11

23. D

28 Light of wavelength λ passes through a diffraction grating with slit spacing d. A series of lines is observed on a screen.

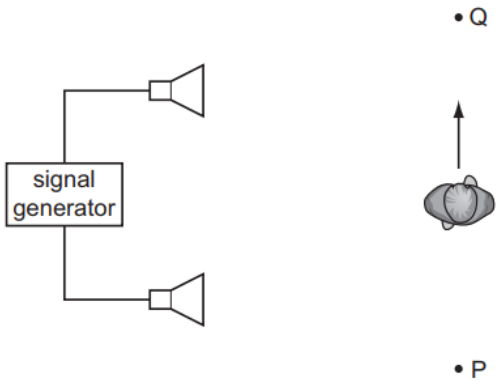


What is the angle α between the two first order lines?

A $\sin^{-1}\left(\frac{\lambda}{2d}\right)$ **B** $\sin^{-1}\left(\frac{\lambda}{d}\right)$ **C** $2\sin^{-1}\left(\frac{\lambda}{2d}\right)$ **D** $2\sin^{-1}\left(\frac{\lambda}{d}\right)$

24. B

29 A student connects two loudspeakers to a signal generator.



As the student walks from P to Q, he notices that the loudness of the sound rises and falls repeatedly.

What causes the loudness of the sound to vary?

A diffraction of the sound waves

B interference of the sound waves

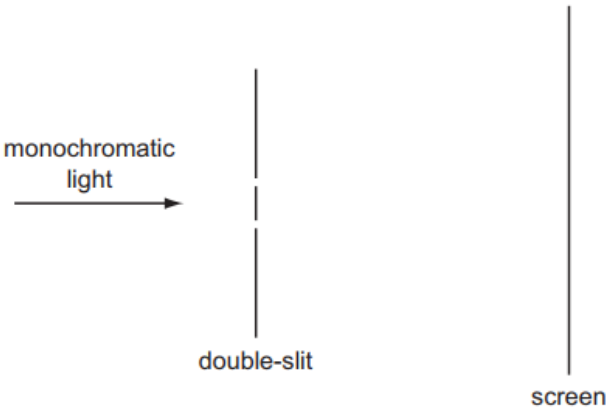
C polarisation of the sound waves

D reflection of the sound waves

W13/13

25. A

29 A student sets up apparatus to observe the double-slit interference of monochromatic light, as shown.



Interference fringes are formed on the screen.

Which change would increase the distance between adjacent fringes?

A Decrease the distance between the two slits.

B Decrease the width of each slit.

C Move the screen closer to the double-slit.

D Use light of a higher frequency.

S13/11

26. A

27 Light of wavelength 600 nm is incident on a pair of slits. Fringes with a spacing of 4.0 mm are formed on a screen.

What will be the fringe spacing when the wavelength of the light is changed to 400 nm and the separation of the slits is doubled?

A 1.3 mm

B 3.0 mm

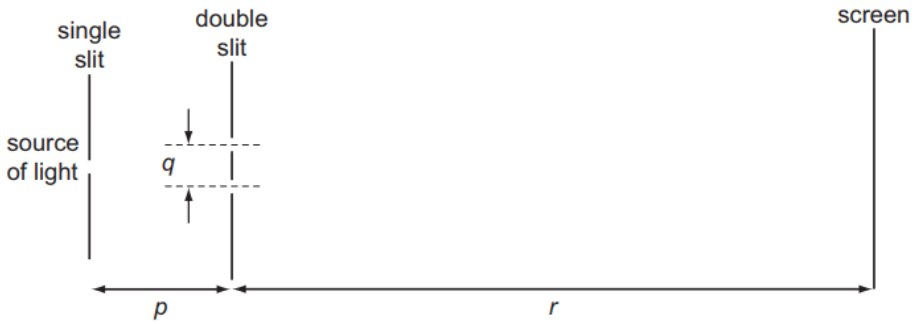
C 5.3 mm

D 12 mm

S13/12

27. B

28 A teacher sets up the apparatus shown to demonstrate a two-slit interference pattern on the screen.



Which change to the apparatus will increase the fringe spacing?

A decreasing the distance *p*

B decreasing the distance *q*

C decreasing the distance *r*

D decreasing the wavelength of the light

28. C

29 Monochromatic light of wavelength 5.30×10^{-7} m is incident normally on a diffraction grating. The first order maximum is observed at an angle of 15.4° to the direction of the incident light.

What is the angle between the first and second order diffraction maxima?

A 7.6° **B** 15.4° **C** 16.7° **D** 32.0°

S13/13

29. D

27 A parallel beam of red light of wavelength 700 nm is incident normally on a diffraction grating that has 400 lines per millimetre.

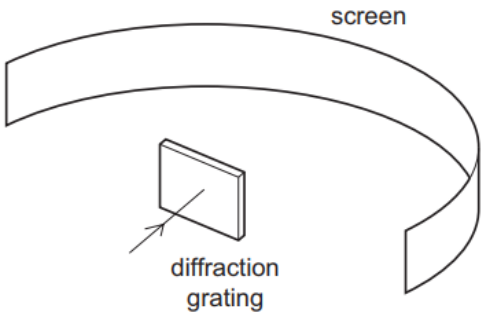
What is the total number of transmitted maxima?

A 3 **B** 4 **C** 6 **D** 7

W12/11

30. B

30 Monochromatic light of wavelength 690 nm passes through a diffraction grating with 300 lines per mm, producing a series of maxima on a screen.



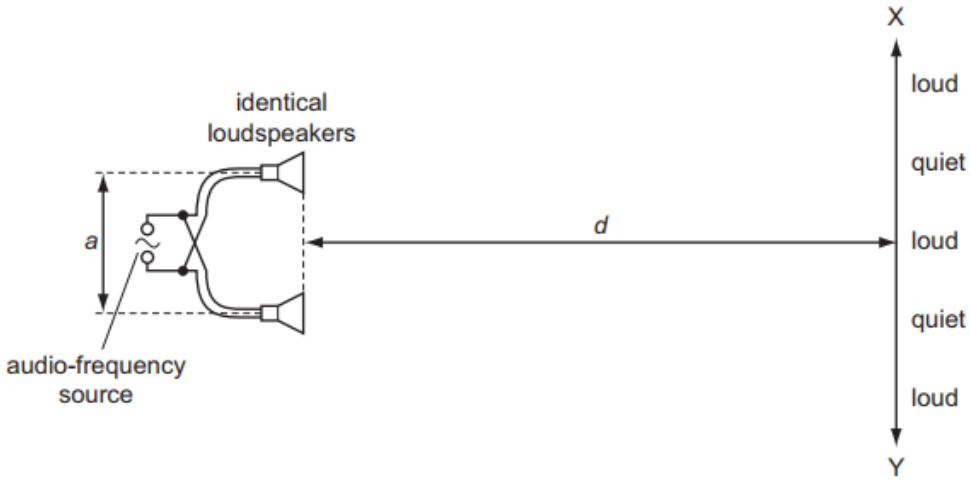
What is the greatest number of maxima that can be observed?

A 4 **B** 5 **C** 8 **D** 9

W12/12

31. C

28 The diagram shows two identical loudspeakers driven in phase by a common audio-frequency source.



When a student moves along line XY, she notices that there are variations in the loudness of the sound. The regions in which the sound is heard are alternately loud and quiet as indicated on the diagram.

How may the distance between loud regions be reduced?

A decreasing the distance *a* between the speakers

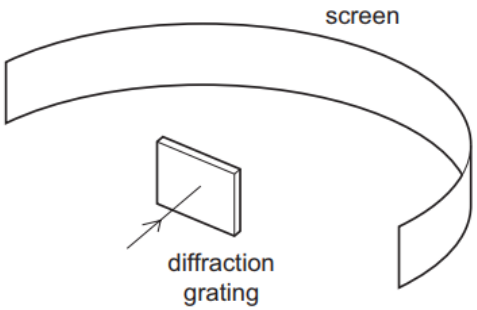
B increasing distance *d*

C increasing the frequency of the audio-frequency source

D increasing the power output from the audio-frequency source

32. D

30 Monochromatic light of wavelength 690 nm passes through a diffraction grating with 300 lines per mm, producing a series of maxima on a screen.



What is the greatest number of maxima that can be observed?

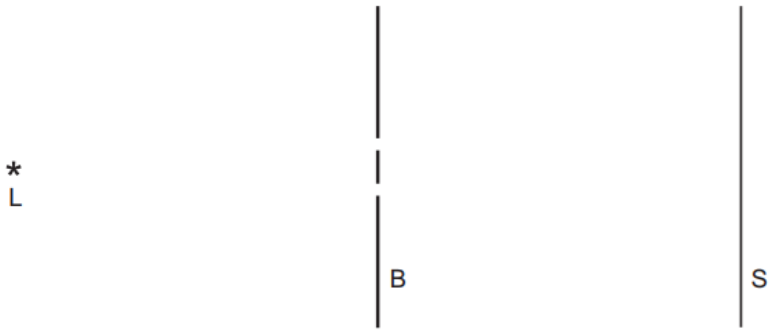
A 4 **B** 5 **C** 8 **D** 9

W11/11

33. D

28 The diagram shows a view from above of a double slit interference demonstration.

L is a monochromatic light source with a vertical filament. B is a barrier with two narrow vertical slits and S is a screen upon which interference fringes form.



The intensity is I at a point on the screen where the centre of the fringe pattern forms.

What is the intensity, at the same point, when one of the slits is covered up?

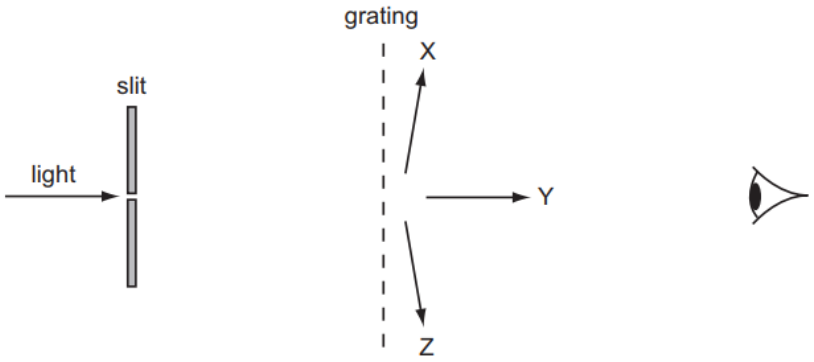
A $\frac{I}{\sqrt{2}}$ **B** $\frac{I}{2}$ **C** $\frac{I}{2\sqrt{2}}$ **D** $\frac{I}{4}$

S11/11

34. D

27 A diffraction grating with 500 lines per mm is used to observe diffraction of monochromatic light of wavelength 600 nm.

The light is passed through a narrow slit and the grating is placed so that its lines are parallel to the slit. Light passes through the slit and then the grating.



An observer views the slit through the grating at different angles, moving his head from X parallel to the grating, through Y, opposite the slit, to Z parallel to the grating on the opposite side.

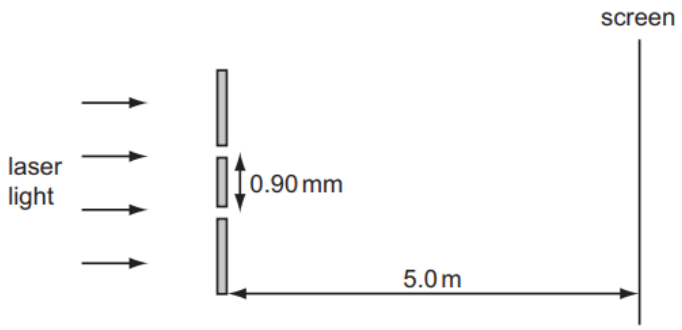
How many images of the slit does he see?

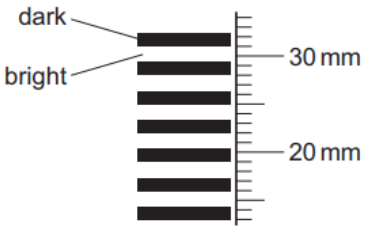
A 3 **B** 4 **C** 6 **D** 7

S11/12

35. B

29 The diagrams show the arrangement of apparatus for a Young's slits experiment and also part of the pattern formed on the screen with a ruler placed next to it.





What is the wavelength of the light?

A 4.8×10^{-7} m **B** 5.4×10^{-7} m **C** 3.2×10^{-6} m **D** 3.4×10^{-6} m

W10/12

36. B

27 A double slit experiment, using light of wavelength 600 nm, results in fringes being produced on a screen. The fringe separation is found to be 1.0 mm.

When the distance between the double slits and the viewing screen is increased **by** 2.0 m, the fringe separation increases **to** 3.0 mm.

What is the separation of the double slits producing the fringes?

A 0.4 mm **B** 0.6 mm **C** 0.9 mm **D** 1.2 mm

S10/11

37. B

23 Using monochromatic light, interference fringes are produced on a screen placed a distance D from a pair of slits of separation a. The separation of the fringes is x.

Both a and D are now doubled.

What is the new fringe separation?

A $\frac{x}{2}$ **B** x **C** $2x$ **D** $4x$

New Topic 9:

9. ELECTRIC FIELD AND ELECTRICITY

S16/11

1. A

28 A charged particle is moving in a uniform electric field.

For the motion of the particle due to the field, which quantity has a constant non-zero value?

A acceleration

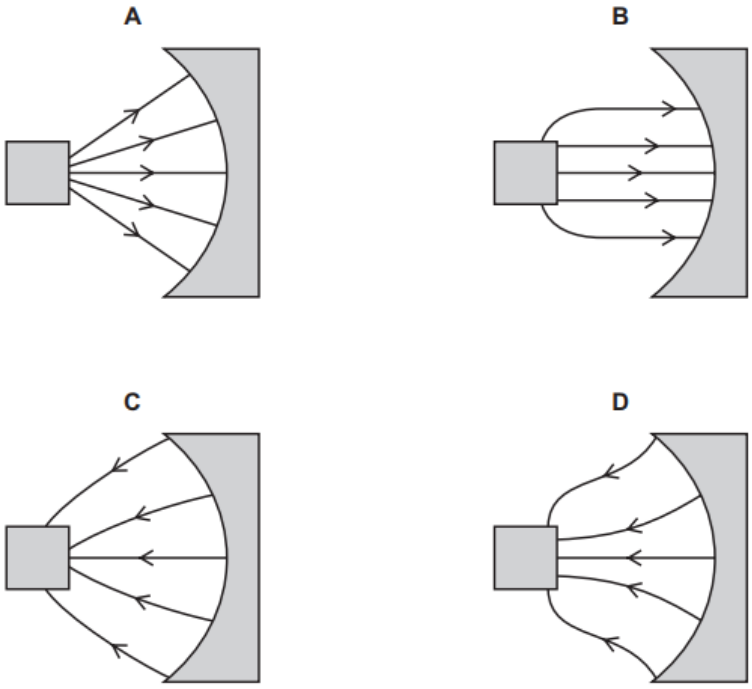
B displacement

C rate of change of acceleration

D velocity

2. D

29 Which diagram could represent the electric field lines between two oppositely charged conducting surfaces?



3. C

30 There is a current in a resistor for an unknown time.

Which two quantities can be used to calculate the energy dissipated by the resistor?

A the current in the resistor and the potential difference across the resistor

B the resistance of the resistor and the current in the resistor

C the total charge passing through the resistor and the potential difference across the resistor

D the total charge passing through the resistor and the resistance of the resistor

S16/12

4. C

30 Before a thunderstorm, the hairs on your head sometimes stand on end.

A hair with mass 0.50 mg and charge 1.0 pC is supported by a force due to an electric field. Ignore any forces other than the weight of the hair and the electric force.

What is the electric field strength?

A $4.9 \times 10^{3}\,\mathrm{N\,C^{-1}}$

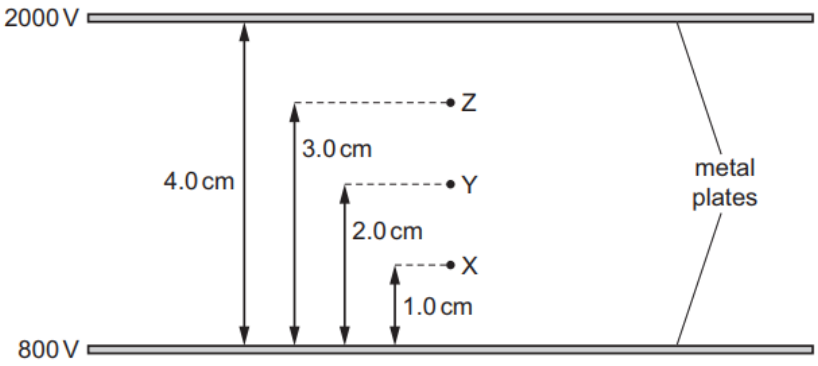
B $4.9 \times 10^{5}\,\mathrm{N\,C^{-1}}$

C $4.9 \times 10^{6}\,\mathrm{N\,C^{-1}}$

D $4.9 \times 10^{9}\,\mathrm{N\,C^{-1}}$

5. C

31 Two parallel metal plates, 4.0 cm apart, are at electric potentials of 800 V and 2000 V. Points X, Y and Z are situated in the space between the plates at distances of 1.0 cm, 2.0 cm and 3.0 cm from the lower plate.



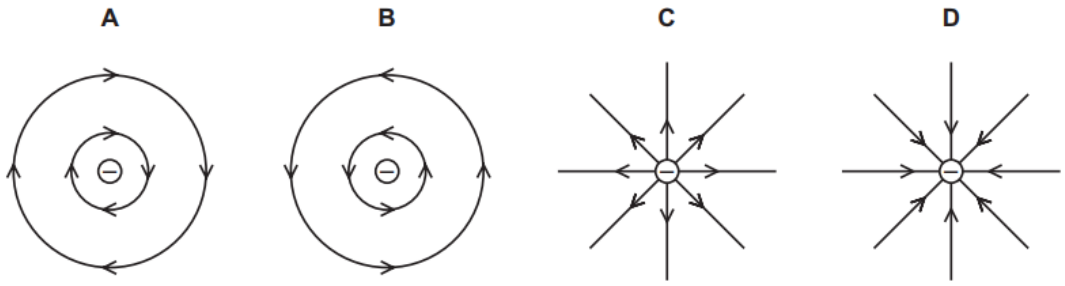
What is the electric field strength, in $V\,m^{-1}$, at X, Y and Z?

	X	Y	Z
A	300	600	900
B	1100	1400	1700
C	3.0×10^4	3.0×10^4	3.0×10^4
D	5.0×10^4	5.0×10^4	5.0×10^4

S16/13

6. D

29 Which diagram shows the electric field pattern of an isolated negative point charge?



7. A

30 An electron is in an electric field of strength $5 \times 10^4\,V\,m^{-1}$. The field is the only influence on the electron.

The mass and charge of an electron are known.

Which quantity can be calculated without any more information?

A the force on the electron

B the momentum of the electron

C the kinetic energy of the electron

D the speed of the electron

8. D

31 In an electrolyte, the electric current is carried by charged particles (ions) in solution.

What is **not** a possible value for the charge on an ion in solution?

A $-4.8 \times 10^{-19}\,C$

B $+1.6 \times 10^{-19}\,C$

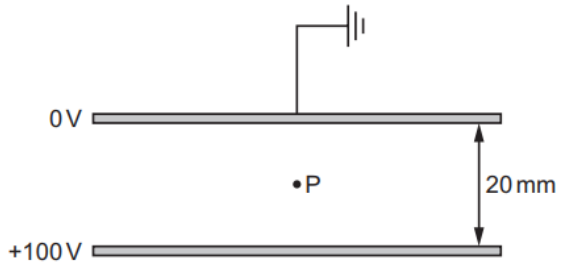
C $+3.2 \times 10^{-19}\,C$

D $+4.0 \times 10^{-19}\,C$

W15/11

9. B

29 Two horizontal parallel plate conductors are separated by a distance of 20 mm in air. The upper plate is earthed and the potential of the lower plate is +100 V.



What is the electric field strength at point P midway between the plates?

A 5000 V m^{-1} downwards

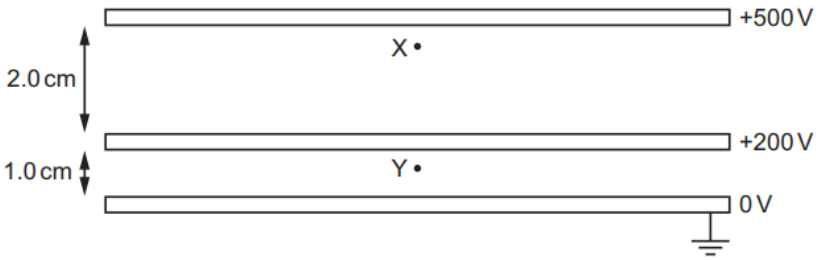
B 5000 V m^{-1} upwards

C 10 000 V m^{-1} downwards

D 10 000 V m^{-1} upwards

10. A

30 Three parallel metal plates of the same area are fixed with a separation of 2.0 cm between the top plate and the centre plate, and 1.0 cm between the centre plate and the bottom plate. The top plate is held at a potential of +500 V, the middle plate at +200 V and the bottom plate is earthed, as shown.



What is the value of the ratio $\frac{\text{magnitude of force on an electron at X}}{\text{magnitude of force on an electron at Y}}$?

A 0.75 **B** 1.00 **C** 1.25 **D** 1.50

W15/12

11. C

18 An electric railway locomotive has a maximum mechanical output power of 4.0 MW. Electrical power is delivered at 25 kV from overhead wires. The overall efficiency of the locomotive in converting electrical power to mechanical power is 80 %.

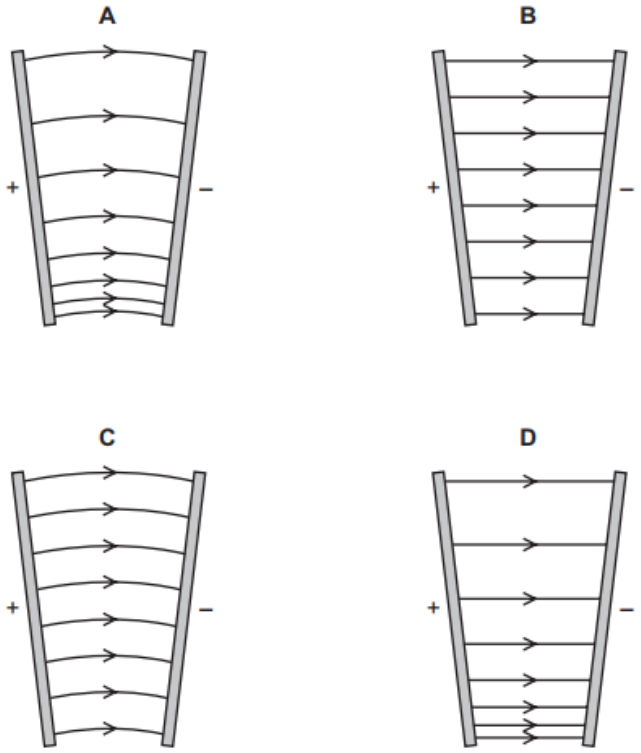
What is the current from the overhead wires when the locomotive is operating at its maximum power?

A 130 A **B** 160 A **C** 200 A **D** 250 A

12. A

31 A potential difference is applied between two metal plates that are **not** parallel.

Which diagram shows the electric field between the plates?



13. A

32 A particle situated between two parallel metal plates carries a charge of 8×10^{-19} C.

The potential difference (p.d.) between the plates is 2000 V. A force of 3.2×10^{-13} N due to the electric field acts on the particle.

What is the distance between the plates?

A 5 mm **B** 8 mm **C** 5 cm **D** 8 cm

14. A

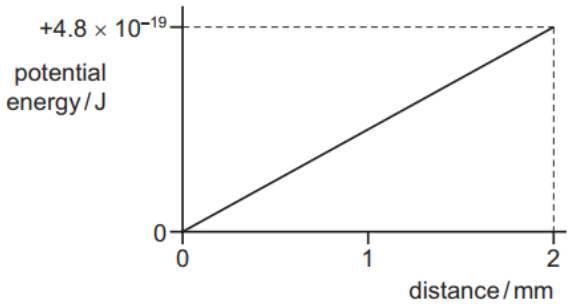
33 Which unit is equivalent to a coulomb (C)?

A As **B** Ωs **C** Vs **D** Ws

W15/13

15. B

29 Two parallel plates R and S are 2 mm apart in a vacuum. An electron with charge -1.6×10^{-19} C moves along a straight line in the electric field between the plates. The graph shows how the potential energy of the electron varies with its distance from plate R.



Which deduction is **not** correct?

A The electric field between R and S is uniform.

B The electric field strength is 3000 N C^{-1}.

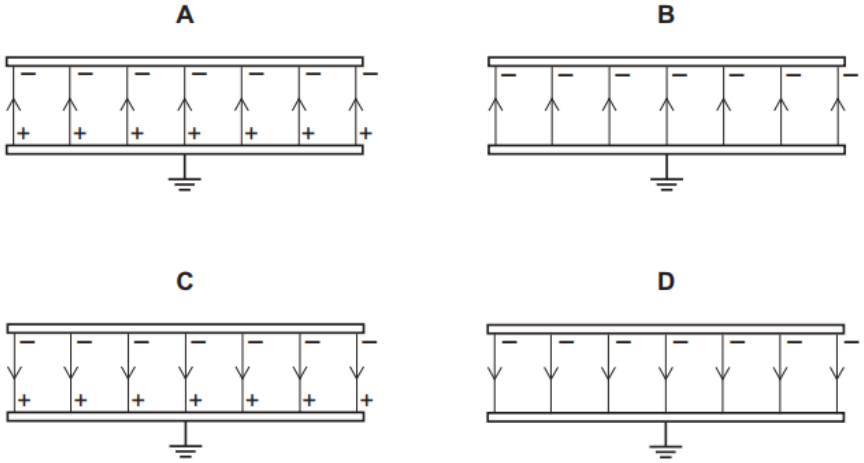
C The force on the electron is constant.

D The magnitude of the potential difference between R and S is 3 V.

16. A

30 Two parallel, conducting plates with air between them are placed close to one another. The top plate is given a negative charge and the bottom one is earthed.

Which diagram best represents the distribution of charges and the field between the plates?



17. A

31 In terms of energy transfer W and charge q, what are the definitions of potential difference (p.d.) and electromotive force (e.m.f.)?

	p.d.	e.m.f.
A	$\frac{W}{q}$	$\frac{W}{q}$
B	$\frac{W}{q}$	Wq
C	Wq	$\frac{W}{q}$
D	Wq	Wq

S15/11

18. D

31 Two parallel metal plates, a distance of 2 mm apart, have a potential difference of 1000 V across them.

What is the electric field strength between the plates?

A $500\,V\,m^{-1}$ **B** $50\,000\,V\,m^{-1}$ **C** $50\,000\,N\,C^{-1}$ **D** $500\,000\,N\,C^{-1}$

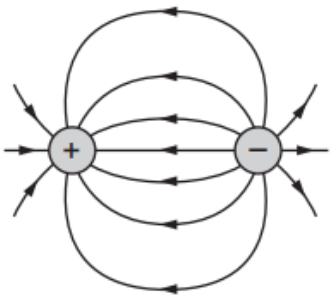
S15/12

19. B

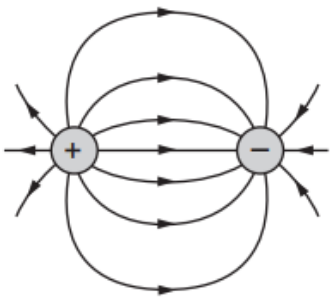
29 A positive charge and a negative charge of equal magnitude are placed a short distance apart.

Which diagram best represents the associated electric field?

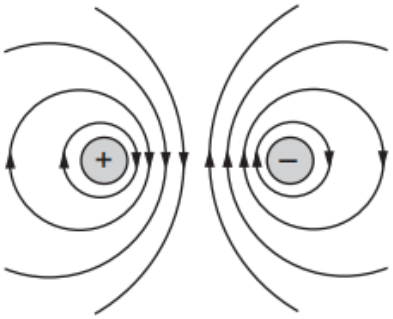
A



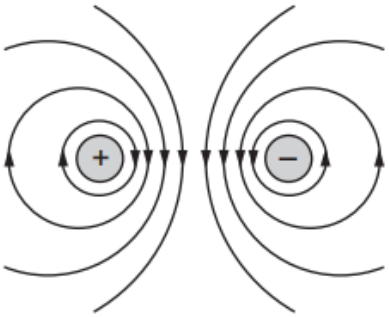
B



C

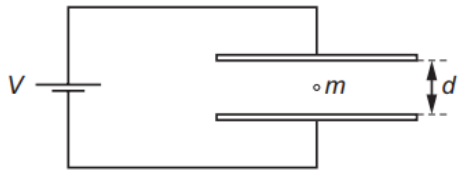


D



20. B

30 A charged oil drop of mass m, with n excess electrons, is held stationary in the uniform electric field between two horizontal plates separated by a distance d.



The voltage between the plates is V, the elementary charge is e and the acceleration of free fall is g.

What is the value of n?

A $\frac{eV}{mgd}$ **B** $\frac{mgd}{eV}$ **C** $\frac{meV}{gd}$ **D** $\frac{gd}{meV}$

21. C

31 Which unit is **not** used in either the definition of the coulomb or the definition of the volt?

A ampere

B joule

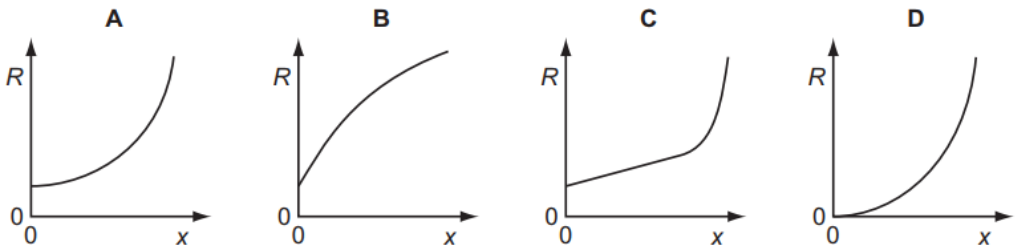
C ohm

D second

22. A

32 When a thin metal wire is stretched, it becomes longer and thinner. This causes a change in the resistance of the wire. The volume of the wire remains constant.

Which graph could represent the variation with extension x of the resistance R of the wire?



23. A

33 Which statement is **not** valid?

A Current is the speed of the charged particles that carry it.

B Electromotive force (e.m.f.) is the energy converted to electrical energy from other forms per unit charge.

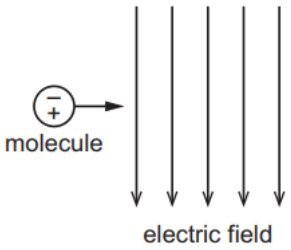
C The potential difference (p.d.) between two points is the work done per unit charge when moving charge from one point to the other.

D The resistance between two points is the p.d. between the two points per unit current.

S15/13

24. B

30 A molecule behaves as an electric dipole consisting of two equal point charges, of opposite sign, separated by a fixed distance. The molecule moves with constant horizontal velocity as it enters a vertical uniform electric field, as shown.



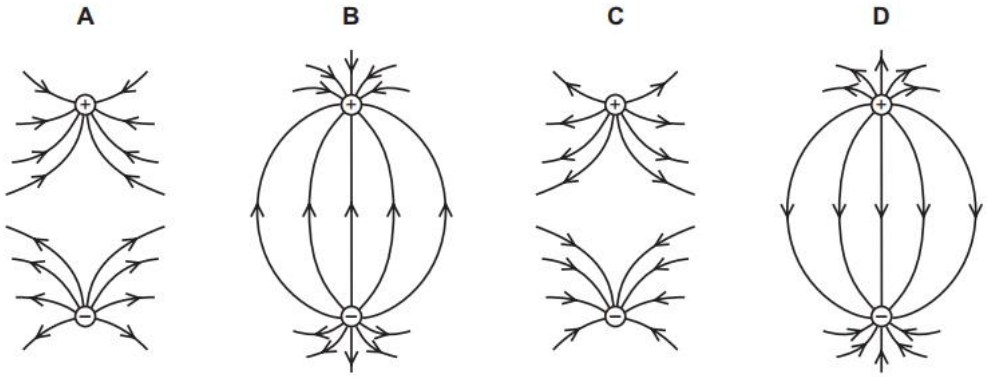
The positive and negative charges of the molecule enter the field at the same time.

Which row describes the velocity of the molecule in the field?

	horizontal component of velocity	vertical component of velocity
A	constant	increases
B	constant	zero
C	increases	increases
D	increases	zero

25. D

31 Which diagram best represents the electric field between two point charges of equal magnitude and opposite sign?



26. D

32 A pedal bicycle is fitted with an electric motor. The rider switches on the motor for a time of 3.0 minutes. A constant current of 3.5 A in the electric motor is provided from a battery with a terminal voltage of 24 V.

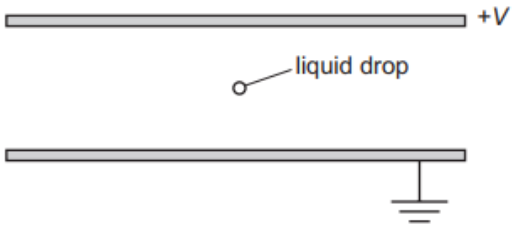
What is the energy supplied by the battery?

A 84 J **B** 250 J **C** 630 J **D** 15 000 J

W14/11

27. B

28 The diagram shows two parallel horizontal metal plates. There is a potential difference *V* between the plates.



A small charged liquid drop, midway between the plates, is held in equilibrium by the combination of its weight and the electric force acting on it.

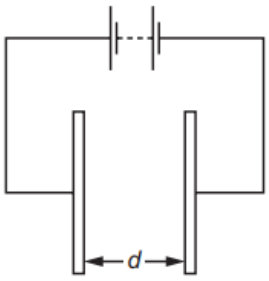
The acceleration of free fall is *g* and the electric field strength is *E*.

What is the polarity of the charge on the drop, and the ratio of charge to mass of the drop?

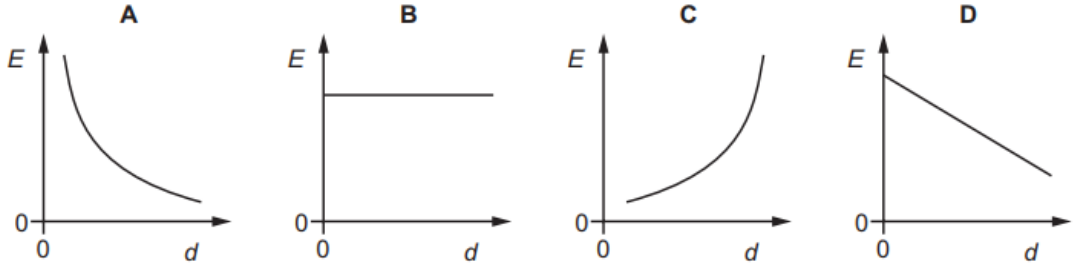
	polarity	$\frac{\text{charge}}{\text{mass}}$
A	negative	$\frac{E}{g}$
B	negative	$\frac{g}{E}$
C	positive	$\frac{E}{g}$
D	positive	$\frac{g}{E}$

28. A

29 The diagram shows two metal plates connected to a constant high voltage.



Which graph shows the variation of the electric field strength *E* midway between the two plates as the distance *d* between the two plates is increased?



29. A

31 A battery is marked 9.0 V.

What does this mean?

A Each coulomb of charge from the battery supplies 9.0 J of electrical energy to the whole circuit.

B The battery supplies 9.0 J to an external circuit for each coulomb of charge.

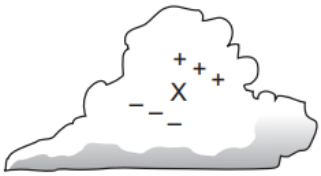
C The potential difference across any component connected to the battery will be 9.0 V.

D There will always be 9.0 V across the battery terminals.

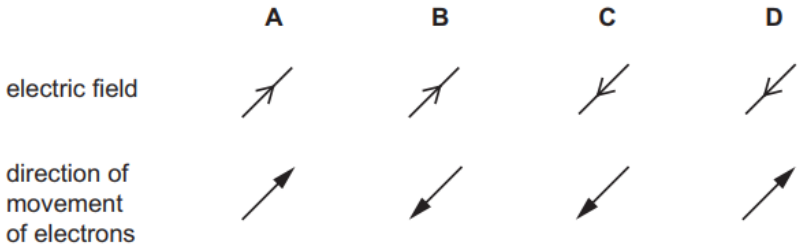
W14/13

30. D

31 Regions of unbalanced charge are produced inside a cloud as shown.

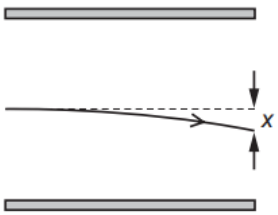


For the region X, which diagram correctly represents the direction of the electric field and the initial direction in which electrons would move?



31. C

32 The path of an electron with initial speed *v* in the uniform electric field between two parallel plates is shown.



The vertical deflection *x* is measured at the right-hand edge of the plates.

The distance between the plates is halved. The potential difference between the plates remains the same.

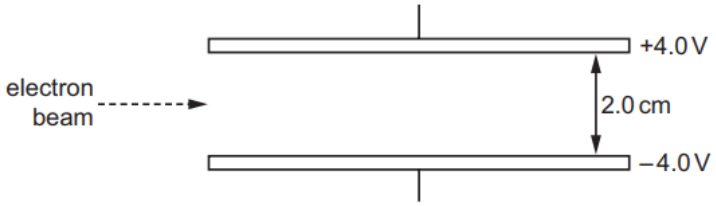
What will be the new deflection of the electron with the same initial speed *v*?

A x **B** $\sqrt{2}x$ **C** $2x$ **D** $4x$

S14/11

32. D

28 A horizontal beam of electrons is passed between two horizontal parallel plates, 2.0 cm apart, as shown.



The upper plate has an electrical potential of +4.0 V, and the lower plate has an electrical potential of −4.0 V.

What is the force on each electron when between the plates?

A 3.2×10^{-17} N downwards

B 3.2×10^{-19} N upwards

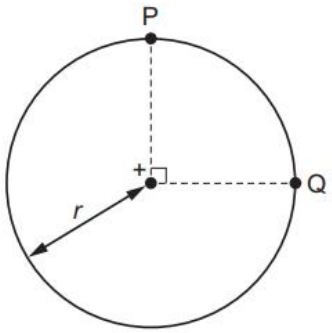
C 6.4×10^{-19} N downwards

D 6.4×10^{-17} N upwards

33. A

29 The diagram shows two points P and Q which lie 90° apart on a circle of radius *r*.

A positive point charge at the centre of the circle creates an electric field of magnitude *E* at both P and Q.



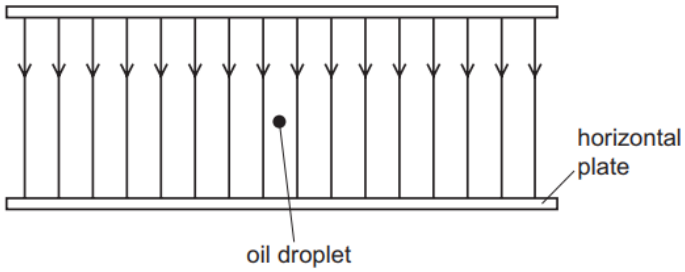
Which expression gives the work done in moving a unit positive charge from P to Q?

A 0 **B** $E \times r$ **C** $E \times \left(\frac{\pi r}{2}\right)$ **D** $E \times (\pi r)$

S14/12

34. D

12 A tiny oil droplet with mass 6.9×10^{-13} kg is at rest in an electric field of electric field strength 2.1×10^{7} N C^{-1}, as shown.



The weight of the droplet is exactly balanced by the electrical force on the droplet.

What is the charge on the droplet?

A 3.3×10^{-20} C

B -3.3×10^{-20} C

C 3.2×10^{-19} C

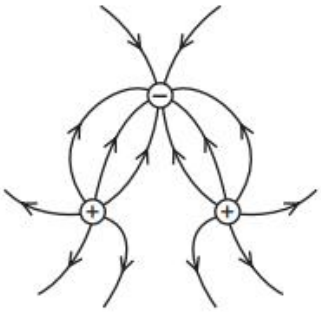
D -3.2×10^{-19} C

35. A

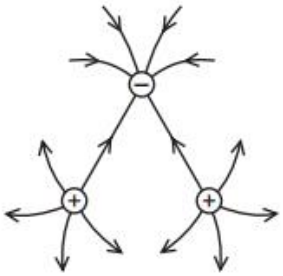
28 Two positive charges and one negative charge, all of equal magnitude, are set at the corners of an equilateral triangle.

Which diagram best represents the electric field surrounding the charges?

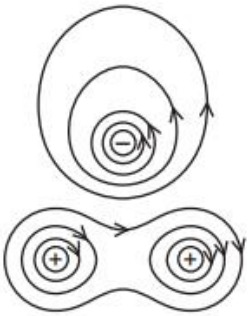
A



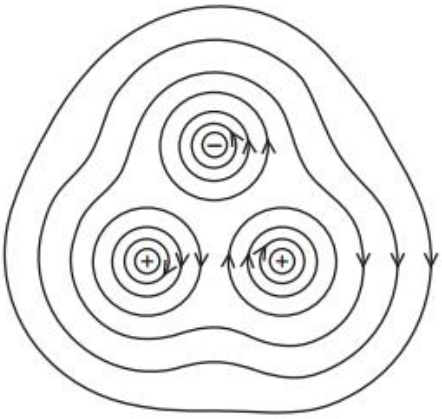
B



C

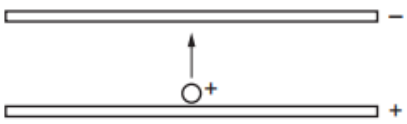


D



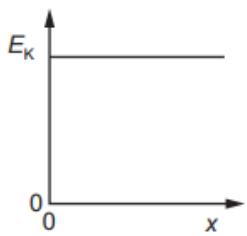
36. D

29 Two oppositely-charged horizontal metal plates are placed in a vacuum. A positively-charged particle starts from rest and moves from one plate to the other plate, as shown.

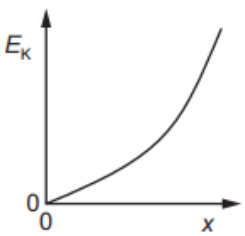


Which graph shows how the kinetic energy E_K of the particle varies with the distance x moved from the positive plate?

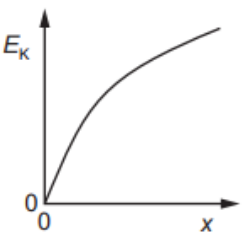
A



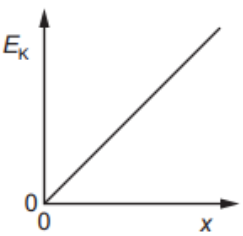
B



C



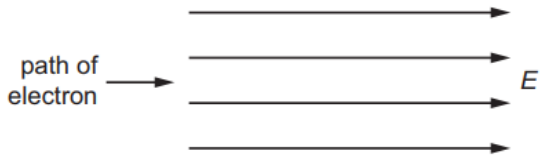
D



S14/13

37. A

31 An electron enters a region of space where there is a uniform electric field *E* as shown.



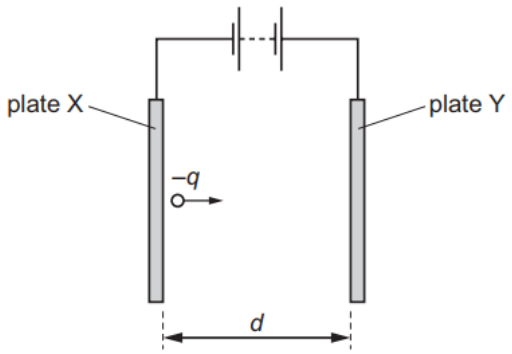
Initially, the electron is moving parallel to, and in the direction of, the electric field.

What is the subsequent path and change of speed of the electron?

	path of electron	speed of electron
A	linear	decreases
B	linear	increases
C	parabolic	decreases
D	parabolic	increases

38. C

32 Two parallel plates X and Y are separated by a distance *d* in a vacuum. There is a potential difference between the plates so that a uniform electric field is produced.



A charge –*q* moves from rest from the surface of plate X and travels towards plate Y.

When the charge reaches plate Y it has kinetic energy *K*.

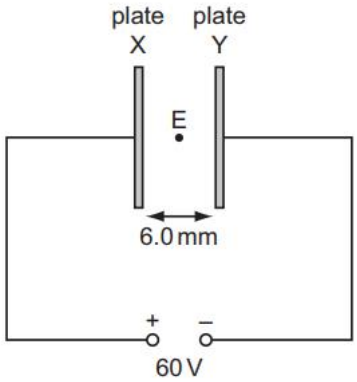
Which expression gives the electric field strength between the plates?

A $\frac{q}{Kd}$ **B** $\frac{qd}{K}$ **C** $\frac{K}{qd}$ **D** $\frac{Kd}{q}$

W13/11

39. B

31 Two vertical conducting plates X and Y are positioned so that they are separated by a distance of 6.0 mm in air. A 60 V d.c. supply is connected as shown.



What is the electric field strength at E, a point midway between the plates?

A $1.0 \times 10^4\,V\,m^{-1}$ towards X

B $1.0 \times 10^4\,V\,m^{-1}$ towards Y

C $2.0 \times 10^4\,V\,m^{-1}$ towards X

D $2.0 \times 10^4\,V\,m^{-1}$ towards Y

40. C

32 Two parallel metal plates have a potential difference between them of 12 V. The distance between the plates is 1.0 mm.

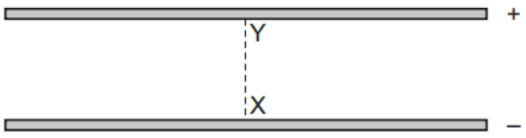
What are the electric field strength between the plates and the work done on a charge of +3.9 μC to move the charge from the negative plate to the positive plate?

	electric field strength / $N\,C^{-1}$	work done / J
A	12	4.7×10^{-5}
B	12	47
C	12 000	4.7×10^{-5}
D	12 000	47

W13/13

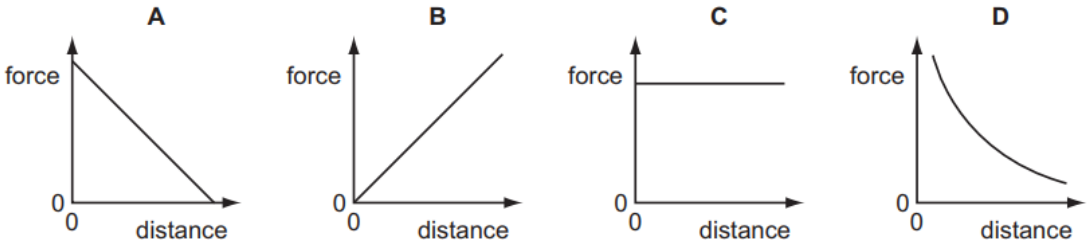
41. C

30 Two charged parallel metal plates produce an electric field.



A charged particle moves from X to Y.

Which graph shows the variation of the force on the particle with distance from X along the line XY?



42. D

31 A small charge q is placed in the electric field of a large charge Q.

Both charges experience a force F.

What is the electric field strength of the charge Q at the position of the charge q?

A $\frac{F}{Qq}$ **B** $\frac{F}{Q}$ **C** FqQ **D** $\frac{F}{q}$

43. C

32 The current in a component is reduced uniformly from 100 mA to 20 mA over a period of 8.0 s.

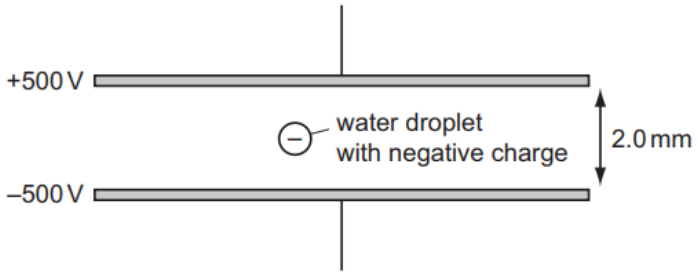
What is the charge that flows during this time?

A 160 mC **B** 320 mC **C** 480 mC **D** 640 mC

S13/11

44. C

13 A small water droplet of mass 3.0 μg carries a charge of -6.0×10^{-11} C. The droplet is situated in the Earth's gravitational field between two horizontal metal plates. The potential of the upper plate is +500 V and the potential of the lower plate is –500 V.



What is the motion of the droplet?

A It accelerates downwards.

B It remains stationary.

C It accelerates upwards.

D It moves upwards at a constant velocity.

45. B

30 A beam of electrons is directed into an electric field and is deflected by it.

Diagram 1 represents an electric field in the plane of the paper.
Diagram 2 represents an electric field directed perpendicular to the plane of the paper.

The lines **A**, **B**, **C** and **D** represent possible paths of the electron beam. All paths are in the plane of the paper.

Which line best represents the path of the electrons inside the field?

diagram 1

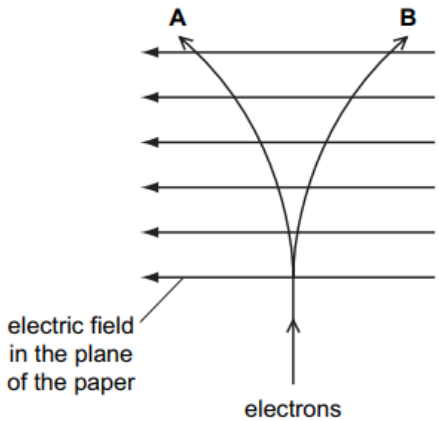
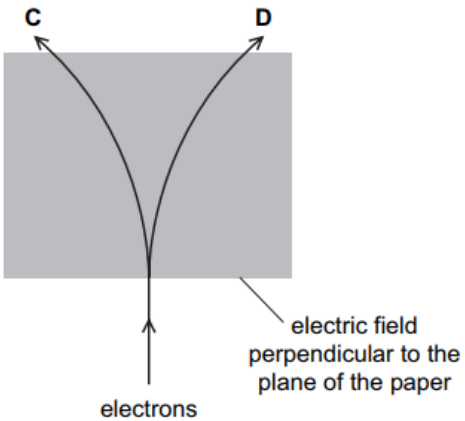
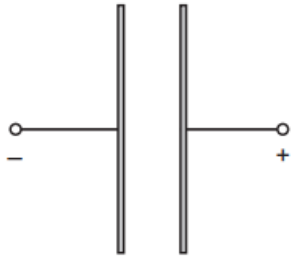


diagram 2



46. D

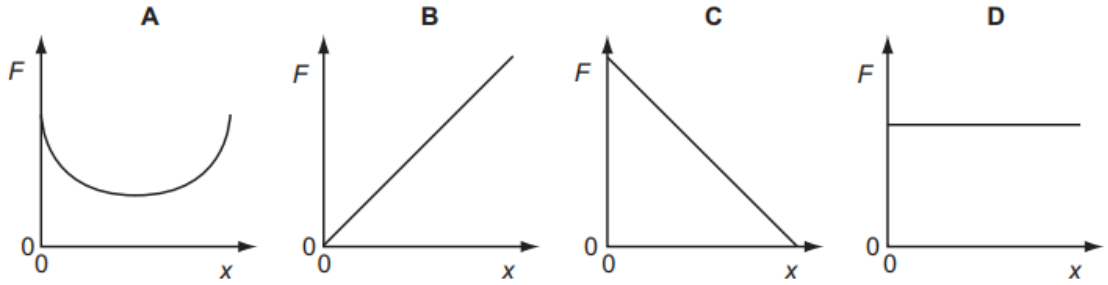
31 Two oppositely-charged parallel plates are arranged as shown.



An electron is released from rest from the surface of the negatively-charged plate.

The electron travels from the negatively-charged plate towards the positively-charged plate.

Which graph shows how the force *F* on the electron varies with its distance *x* from the negative plate?



S13/12

47. D

30 Two conducting layers of a liquid crystal display of a calculator are 8 μm apart. A 1.5 V cell is connected across the conducting layers when the calculator is switched on.

What is the electric field strength between the layers?

A $1.2 \times 10^{-5}\,V\,m^{-1}$

B $0.19\,V\,m^{-1}$

C $12\,V\,m^{-1}$

D $1.9 \times 10^{5}\,V\,m^{-1}$

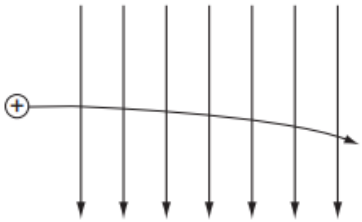
48. A

31 A positively-charged particle is projected into a uniform electric field.

Which diagram represents the path of the particle in the electric field?

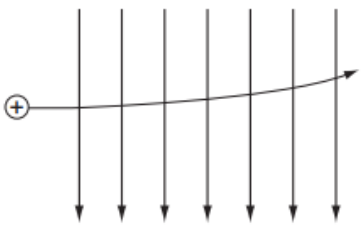
A

electric field in plane of the paper



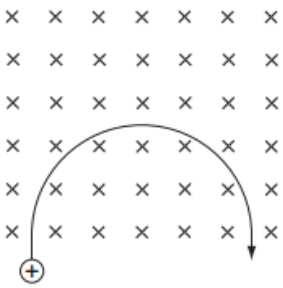
B

electric field in plane of the paper



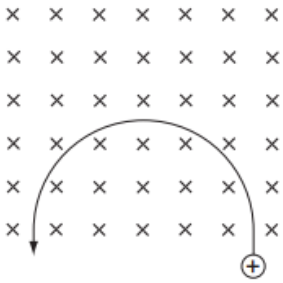
C

electric field into paper



D

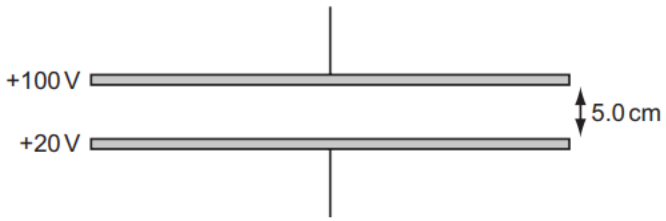
electric field into paper



S13/13

49. C

29 Two metal plates are held horizontal and parallel, 5.0 cm apart. The plates are at potentials of +100 V and +20 V.



What is the force experienced by an electron in the electric field between the plates?

A 2.6×10^{-18} N

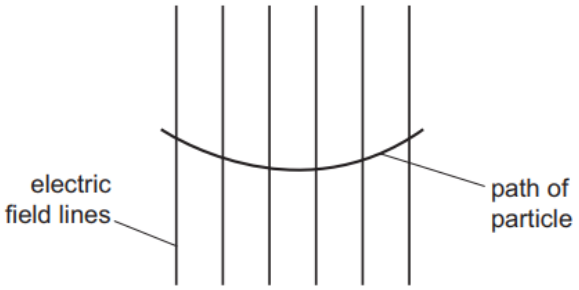
B 3.8×10^{-18} N

C 2.6×10^{-16} N

D 3.8×10^{-16} N

50. D

30 The diagram shows the path of a charged particle through a uniform electric field, having vertical field lines.



What could give a path of this shape?

A a positive charge travelling left to right in a field directed downwards

B a positive charge travelling right to left in a field directed downwards

C a negative charge travelling right to left in a field directed upwards

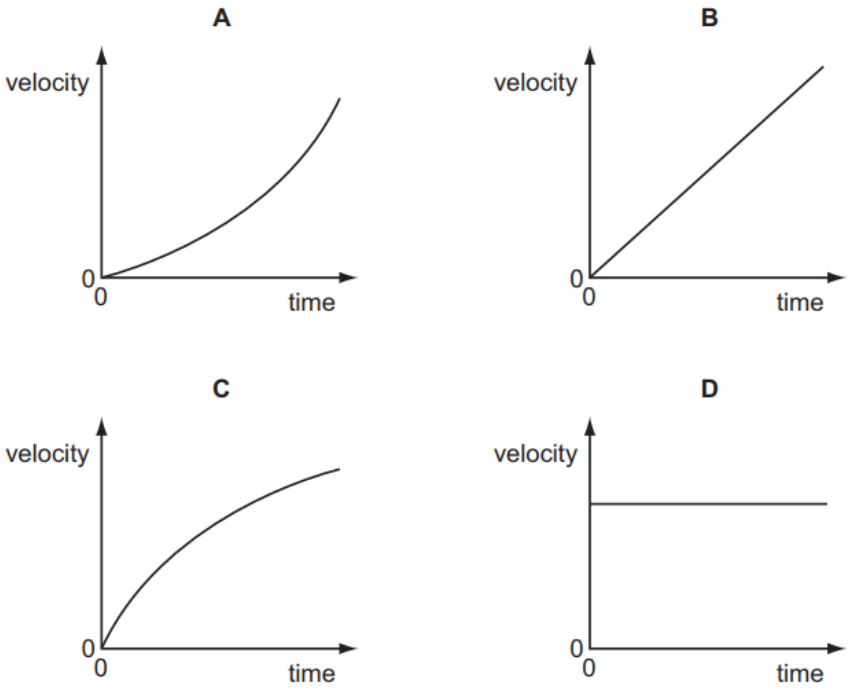
D a negative charge travelling left to right in a field directed downwards

W12/11

51. B

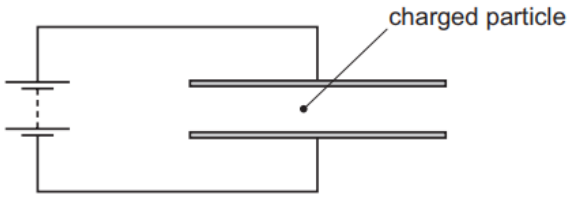
30 An electron is initially at rest in a uniform electric field.

Which graph shows the variation with time of the velocity of the electron?



52. B

31 A charged particle is in the electric field between two horizontal metal plates connected to a source of constant potential difference, as shown.



There is a force F on the particle due to the electric field.

The separation of the plates is doubled.

What will be the new force on the particle?

A $\frac{F}{4}$ **B** $\frac{F}{2}$ **C** F **D** $2F$

W12/12

53. B

32 A charged particle moves in a uniform electric field between two parallel metal plates.

To calculate the force acting on the particle due to the electric field, which quantity is **not** required?

A particle charge

B particle speed

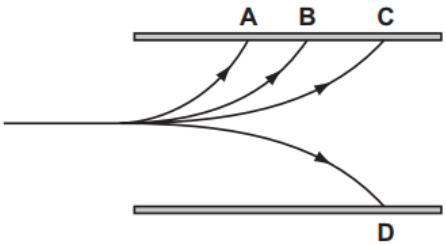
C plate separation

D potential difference between the plates

54. C

33 A single proton travelling with a constant horizontal velocity enters a uniform electric field between two parallel charged plates. In the diagram, **B** shows the path taken by the proton.

Which path is taken by a helium nucleus that enters the electric field at the same point and with the same velocity as the proton?

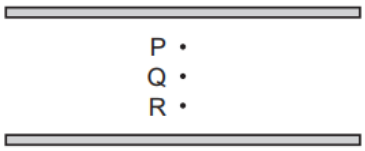


W12/13

55. A

30 The diagram shows two parallel plates.

The plates are charged so that there is an electric field between them. P, Q and R are points which are $\frac{1}{4}$, $\frac{1}{2}$ and $\frac{3}{4}$ of the distance from the top plate to the bottom plate.



What is the electric field strength at point P?

A the same as that at point Q

B twice that at point R

C half that at point R

D one third that at point Q

56. A

31 A positive charge of 2.6×10^{-8} C is in an electric field of constant field strength 300 000 V m^{-1}.

How much work must be done on the charge in order to move it a distance of 4.0 mm in the opposite direction to the direction of the field?

A 3.1×10^{-5} J

B 2.0×10^{-3} J

C 3.1×10^{-2} J

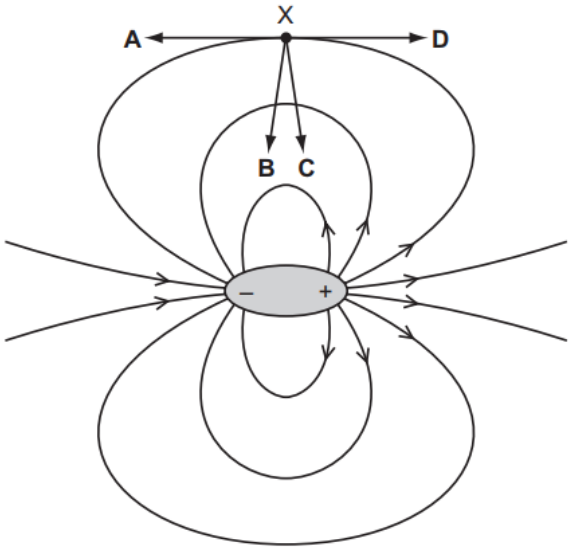
D 2.0 J

S12/11

57. D

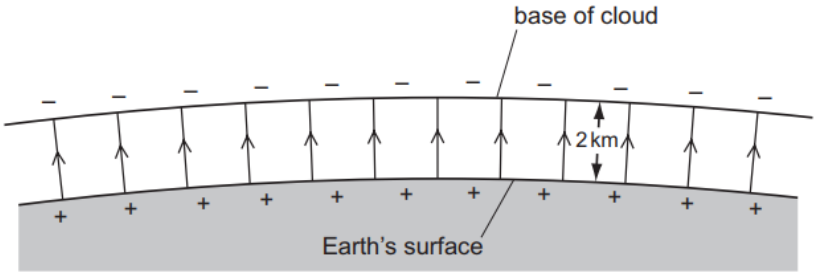
31 A dipole is a pair of one negative charge and one positive charge of equal magnitude. The electric field of a dipole is shown below.

In which direction does the force act on an electron when at point X?



58. C

32 Lightning can occur between a charged cloud and the Earth's surface when the electric field strength in the intervening atmosphere reaches 25 kN C^{-1}. The diagram shows the electric field between the base of a cloud and the Earth's surface.



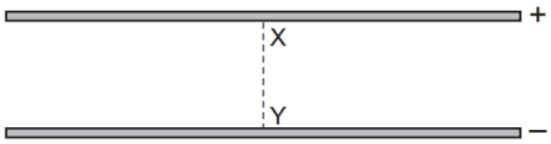
What is the minimum potential difference between the Earth and the base of a cloud, 2 km high, for lightning to occur?

A 12.5 MV **B** 25 MV **C** 50 MV **D** 100 MV

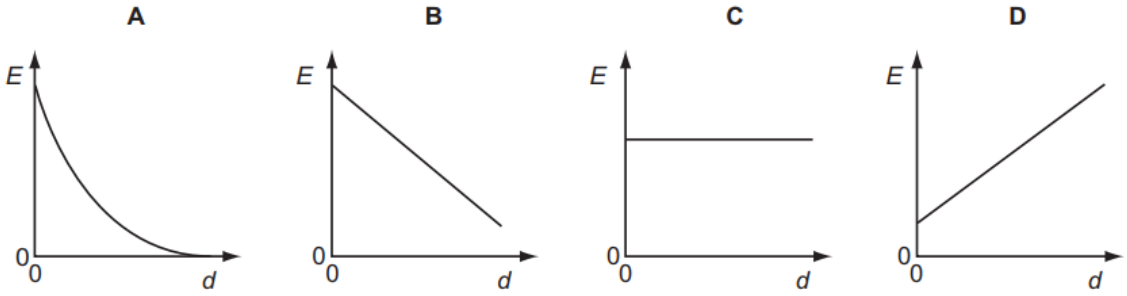
S12/12

59. C

31 An electric field exists in the space between two charged metal plates.



Which graph shows the variation of electric field strength E with distance d from X along the line XY?



W11/11

60. A

31 Two horizontal parallel plate conductors are separated by a distance of 5.0 mm in air. The lower plate is earthed and the potential of the upper plate is +50 V.

What is the electric field strength E at a point midway between the plates?

A $1.0 \times 10^4\,V\,m^{-1}$ downwards

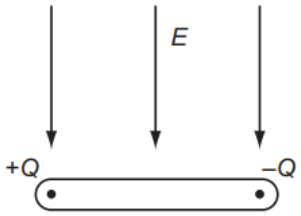
B $1.0 \times 10^4\,V\,m^{-1}$ upwards

C $2.0 \times 10^4\,V\,m^{-1}$ downwards

D $2.0 \times 10^4\,V\,m^{-1}$ upwards

61. C

32 The diagram shows an insulating rod with equal and opposite point charges at each end. An electric field of strength *E* acts on the rod in a downwards direction.



Which row is correct?

	resultant force	resultant torque
A	zero	clockwise
B	downwards	clockwise
C	zero	anti-clockwise
D	downwards	anti-clockwise

W11/12

62. D

29 The diagram shows a pair of parallel metal plates 4.0 mm apart connected to a 9.0 V battery.

What is the electric field strength between the plates?

A $4.4 \times 10^{-4}\,\text{N C}^{-1}$

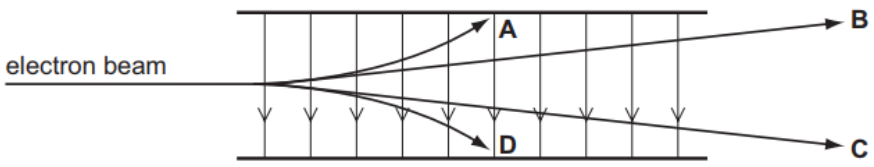
B $3.6 \times 10^{-2}\,\text{N C}^{-1}$

C $36\,\text{N C}^{-1}$

D $2.3 \times 10^{3}\,\text{N C}^{-1}$

63. A

30 Which path shows a possible movement of an electron in the electric field shown?

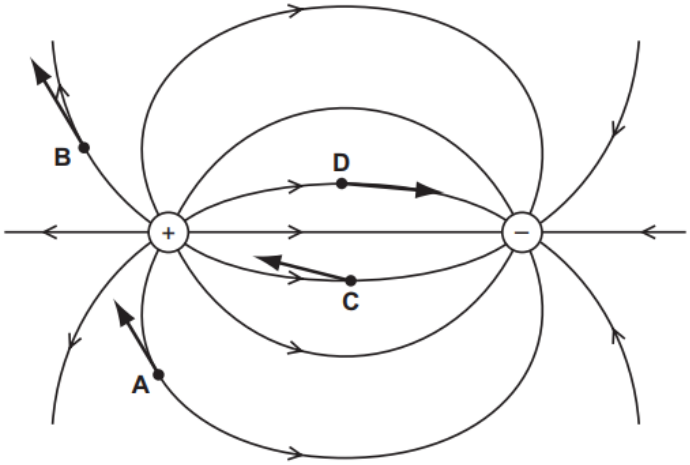


64. A

31 The diagram shows a non-uniform electric field near a positively charged and a negatively charged sphere.

Four electrons, **A**, **B**, **C** and **D**, are shown at different positions in the field.

On which electron is the direction of the force on the electron shown correctly?

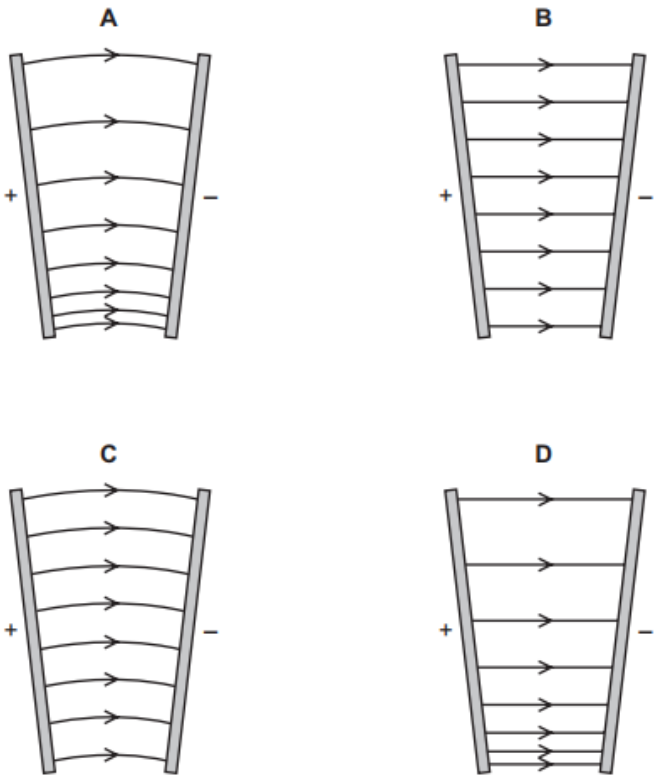


S11/11

65. A

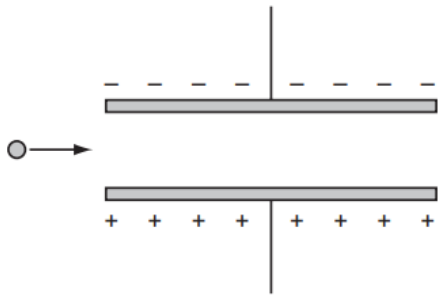
28 A potential difference is applied between two metal plates that are **not** parallel.

Which diagram shows the electric field between the plates?



66. C

29 The diagram shows a charged particle as it approaches a pair of charged parallel plates in a vacuum.



Which row describes the horizontal and vertical components of its motion as it travels between the plates?

	horizontal component	vertical component
A	constant acceleration	constant acceleration
B	constant acceleration	constant velocity
C	constant velocity	constant acceleration
D	constant velocity	constant velocity

67. D

30 Two parallel plates, a distance 25 mm apart, have a potential difference between them of 12 kV.

What is the force on an electron when it is in the uniform electric field between the plates?

A 4.8×10^{-20} N

B 7.7×10^{-20} N

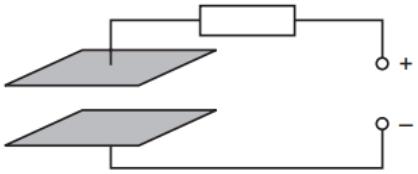
C 4.8×10^{-17} N

D 7.7×10^{-14} N

S11/12

68. A

30 The diagram shows two parallel metal plates connected to a d.c. power supply through a resistor.



There is a uniform electric field in the region between the plates.

Which change would cause a **decrease** in the strength of the electric field?

A a small increase in the distance between the plates

B a small increase in the potential difference between the plates

C a small increase in the value of the resistor

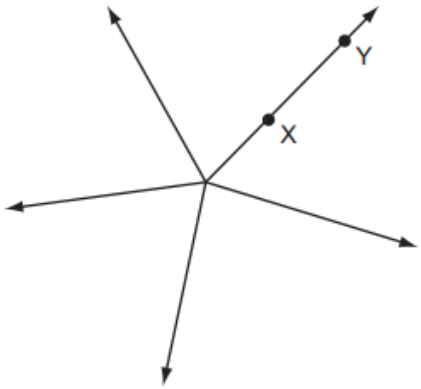
D a small increase to the area of both plates

69. B

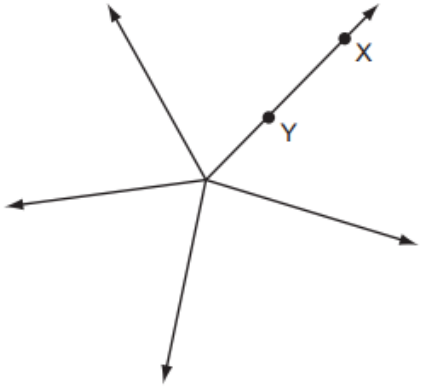
31 In each electric field diagram, a positively charged particle is moved from X to Y.

In which diagram would the particle experience an increasing repulsive force?

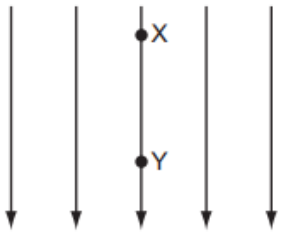
A



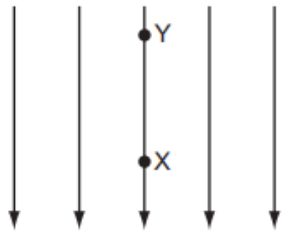
B



C



D



W10/11

70. A

28 An electron is in an electric field of strength 5×10^4 V m^{-1}. The field is the only influence on the electron.

The mass and charge of an electron are known.

Which quantity can be calculated without any more information?

A the force on the electron

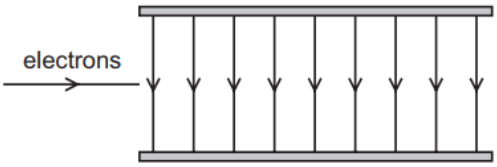
B the momentum of the electron

C the kinetic energy of the electron

D the speed of the electron

71. D

29 Electrons are accelerated and then directed into the uniform electric field between two parallel plates in a vacuum.



What best describes the shape of the path followed by the electrons in the field?

A a downwards curve along a line that is part of a circle

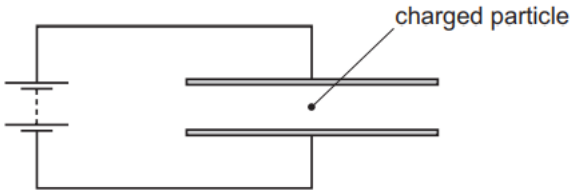
B a downwards curve along a line that is **not** part of a circle

C an upwards curve along a line that is part of a circle

D an upwards curve along a line that is **not** part of a circle

72. B

30 A charged particle is in the electric field between two horizontal metal plates connected to a source of constant potential difference, as shown. There is a force *F* on the particle due to the electric field.



The separation of the plates is doubled.

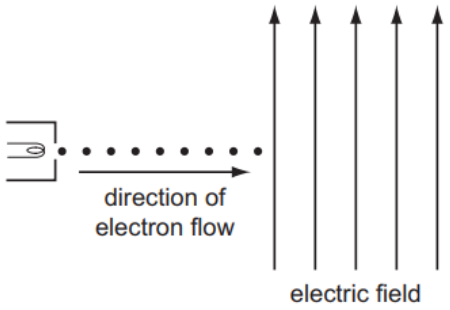
What will be the new force on the particle?

A $\frac{F}{4}$ **B** $\frac{F}{2}$ **C** F **D** $2F$

W10/12

73. A

28 The diagram shows a vertical uniform electric field in a vacuum.



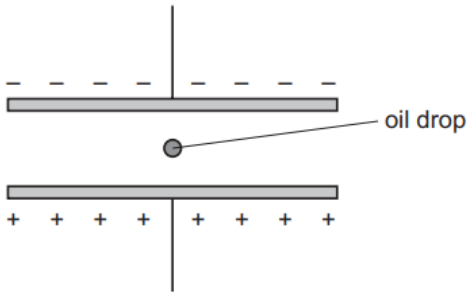
An electron gun injects a beam of electrons horizontally into the field.

Which changes, if any, have occurred to the path and speed of the electrons by the time the beam leaves the field?

	path of electrons	speed of electrons
A	deflected downwards	increased
B	deflected downwards	unchanged
C	deflected upwards	increased
D	deflected upwards	unchanged

74. A

29 A very small oil drop of mass m carries a charge $+q$.



The potential difference across the plates is V and the separation is d.

The weight of the drop is balanced by the electric force. (Buoyancy forces may be considered to be negligible.)

Which formula gives the charge on the drop?

A $q = \frac{mgd}{V}$ **B** $q = \frac{mgV}{d}$ **C** $q = \frac{Vd}{mg}$ **D** $q = \frac{V}{mgd}$

S10/11

75. C

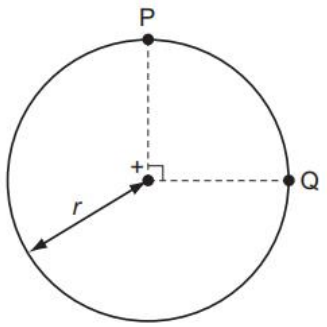
26 Which row describes the circumstances under which forces act on a charged particle in a uniform electric field?

	charged particle	direction of force
A	moving charges only	parallel to the field
B	stationary charges only	perpendicular to the field
C	stationary and moving charges	parallel to the field
D	stationary and moving charges	perpendicular to the field

76. A

27 The diagram shows two points P and Q which lie, 90° apart, on a circle of radius *r*.

A positive point charge at the centre of the circle creates an electric field of magnitude *E* at both P and Q.

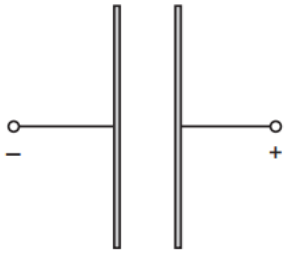


Which expression gives the work done in moving a unit positive charge from P to Q?

A 0 **B** $E \times r$ **C** $E \times \left(\frac{\pi r}{2}\right)$ **D** $E \times (\pi r)$

77. D

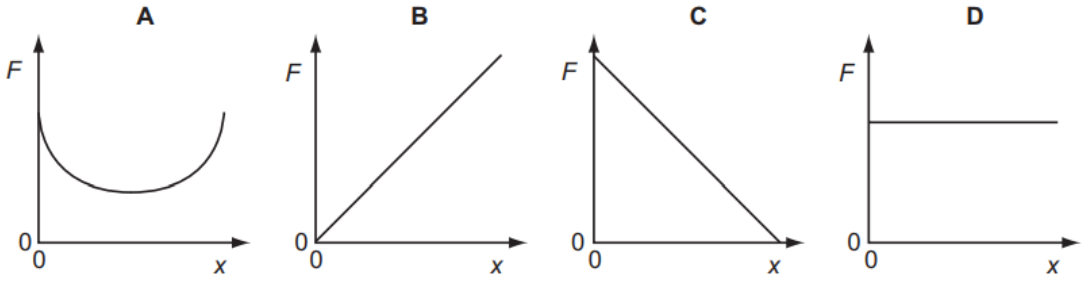
28 Two oppositely-charged parallel plates are arranged as shown.



An electron is released from rest from the surface of the negatively-charged plate.

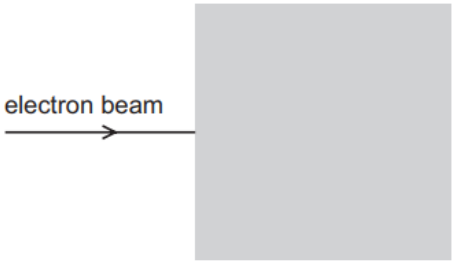
The electron travels from the negatively-charged plate towards the positively-charged plate.

Which graph shows how the force *F* on the electron varies with its distance *x* from the negative plate?



78. D

29 In the diagram, the shaded area represents a uniform electric field directed away from the observer (at right-angles into the plane of the paper).



A horizontal beam of electrons enters the field, travelling from left to right.

In which direction is this beam deflected by the field?

A upwards (in the plane of the paper)

B downwards (in the plane of the paper)

C away from the observer

D towards the observer

New Topic 10:

10. PRACTICAL CIRCUITS AND KIRCHOFF'S LAW

S16/11

1. D

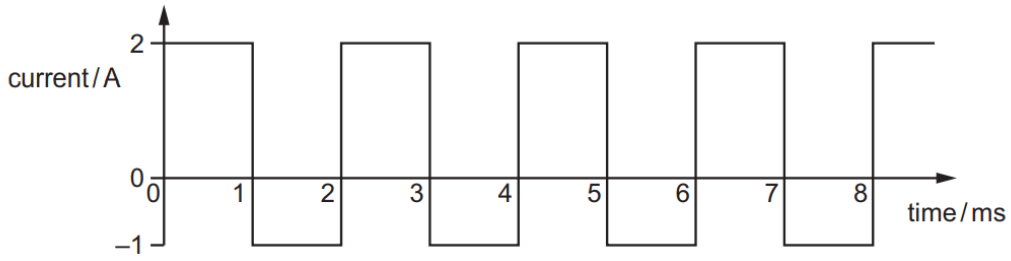
31 Two copper wires of equal length are connected in parallel. A potential difference is applied across the ends of this parallel arrangement. Wire S has a diameter of 3.0 mm. Wire T has a diameter of 1.5 mm.

What is the value of the ratio $\frac{\text{current in S}}{\text{current in T}}$?

A $\frac{1}{4}$ **B** $\frac{1}{2}$ **C** 2 **D** 4

2. C

32 A 100 Ω resistor conducts a current with changing direction and magnitude, as shown.

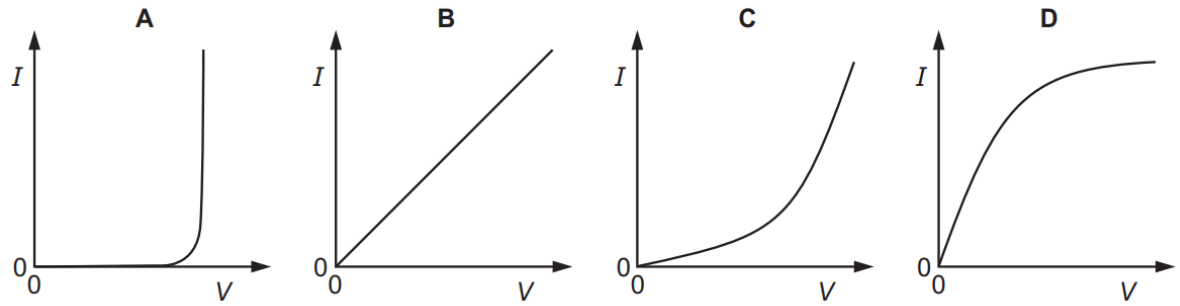


What is the mean power dissipated in the resistor?

A 100 W **B** 150 W **C** 250 W **D** 400 W

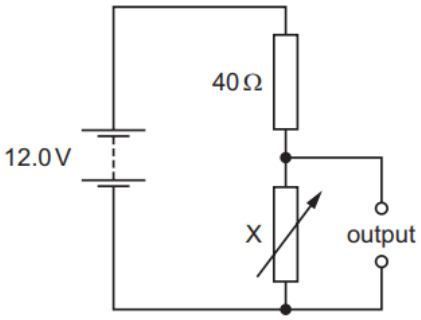
3. D

33 Which graph shows the I–V characteristic of a filament lamp?



4. A

34 In the circuit shown, X is a variable resistor whose resistance can be changed from 5.0Ω to 500Ω. The e.m.f. of the battery is 12.0V. It has negligible internal resistance.



What is the maximum range of values of potential difference across the output?

A 1.3V to 11.1V

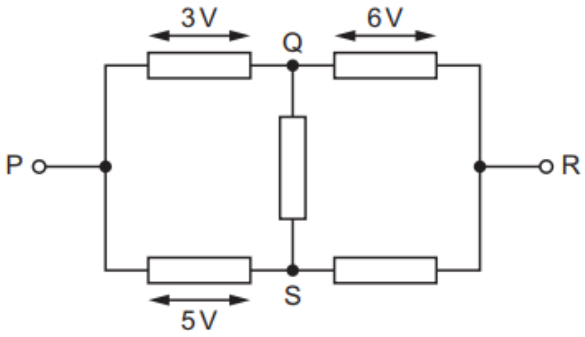
B 1.3V to 12.0V

C 1.5V to 11.1V

D 1.5V to 12.0V

5. A

35 There is a current from P to R in the resistor network shown.



The potential difference (p.d.) between P and Q is 3V.

The p.d. between Q and R is 6V.

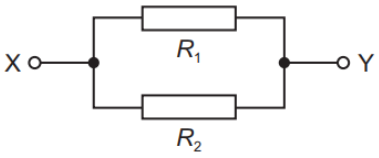
The p.d. between P and S is 5V.

Which row in the table is correct?

	p.d. between Q and S	p.d. between S and R
A	2V	4V
B	2V	10V
C	3V	4V
D	3V	10V

6. B

36 Two resistors of resistances R_1 and R_2 are connected in parallel.



What is the combined resistance between X and Y?

A $R_1 + R_2$ **B** $\frac{R_1 R_2}{R_1 + R_2}$ **C** $\frac{R_1 + R_2}{R_1 R_2}$ **D** $\frac{R_1}{R_2}$

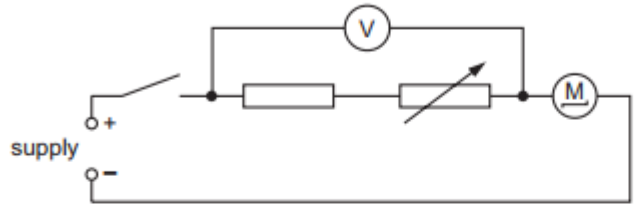
7.B

37 A voltmeter is used to monitor the operation of an electric motor. The motor speed is controlled by a variable resistor. A fixed resistor is used to limit the speed.

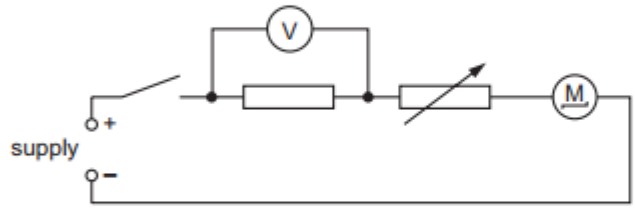
The current in the motor is gradually changed.

In which circuit is the voltmeter reading proportional to the current in the motor?

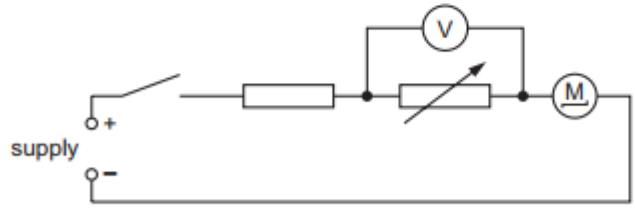
A



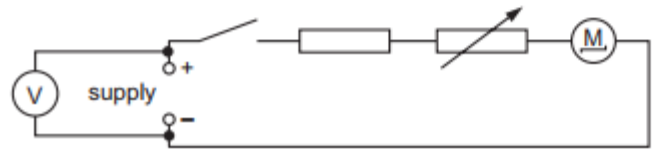
B



C



D

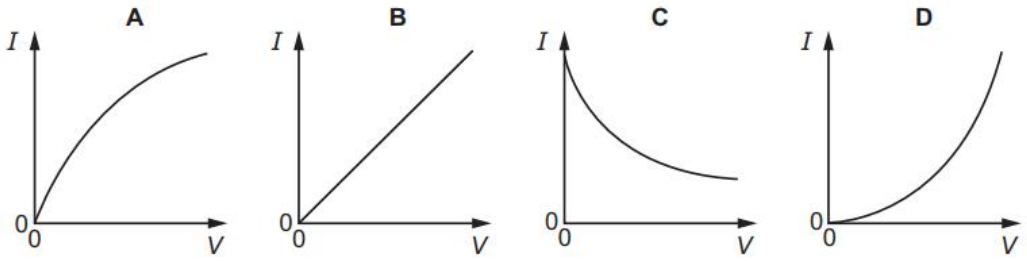


S16/12

8. A

32 The potential difference V across a filament lamp is slowly raised from zero to its normal operating value.

Which graph represents the variation with V of the current I in the lamp?



9. B

33 Two lamps are connected in series to a 250 V power supply. One lamp is rated 240 V, 60 W and the other is rated 10 V, 2.5 W.

Which statement most accurately describes what happens?

A Both lamps light at less than their normal brightness.

B Both lamps light at their normal brightness.

C Only the 240 V lamp lights.

D The 10 V lamp blows.

10. B

34 Which equation is used to define resistance?

A energy = $(\text{current})^2 \times$ resistance $\times$ time

B potential difference = current $\times$ resistance

C power = $(\text{current})^2 \times$ resistance

D resistivity = resistance $\times$ area $\div$ length

11. D

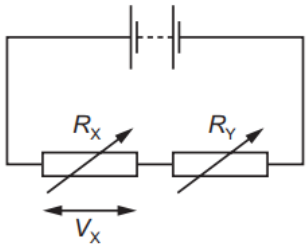
35 The charge that a fully charged 12 V car battery can supply is 100 kC. The starter motor of the car requires a current of 200 A for an average period of 2.0 s. The battery does not recharge because of a fault.

What is the maximum number of times the starter motor of the car can be used?

A 21 **B** 25 **C** 42 **D** 250

12. B

36 A potential divider circuit is formed by connecting a battery of negligible internal resistance in series with two variable resistors, as shown.



The variable resistors have resistances R_X and R_Y.
V_X is the potential difference across resistance R_X.

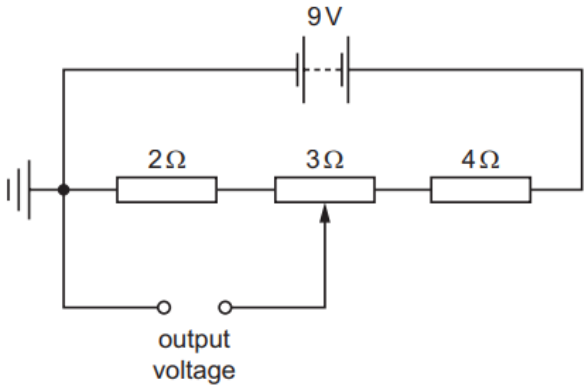
R_X and R_Y are both changed at the same time.

Which combination of changes **must** cause V_X to increase?

	R_X	R_Y
A	larger	larger
B	larger	smaller
C	smaller	larger
D	smaller	smaller

13. D

37 In the circuit shown, contact may be made at any point along the 3 Ω resistor (potentiometer).



The battery has e.m.f. 9 V and negligible internal resistance.

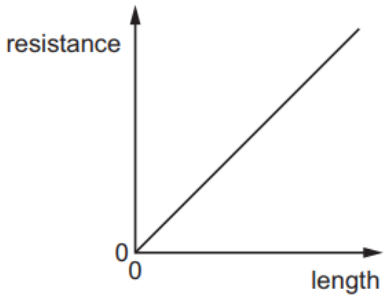
What is the maximum range of the output voltage?

A 0–2 V **B** 0–5 V **C** 2–3 V **D** 2–5 V

S16/13

14. A

32 The graph shows the variation with length of the resistance of a uniform metal wire.



The gradient of the graph is G.
The wire has cross-sectional area A.

Which expression could be used to calculate the resistivity of the metal of the wire?

A $G \times A$ **B** $\frac{G}{A}$ **C** $\frac{A}{G}$ **D** $G \times A^2$

15. C

33 What describes the electric potential difference between two points in a wire that carries a current?

A the force required to move a unit positive charge between the points

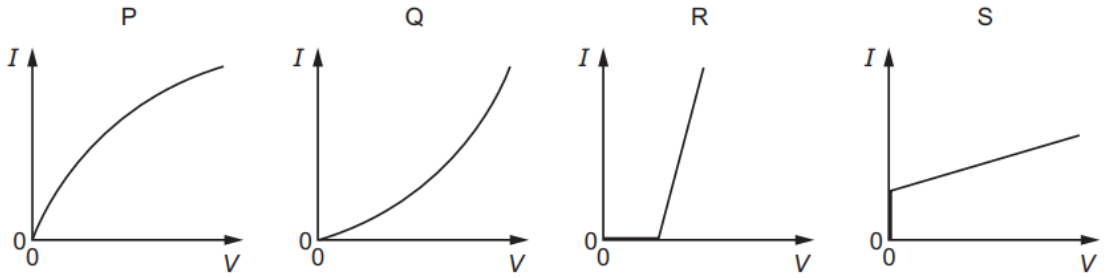
B the ratio of the energy dissipated between the points to the current

C the ratio of the power dissipated between the points to the current

D the ratio of the power dissipated between the points to the charge moved

16. A

34 The graphs show possible current-voltage (I-V) characteristics for a filament lamp and for a semiconductor diode.

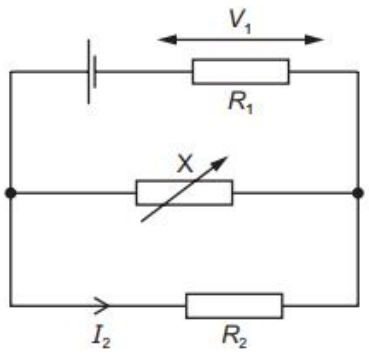


Which row in the table best specifies the correct I-V graphs for the lamp and for the diode?

	filament lamp	semiconductor diode
A	P	R
B	P	S
C	Q	R
D	Q	S

17. C

35 A circuit contains a cell, two resistors of resistances R_1 and R_2 and a variable resistor X. The cell has negligible internal resistance.



V_1 is the potential difference across the resistor of resistance R_1.

I_2 is the current through the resistor of resistance R_2.

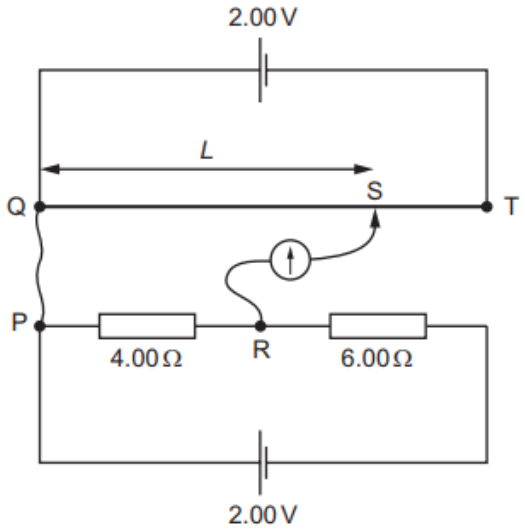
The resistance of X is reduced.

What is the effect on V_1 and I_2?

	V_1	I_2
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

18. B

36 A 100 cm potentiometer wire QT is connected in series with a 2.00 V cell. Another circuit, consisting of a 2.00 V cell in series with resistors of resistance 4.00 Ω and 6.00 Ω, is set up alongside the potentiometer. Connections PQ and RS are then made so that the potential difference (p.d.) across the 4.00 Ω resistor is balanced against the p.d. across a length *L* of potentiometer wire. Both cells have negligible internal resistance.

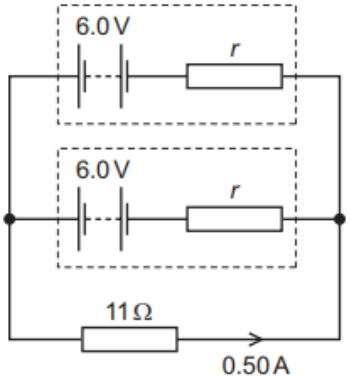


What is the balance length *L*?

A 0 cm **B** 40 cm **C** 60 cm **D** 100 cm

19. B

37 Two identical batteries each have e.m.f. 6.0 V and internal resistance *r*. The batteries are connected to an external resistor of resistance 11 Ω, as shown.



The current in the external resistor is 0.50 A.

What is the internal resistance *r* of each battery?

A 1.0 Ω **B** 2.0 Ω **C** 4.0 Ω **D** 6.5 Ω

W15/11

20. B

33 The Atlantic torpedo is a large electric fish capable of generating a voltage of 220 V between its tail and its head. This drives a pulse of current of 15 A lasting for a time of 2.0 ms. The fish produces 200 pulses per second.

What is the average power output of the fish?

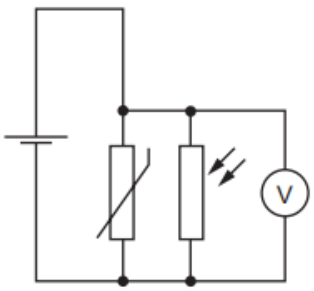
A 33 W **B** 1.3 kW **C** 3.3 kW **D** 6.6 kW

21. C

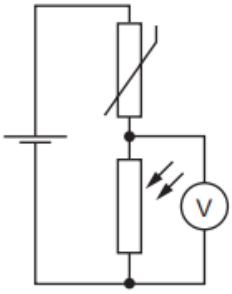
34 A thermistor and another component are connected to a constant voltage supply. A voltmeter is connected across one of the components. The temperature of the thermistor is then reduced but no other changes are made.

In which circuit will the voltmeter reading increase?

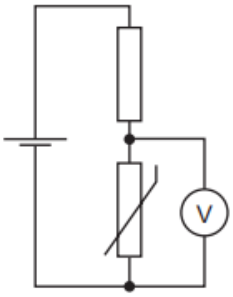
A



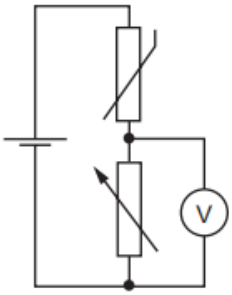
B



C

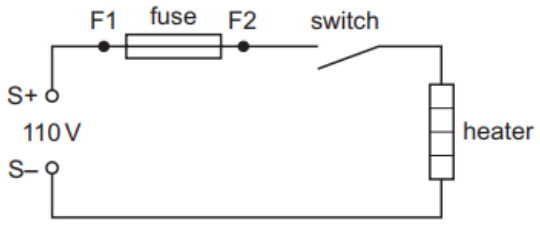


D



22. A

35 A 110 V d.c. supply is connected to a heater, a fuse and a switch, as shown.



Owing to a fault in the system, power is not supplied to the heater. A technician diagnoses the fault using a voltmeter.

He closes the switch and connects his meter between the positive supply terminal S+ and the fuse terminal F2. The voltmeter reads 110 V.

Which diagnosis is correct?

A The fuse has melted.

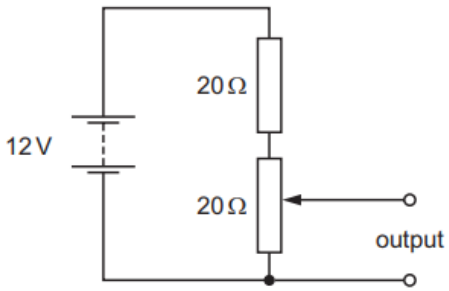
B The fuse has not melted and there is a short circuit in the heater.

C The fuse has not melted and there is no path for current through the heater.

D The fuse has not melted and the switch has operated correctly.

23. A

36 The diagram shows a potentiometer and a fixed resistor connected across a 12 V battery of negligible internal resistance.



The fixed resistor and the potentiometer each have resistance 20 Ω. The circuit is designed to provide a variable output voltage.

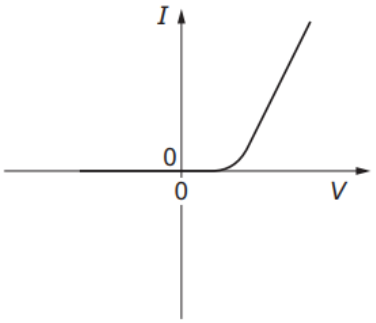
What is the range of output voltages?

A 0–6 V **B** 0–12 V **C** 6–12 V **D** 12–20 V

W15/12

24. C

34 The graph shows the *I*-*V* characteristic of an electrical component.



What is the component?

A a filament lamp

B a metallic conductor at constant temperature

C a semiconductor diode

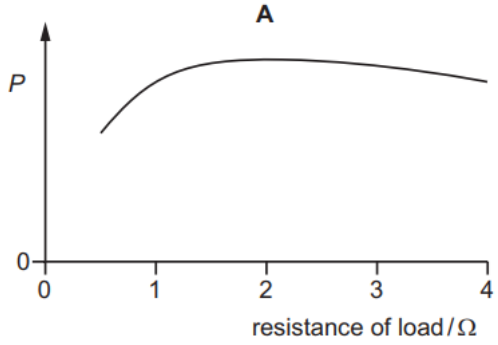
D a thermistor

25. A

35 A power supply of electromotive force (e.m.f.) 12 V and internal resistance 2 Ω is connected in series with a load resistor. The resistance of the load resistor is varied from 0.5 Ω to 4 Ω.

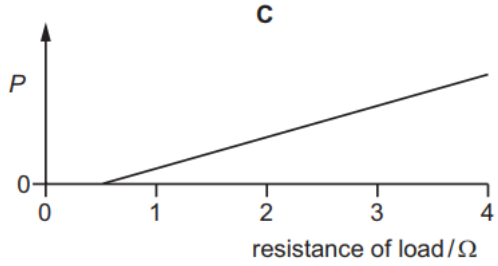
Which graph shows how the power *P* dissipated in the load resistor varies with the resistance of the load resistor?

A



B

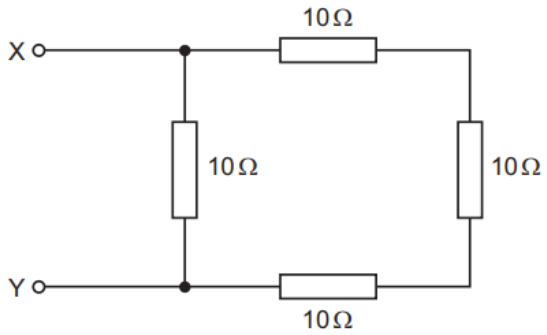
C



D

26. B

36 The diagram shows an arrangement of resistors.



What is the total electrical resistance between X and Y?

A less than 1Ω

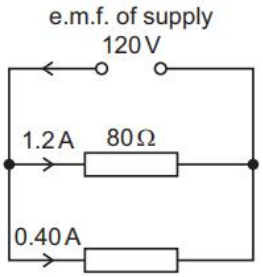
B between 1Ω and 10Ω

C between 10Ω and 30Ω

D 40Ω

27. A

37 The electromotive force of a power supply is 120V. It delivers a current of 1.2A to a resistor of resistance 80Ω and a current of 0.40A to another resistor, as shown.

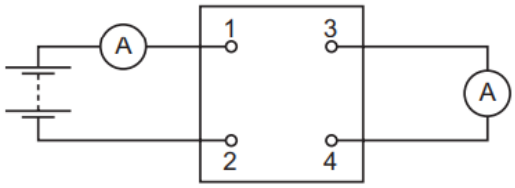


What is the internal resistance of the power supply?

A 15Ω **B** 20Ω **C** 60Ω **D** 75Ω

28. D

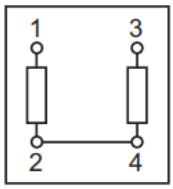
38 The diagram shows a four-terminal box connected to a battery and two ammeters.



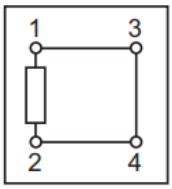
The currents in the two meters are identical.

Which circuit, within the box, will give this result?

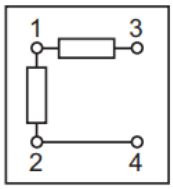
A



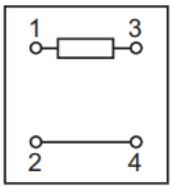
B



C



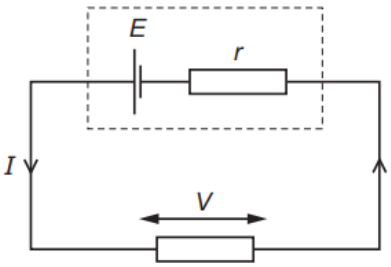
D



W15/13

29. A

32 A cell of electromotive force E and internal resistance r is connected to an external resistor, as shown.



The current in the circuit is I and the potential difference (p.d.) across the external resistor is V.

In the equation $(E - V) = Ir$, what does the term $(E - V)$ represent?

A electrical energy per unit charge lost in the cell

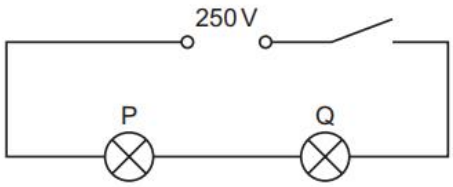
B electrical energy per unit charge lost in the complete circuit

C electrical energy per unit charge lost in the connecting wire

D electrical energy per unit charge lost in the external resistor

30. A

34 In the circuit shown, lamp P is rated 250 V, 50 W and lamp Q is rated 250 V, 200 W. The two lamps are connected in series to a 250 V power supply.



Assume that the resistance of each lamp remains constant.

Which statement most accurately describes what happens when the switch is closed?

A Lamp P emits four times as much power as lamp Q.

B Lamp P emits twice as much power as lamp Q.

C Lamp Q emits four times as much power as lamp P.

D Lamp Q emits twice as much power as lamp P.

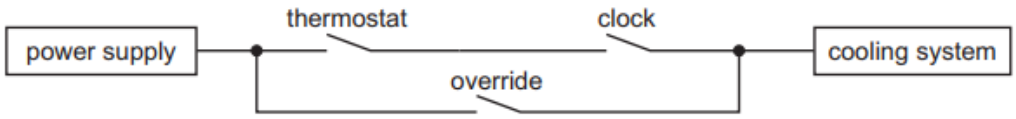
31. A

35 The cooling system in many houses is controlled by three electrical switches. These are:

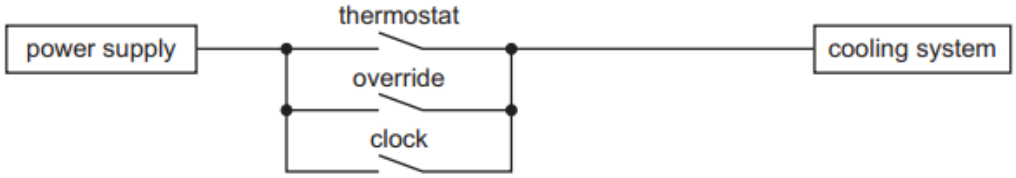
- a thermostat switch that closes when the temperature rises to a given value,
- a clock switch that closes at times when cooling may be required,
- an override switch that closes to turn on the system when exceptional temperature rises occur.

Which diagram shows the switches correctly connected between the power supply and the cooling system?

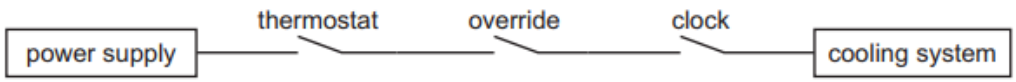
A



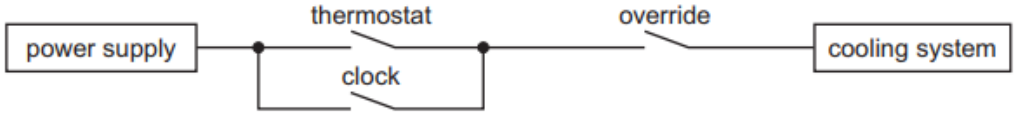
B



C

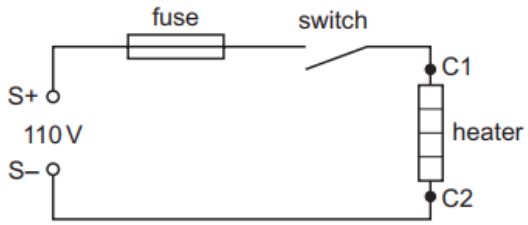


D



32. A

36 A 110 V supply of negligible internal resistance is connected to a heater through a fuse and a switch.



Terminals S+ and S– are the positive and negative terminals of the supply. Points C1 and C2 at either side of the heater are accessible for fault-finding.

A voltmeter is connected between S– and C1.

With the circuit working correctly, the voltmeter reading is noted with the switch closed.

A fault occurs and the voltmeter is again connected between S– and C1 with the switch closed.

Which fault would result in the same two voltmeter readings?

A a break in the wire of the heater

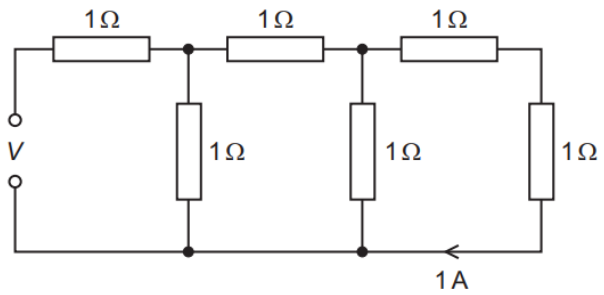
B a broken switch that cannot close correctly

C a melted fuse

D a short circuit in the heater

33. D

37 A network of resistors, each of resistance 1 Ω, is connected as shown.



The current passing through the end resistor is 1 A.

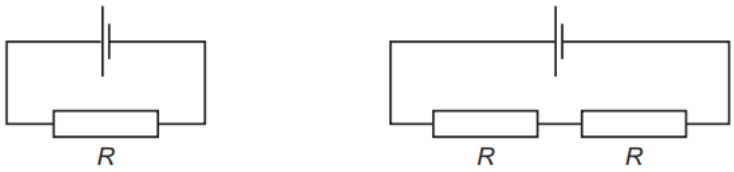
What is the potential difference (p.d.) *V* across the input terminals?

A 2 V **B** 5 V **C** 8 V **D** 13 V

S15/11

34. B

33 The diagrams show two different circuits.



The cells in each circuit have the same electromotive force and zero internal resistance. The three resistors each have the same resistance *R*.

In the circuit on the left, the power dissipated in the resistor is *P*.

What is the total power dissipated in the circuit on the right?

A $\frac{P}{4}$ **B** $\frac{P}{2}$ **C** P **D** $2P$

35. D

34 Which equation that links some of the following terms is correct?

potential difference (p.d.)	V
current	I
resistance	R
charge	Q
energy	E
power	P
time	t

A $P = \frac{Q^2R}{t}$

B $ER^2 = V^2t$

C $\frac{VI}{P} = t$

D $PQ = EI$

36. C

35 The charge that an electric battery can deliver is specified in ampere-hours.

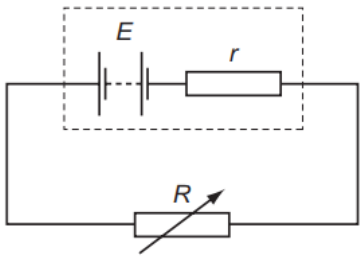
For example, a battery of capacity 40 ampere-hours could supply, when fully charged, 0.2 A for 200 hours.

What is the maximum energy that a fully charged 12 V, 40 ampere-hour battery could supply?

A 1.7 kJ **B** 29 kJ **C** 1.7 MJ **D** 29 MJ

37. D

36 A battery with e.m.f. E and internal resistance r is connected in series with a variable external resistor.



The value of the external resistance R is slowly increased from zero.

Which statement is correct? (Ignore any temperature effects.)

A The potential difference across the external resistance decreases.

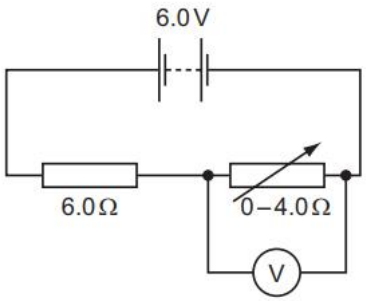
B The potential difference across the internal resistance increases.

C The power dissipated in r increases and then decreases.

D The power dissipated in R increases and then decreases.

38. A

37 A battery of electromotive force (e.m.f.) 6.0 V and negligible internal resistance is connected in series with a resistor of resistance 6.0 Ω and a variable resistor of resistance from zero to 4.0 Ω. A voltmeter is connected across the variable resistor. The resistance of the variable resistor is changed.



What is the range of the voltmeter reading?

A 0 V – 2.4 V

B 0 V – 3.6 V

C 2.4 V – 6.0 V

D 3.6 V – 6.0 V

S15/12

39. D

34 A cell of e.m.f. E delivers a charge Q to an external circuit.

Which statement is correct?

A The energy dissipation in the external circuit is EQ.

B The energy dissipation within the cell is EQ.

C The external resistance is EQ.

D The total energy dissipation in the cell and the external circuit is EQ.

40. A

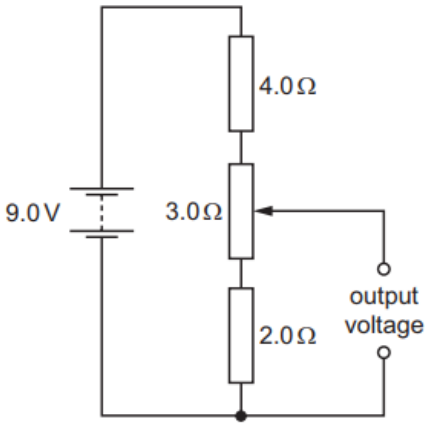
35 Each of Kirchhoff's two laws presumes that some quantity is conserved.

Which row states Kirchhoff's **first** law and names the quantity that is conserved?

	statement	quantity
A	the algebraic sum of currents into a junction is zero	charge
B	the algebraic sum of currents into a junction is zero	energy
C	the e.m.f. in a loop is equal to the algebraic sum of the product of current and resistance round the loop	charge
D	the e.m.f. in a loop is equal to the algebraic sum of the product of current and resistance round the loop	energy

41. B

36 A potential divider circuit consists of fixed resistors of resistance 2.0Ω and 4.0Ω connected in series with a 3.0Ω resistor fitted with a sliding contact. These are connected across a battery of e.m.f. 9.0V and zero internal resistance, as shown.

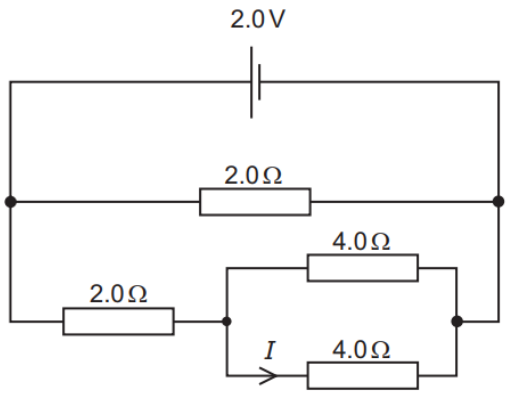


What are the maximum and the minimum output voltages of this potential divider circuit?

	maximum voltage/V	minimum voltage/V
A	4.0	2.0
B	5.0	2.0
C	9.0	0
D	9.0	2.0

42. A

37 A cell of e.m.f. 2.0 V and negligible internal resistance is connected to a network of resistors as shown.



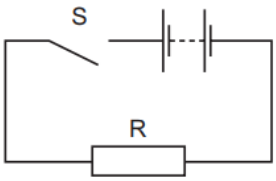
What is the current I?

A 0.25A **B** 0.33A **C** 0.50A **D** 1.5A

S15/13

43. C

33 The diagram shows a simple circuit.



Which statement is correct?

A When switch S is closed, the electromotive force (e.m.f.) of the battery falls because work is done against the internal resistance of the battery.

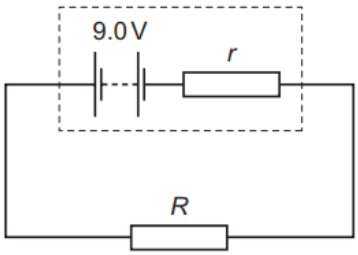
B When switch S is closed, the e.m.f. of the battery falls because work is done against the resistance of R.

C When switch S is closed, the potential difference across the battery falls because work is done against the internal resistance of the battery.

D When switch S is closed, the potential difference across the battery falls because work is done against the resistance of R.

44. C

34 A simple circuit is formed by connecting a resistor of resistance *R* between the terminals of a battery of electromotive force (e.m.f.) 9.0 V and constant internal resistance *r*.



A charge of 6.0 C flows through the resistor in a time of 2.0 minutes causing it to dissipate 48 J of thermal energy.

What is the internal resistance *r* of the battery?

A 0.17 Ω **B** 0.33 Ω **C** 20 Ω **D** 160 Ω

45. A

35 A source of e.m.f. 9.0 mV has an internal resistance of 6.0 Ω.

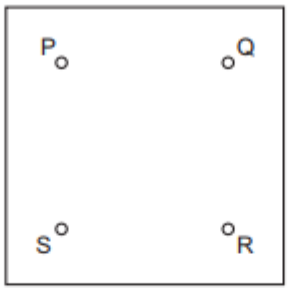
It is connected across a galvanometer of resistance 30 Ω.

What is the current in the galvanometer?

A 250 μA **B** 300 μA **C** 1.5 mA **D** 2.5 mA

46.A

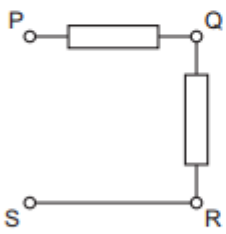
36 A box with four terminals P, Q, R and S contains two identical resistors.



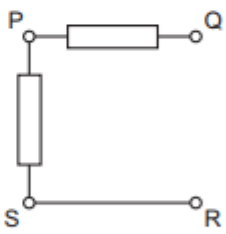
When a battery of electromotive force (e.m.f.) E and negligible internal resistance is connected across PS, a high-resistance voltmeter connected across QR reads $\frac{E}{2}$.

Which diagram shows the correct arrangement of the two resistors inside the box?

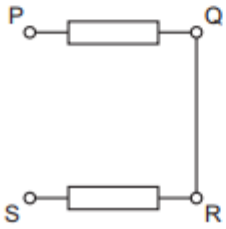
A



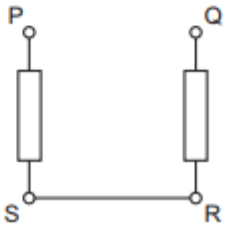
B



C

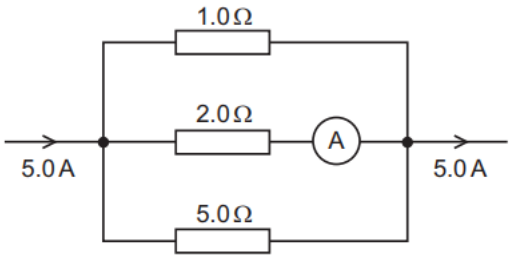


D



47. C

37 The diagram shows part of a current-carrying circuit. The ammeter has negligible resistance.



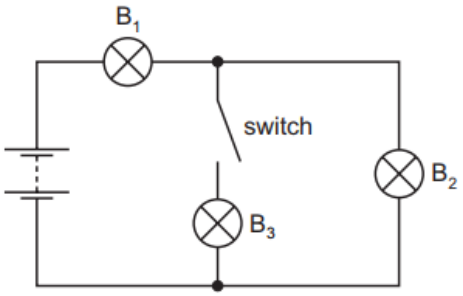
What is the reading on the ammeter?

A 0.7A **B** 1.3A **C** 1.5A **D** 1.7A

W14/11

48. B

30 B_1, B_2 and B_3 are three identical lamps. They are connected to a battery with zero internal resistance, as shown.



Initially the switch is closed. The switch is then opened and lamp B_3 goes out.

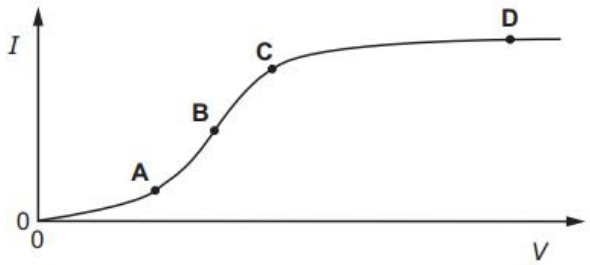
What happens to the brightness of lamps B_1 and B_2 when the switch is opened?

	brightness of lamp B_1	brightness of lamp B_2
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

49. C

34 The graph shows how the electric current I through a conducting liquid varies with the potential difference V across it.

At which point on the graph does the liquid have the smallest resistance?



50. B

35 The combined resistance R_T of two resistors of resistances R_1 and R_2 connected in parallel is given by the formula shown.

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$$

Which statement is used in the derivation of this formula?

A The currents through the two resistors are equal.

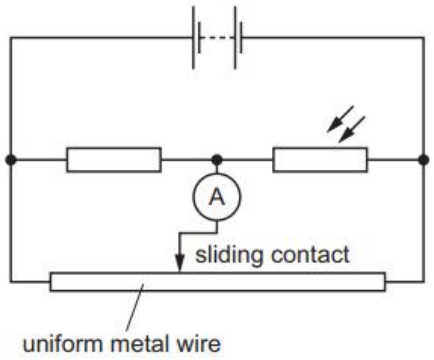
B The potential difference across each resistor is the same.

C The supply current is split between the two resistors in the same ratio as the ratio of their resistances.

D The total power dissipated is the sum of the powers dissipated in the two resistors separately.

51. C

36 In the potentiometer circuit shown, the reading on the ammeter is zero.



The light-dependent resistor (LDR) is then covered up and the ammeter gives a non-zero reading.

Which change could return the ammeter reading to zero?

A Decrease the supply voltage.

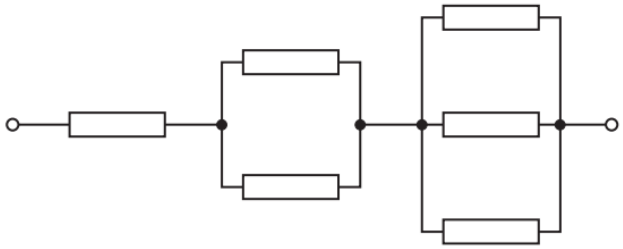
B Increase the supply voltage.

C Move the sliding contact to the left.

D Move the sliding contact to the right.

52. D

37 Six resistors, each of resistance *R*, are connected as shown.



The combined resistance is 66 kΩ.

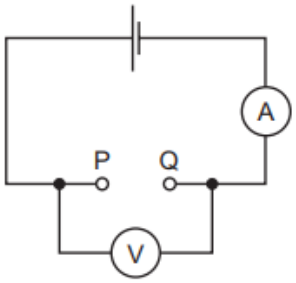
What is the value of *R*?

A 11 kΩ **B** 18 kΩ **C** 22 kΩ **D** 36 kΩ

W14/13

53. D

34 A student found two unmarked resistors. To determine the resistance of the resistors, the circuit below was set up. The resistors were connected in turn between P and Q, noting the current readings. The voltage readings were noted without the resistors and with each resistor in turn.



The results were entered into a spreadsheet as shown.

1.5	1.3	28	46
1.5	1.4	14	100

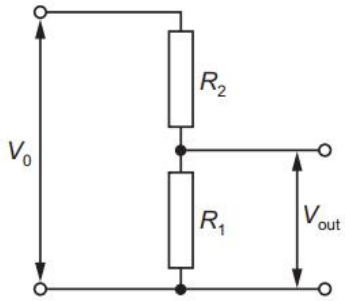
The student forgot to enter the column headings.

Which order of the headings would be correct?

A	e.m.f./V	*V*/V	*R*/Ω	*I*/mA
B	*V*/V	e.m.f./V	*R*/Ω	*I*/mA
C	*V*/V	e.m.f./V	*I*/mA	*R*/Ω
D	e.m.f./V	*V*/V	*I*/mA	*R*/Ω

54. B

35 A potential divider consists of resistors of resistance R_1 and R_2 connected in series across a source of potential difference V_0. The potential difference across R_1 is V_{out}.

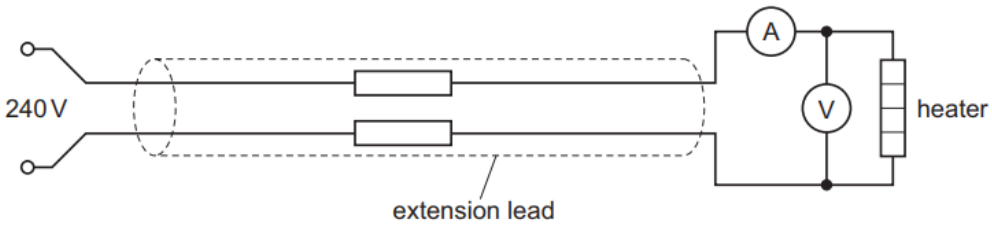


Which changes to R_1 and R_2 will increase the value of V_{out}?

	R_1	R_2
A	doubled	doubled
B	doubled	halved
C	halved	doubled
D	halved	halved

55. A

36 An extension lead is used to connect a 240 V electrical supply to a heater as shown.



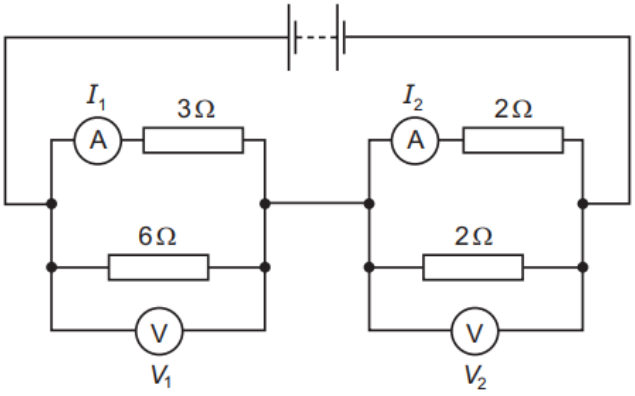
A voltmeter measures the potential difference (p.d.) across the heater as 216 V and an ammeter measures the current through the heater as 7.7 A.

What is the total resistance of the extension lead?

A 3.1 Ω **B** 6.2 Ω **C** 28 Ω **D** 31 Ω

56. A

37 In the circuit shown, the ammeters have negligible resistance and the voltmeters have infinite resistance.



The readings on the meters are I_1, I_2, V_1 and V_2, as labelled on the diagram.

Which statement is correct?

A $I_1 > I_2$ and $V_1 > V_2$

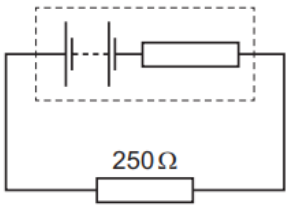
B $I_1 > I_2$ and $V_1 < V_2$

C $I_1 < I_2$ and $V_1 > V_2$

S14/11

57. D

31 A battery, with a constant internal resistance, is connected to a resistor of resistance 250 Ω, as shown.



The current in the resistor is 40 mA for a time of 60 s. During this time 6.0 J of energy is lost in the internal resistance.

What are the energy supplied to the external resistor during the 60 s and the e.m.f. of the battery?

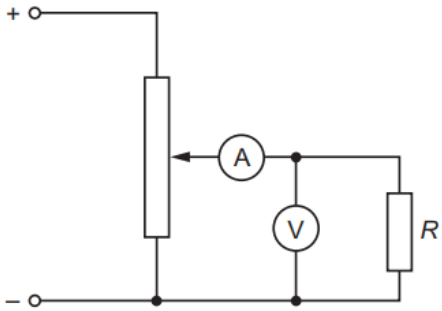
	energy / J	e.m.f. / V
A	2.4	2.4
B	2.4	7.5
C	24	10.0
D	24	12.5

58. B

32 Which symbol represents a component whose resistance is designed to change with temperature?

59. A

33 In the circuit below, a voltmeter of resistance R_V and an ammeter of resistance R_A are used to measure the resistance R of the fixed resistor.



Which condition is necessary for an accurate value to be obtained for R?

A R is much smaller than R_V.

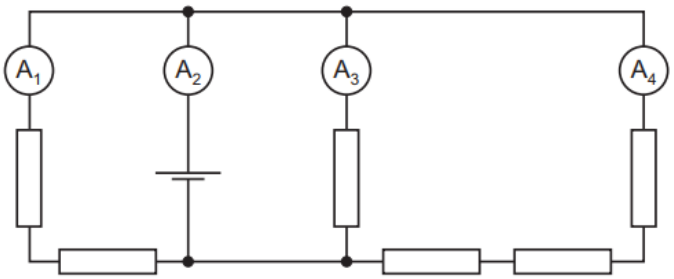
B R is much smaller than R_A.

C R is much greater than R_V.

D R is much greater than R_A.

60. D

34 In the circuit shown, all the resistors are identical and all the ammeters have negligible resistance.



The reading on ammeter A_1 is 0.6 A.

What are the readings on the other ammeters?

	reading on ammeter A_2 / A	reading on ammeter A_3 / A	reading on ammeter A_4 / A
A	1.0	0.3	0.1
B	1.4	0.6	0.2
C	1.8	0.9	0.3
D	2.2	1.2	0.4

61. B

35 The potential difference across a component in a circuit is 2.0 V.

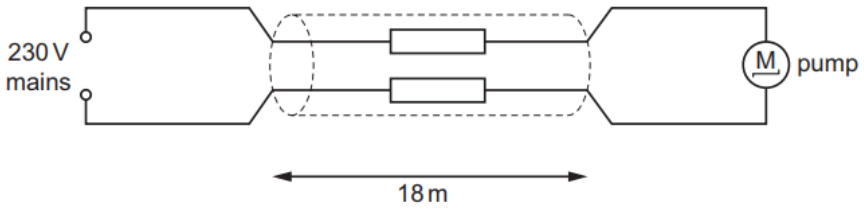
How many electrons must flow through this component in order for it to be supplied with 4.8 J of energy?

A 2.6×10^{18} **B** 1.5×10^{19} **C** 3.0×10^{19} **D** 6.0×10^{19}

S14/12

62. A

32 The diagram shows an electric pump for a garden fountain connected by an 18 m cable to a 230 V mains electrical supply.



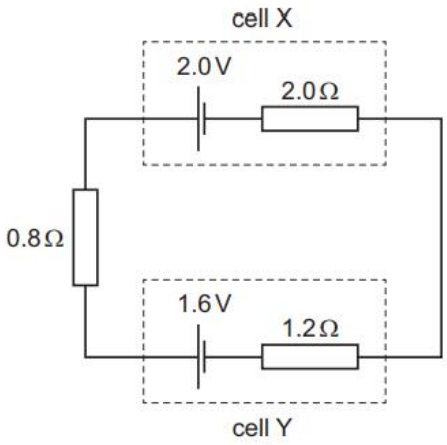
The performance of the pump is acceptable if the potential difference (p.d.) across it is at least 218 V. The current through it is then 0.83 A.

What is the maximum resistance per metre of each of the two wires in the cable if the pump is to perform acceptably?

A $0.40\,\Omega m^{-1}$ **B** $0.80\,\Omega m^{-1}$ **C** $1.3\,\Omega m^{-1}$ **D** $1.4\,\Omega m^{-1}$

63. A

33 Cell X has an e.m.f. of 2.0 V and an internal resistance of 2.0 Ω. Cell Y has an e.m.f. of 1.6 V and an internal resistance of 1.2 Ω. These two cells are connected to a resistor of resistance 0.8 Ω, as shown.

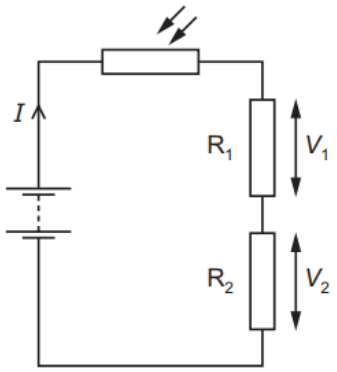


What is the current in cell X?

A 0.10 A **B** 0.50 A **C** 0.90 A **D** 1.0 A

64. D

34 In the circuit shown, a light-dependent resistor (LDR) is connected to two resistors R_1 and R_2. The potential difference (p.d.) across R_1 is V_1 and the p.d. across R_2 is V_2. The current in the circuit is I.



Which statement about this circuit is correct?

A The current I increases when the light intensity decreases.

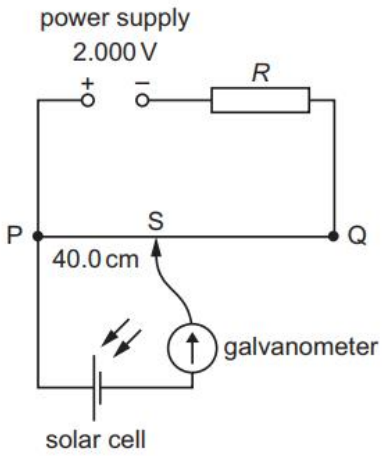
B The LDR is an ohmic conductor.

C The p.d. V_2 increases when the light intensity decreases.

D The ratio $\frac{V_1}{V_2}$ is independent of light intensity.

65. B

35 A power supply and a solar cell are compared using the potentiometer circuit shown.



The e.m.f. produced by the solar cell is measured on the potentiometer.

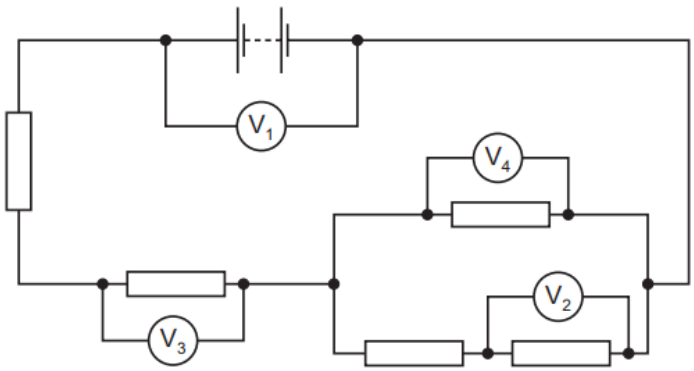
The potentiometer wire PQ is 100.0 cm long and has a resistance of 5.00 Ω. The power supply has an e.m.f. of 2.000 V and the solar cell has an e.m.f. of 5.00 mV.

Which resistance *R* must be used so that the galvanometer reads zero when PS = 40.0 cm?

A 395 Ω **B** 795 Ω **C** 995 Ω **D** 1055 Ω

66. B

36 In the circuit shown, all the resistors are identical.



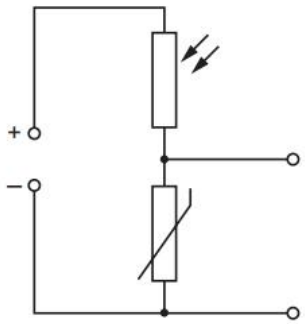
The reading on voltmeter V_1 is 8.0 V and the reading on voltmeter V_2 is 1.0 V.

What are the readings on the other voltmeters?

	reading on voltmeter V_3/V	reading on voltmeter V_4/V
A	1.5	1.0
B	3.0	2.0
C	4.5	3.0
D	6.0	4.0

67. B

37 The diagram shows a light-dependent resistor (LDR) and a thermistor forming a potential divider.



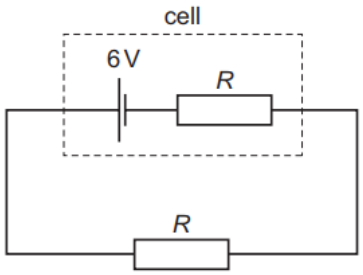
Under which set of conditions will the potential difference across the thermistor have the greatest value?

	illumination	temperature
A	low	low
B	high	low
C	low	high
D	high	high

S14/13

68. D

34 A cell has an electromotive force (e.m.f.) of 6 V and internal resistance *R*. An external resistor, also of resistance *R*, is connected across this cell, as shown.



Power *P* is dissipated by the external resistor.

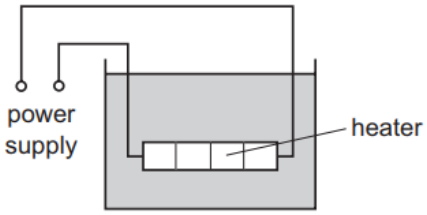
The cell is replaced by a different cell that has an e.m.f. of 6 V and negligible internal resistance.

What is the new power that is dissipated in the external resistor?

A 0.5*P** **B** *P** **C** 2*P** **D** 4*P*

69. A

35 The diagram shows a low-voltage circuit for heating the water in a fish tank.



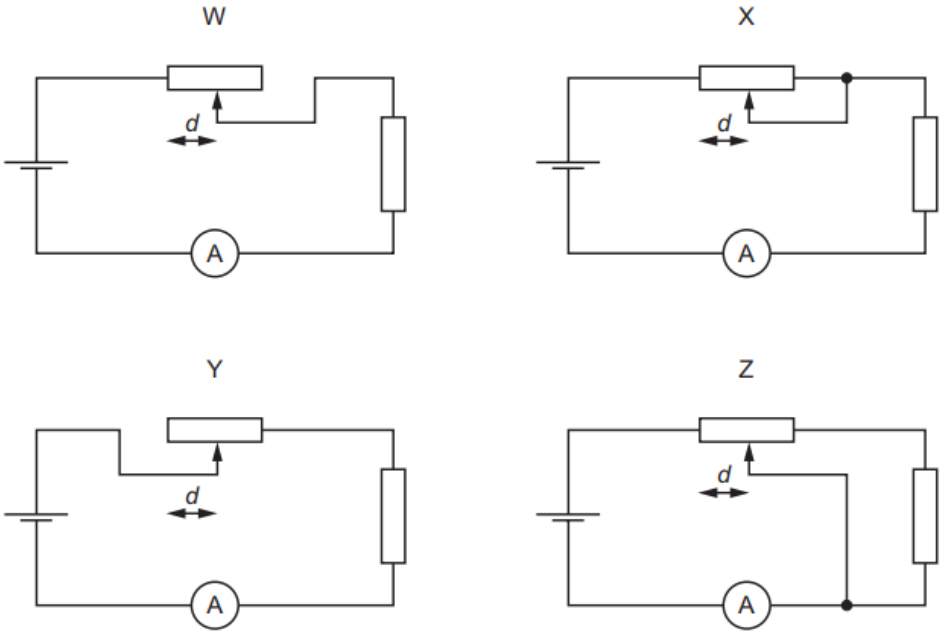
The heater has a resistance of 3.0Ω. The power supply has an e.m.f. of 12V and an internal resistance of 1.0Ω.

At which rate is energy supplied to the heater?

A 27W **B** 36W **C** 48W **D** 64W

70. A

36 The diagrams show the same cell, ammeter, potentiometer and fixed resistor connected in different ways.



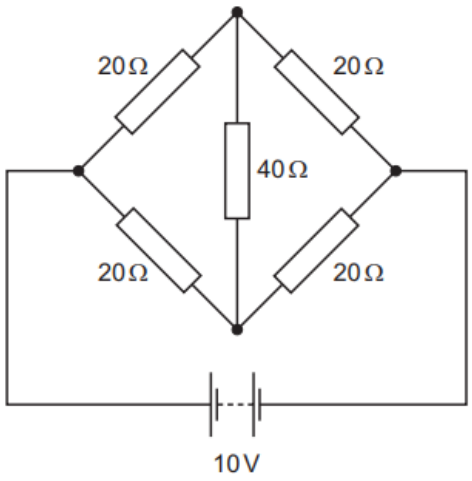
The distance *d* between the sliding contact and a particular end of the potentiometer is varied. The current measured is then plotted against the distance *d*.

For which two circuits will the graphs be identical?

A W and X **B** W and Y **C** X and Y **D** Y and Z

71. A

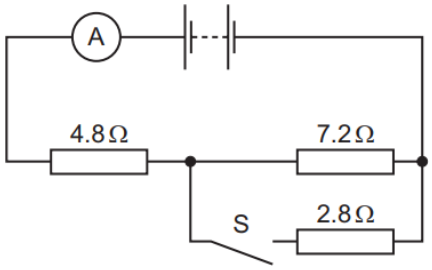
37 What is the current in the 40 Ω resistor of the circuit shown?



A zero **B** 0.13 A **C** 0.25 A **D** 0.50 A

72. C

38 A battery of negligible internal resistance is connected to a resistor network, an ammeter and a switch S, as shown.



When S is open, the reading on the ammeter is 250 mA.

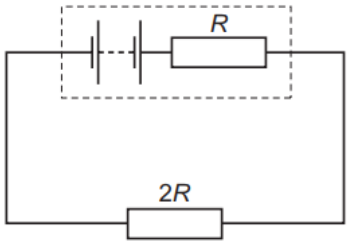
When S is closed, what is the **change** in the reading on the ammeter?

A 1.07 A **B** 1.32 A **C** 190 mA **D** 440 mA

W13/11

73. C

33 The diagram shows an electric circuit in which the resistance of the external resistor is $2R$ and the internal resistance of the source is R.



What is the ratio $\frac{\text{power in external resistor}}{\text{power in internal resistance}}$?

A $\frac{1}{4}$ **B** $\frac{1}{2}$ **C** 2 **D** 4

74. B

34 Two lamps are connected in series to a 250 V power supply. One lamp is rated 240 V, 60 W and the other is rated 10 V, 2.5 W.

Which statement most accurately describes what happens?

A Both lamps light at less than their normal brightness.

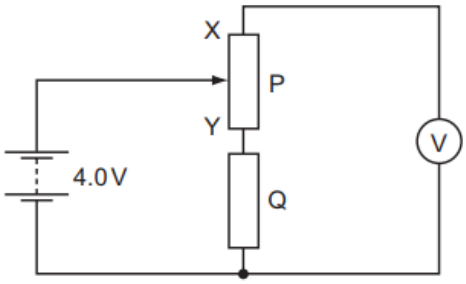
B Both lamps light normally.

C Only the 60 W lamp lights.

D The 10 V lamp blows.

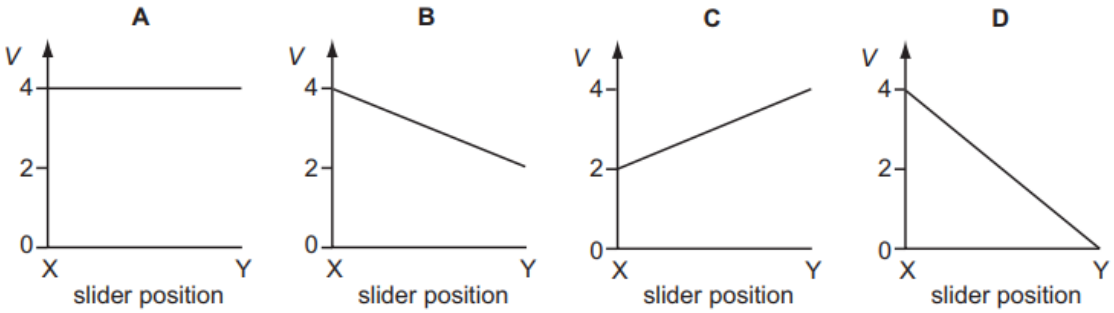
75. A

36 In the circuit below, P is a potentiometer of total resistance 10Ω and Q is a fixed resistor of resistance 10Ω. The battery has an electromotive force (e.m.f.) of 4.0V and negligible internal resistance. The voltmeter has a very high resistance.



The slider on the potentiometer is moved from X to Y and a graph of voltmeter reading *V* is plotted against slider position.

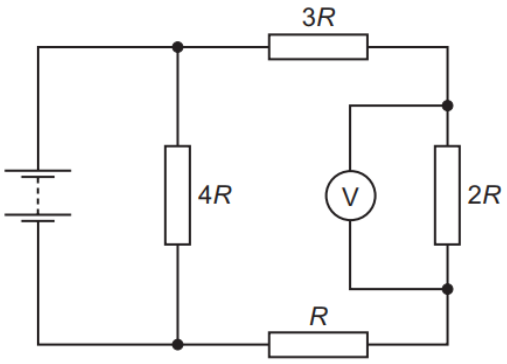
Which graph would be obtained?



76. C

38 Four resistors of resistance *R*, 2*R*, 3*R* and 4*R* are connected to form a network.

A battery of negligible internal resistance and a voltmeter are connected to the resistor network as shown.



The voltmeter reading is 2V.

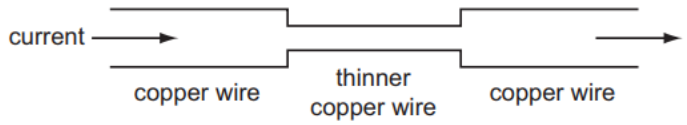
What is the electromotive force (e.m.f.) of the battery?

A 2V **B** 4V **C** 6V **D** 10V

W13/13

77. C

33 An electric current is passed from a thick copper wire through a section of thinner copper wire before entering a second thick copper wire as shown.



Which statement about the current and the speed of electrons in the wires is correct?

A The current and the speed of the electrons in the thinner wire are both less than in the thicker copper wires.

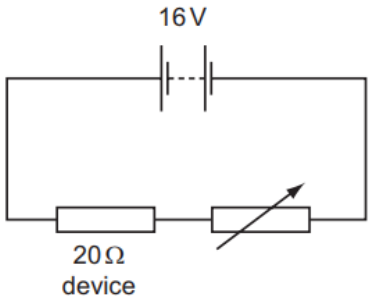
B The current and the speed of the electrons is the same in all the wires.

C The current is the same in all the wires but the speed of the electrons in the thinner wire is greater than in the thicker wires.

D The current is the same in all the wires but the speed of the electrons in the thinner wire is less than in the thicker wire.

78. A

34 An electrical device of fixed resistance 20 Ω is connected in series with a variable resistor and a battery of electromotive force (e.m.f.) 16 V and negligible internal resistance.

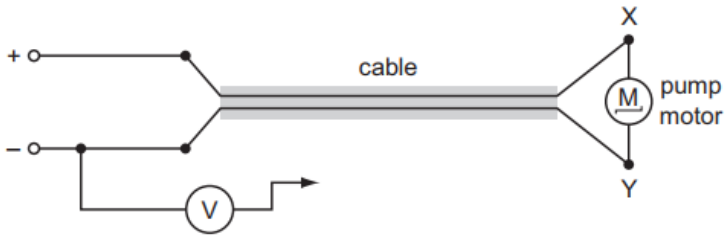


What is the resistance of the variable resistor when the power dissipated in the electrical device is 4.0 W?

A 16 Ω **B** 36 Ω **C** 44 Ω **D** 60 Ω

79. D

36 The diagram shows the electric motor for a garden pump connected to a 24 V power supply by an insulated two-core cable.



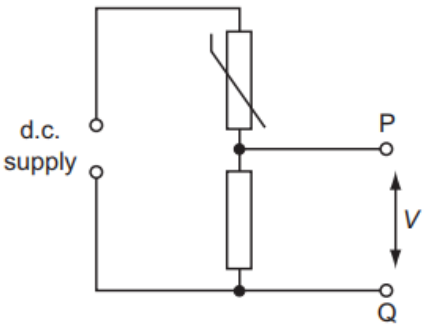
The motor does not work so, to find the fault, the negative terminal of a voltmeter is connected to the negative terminal of the power supply and its other end is connected in turn to terminals X and Y at the motor.

Which row represents two readings and a correct conclusion?

	voltmeter reading when connected to X / V	voltmeter reading when connected to Y / V	conclusion
A	24	0	break in positive wire of cable
B	24	12	break in negative wire of cable
C	24	24	break in connection within the motor
D	24	24	break in negative wire of cable

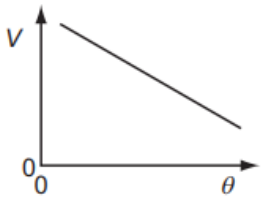
80. C

37 In the circuit shown, the resistance of the thermistor decreases as temperature increases.

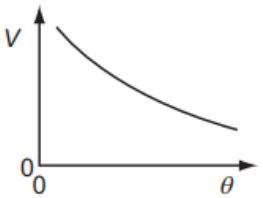


Which graph shows the variation with Celsius temperature θ of potential difference V between points P and Q?

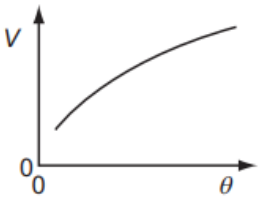
A



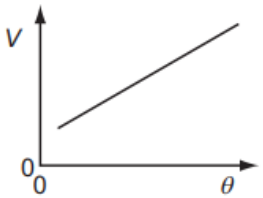
B



C

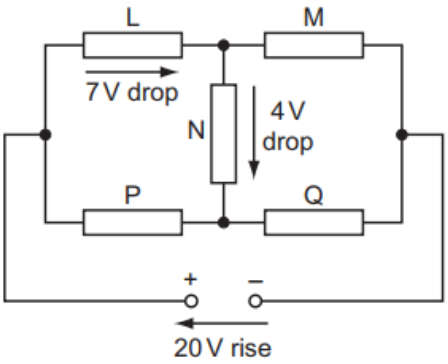


D



81. C

38 A 20 V d.c. supply is connected to a circuit consisting of five resistors L, M, N, P and Q.



There is a potential drop of 7 V across L and a further 4 V potential drop across N.

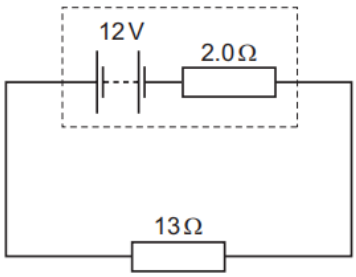
What are the potential drops across M, P and Q?

	potential drop across M/V	potential drop across P/V	potential drop across Q/V
A	9	7	13
B	13	7	13
C	13	11	9
D	17	3	17

S13/11

82. A

32 A power supply of electromotive force (e.m.f.) 12 V and internal resistance 2.0 Ω is connected in series with a 13 Ω resistor.



What is the power dissipated in the 13 Ω resistor?

A 8.3 W **B** 9.6 W **C** 10 W **D** 11 W

83. A

33 When a battery is connected to a resistor, the battery gradually becomes warm. This causes the internal resistance of the battery to increase whilst its e.m.f. stays unchanged.

As the internal resistance of the battery increases, how do the terminal potential difference and the output power change, if at all?

	terminal potential difference	output power
A	decrease	decrease
B	decrease	unchanged
C	unchanged	decrease
D	unchanged	unchanged

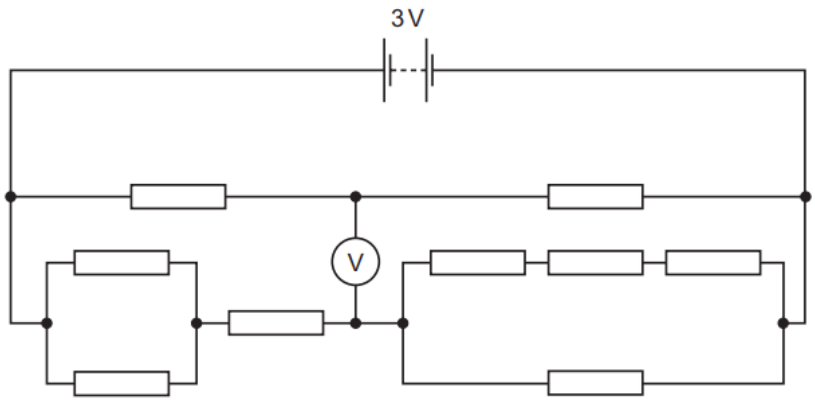
84. A

34 The principles of conservation of which two quantities are associated with Kirchhoff's first and second laws?

	first law	second law
A	charge	energy
B	charge	voltage
C	energy	charge
D	voltage	charge

85. B

35 A circuit is set up as shown, supplied by a 3 V battery. All resistances are 1 kΩ.

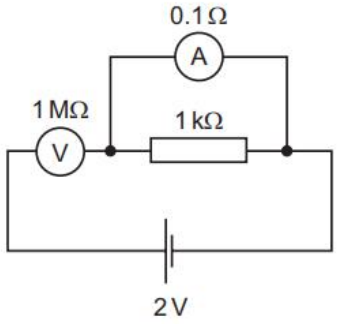


What will be the reading on the voltmeter?

A 0 **B** 0.5 V **C** 1.0 V **D** 1.5 V

86. D

36 The diagram shows an incorrectly connected circuit. The ammeter has a resistance of 0.1 Ω and the voltmeter has a resistance of 1 MΩ.



Which statement is correct?

A The ammeter reads 2 mA.

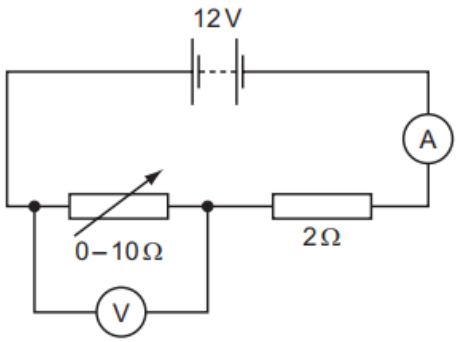
B The ammeter reads 20 A.

C The voltmeter reads zero.

D The voltmeter reads 2 V.

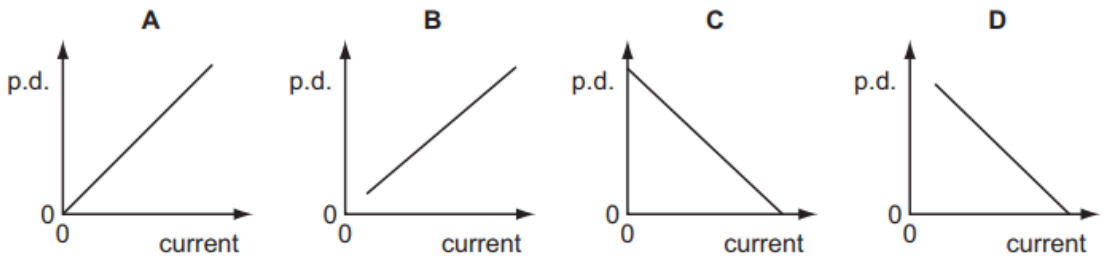
87. D

37 A 12 V battery is in series with an ammeter, a 2 Ω fixed resistor and a 0 – 10 Ω variable resistor. A high-resistance voltmeter is connected across the variable resistor.



The resistance of the variable resistor is changed from zero to its maximum value.

Which graph shows how the potential difference (p.d.) measured by the voltmeter varies with the current measured by the ammeter?



S13/12

88. A

33 A low-voltage supply with an e.m.f. of 20 V and an internal resistance of 1.5 Ω is used to supply power to a heater of resistance 6.5 Ω in a fish tank.

What is the power supplied to the water in the fish tank?

A 41 W **B** 50 W **C** 53 W **D** 62 W

89. A

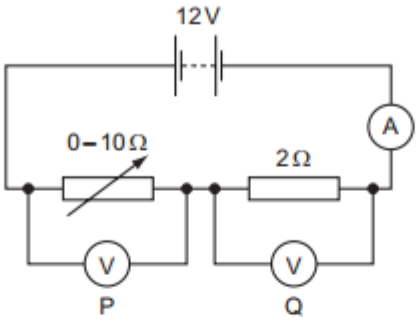
34 A filament lamp has a resistance of 180 Ω when the current in it is 500 mA.

What is the power transformed in the lamp?

A 45 W **B** 50 W **C** 90 W **D** 1400 W

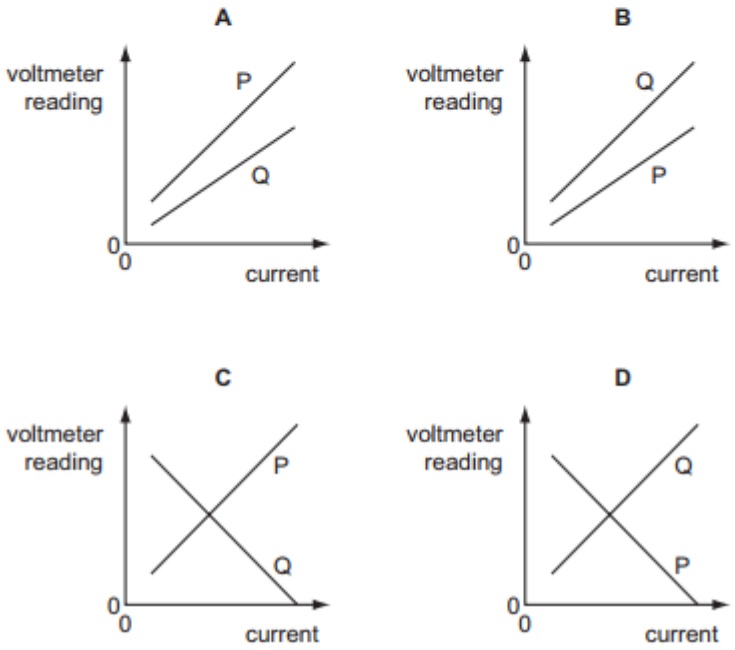
90. D

36 A 12 V battery is in series with an ammeter, a 2 Ω fixed resistor and a 0 – 10 Ω variable resistor. High-resistance voltmeters P and Q are connected across the variable resistor and the fixed resistor respectively, as shown.



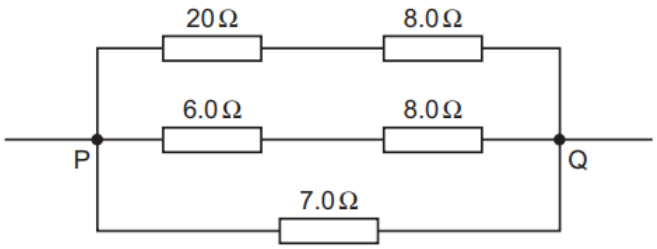
The resistance of the variable resistor is changed from its maximum value to zero.

Which graph shows the variation with current of the voltmeter readings?



91. C

37 Five resistors are connected as shown.

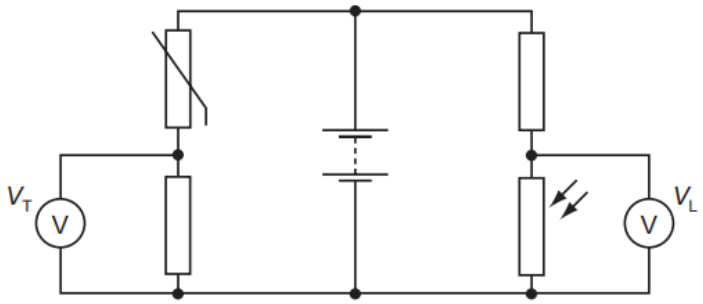


What is the total resistance between P and Q?

A 0.25Ω **B** 0.61Ω **C** 4.0Ω **D** 16Ω

92. C

38 In the circuit below, the reading V_T on the voltmeter changes from high to low as the temperature of the thermistor changes. The reading V_L on the voltmeter changes from high to low as the level of light on the light-dependent resistor (LDR) changes.



The readings V_T and V_L are both high.

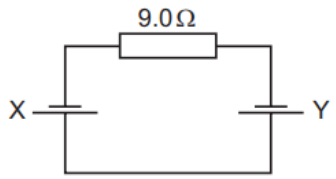
What are the conditions of temperature and light level?

	temperature	light level
A	low	low
B	low	high
C	high	low
D	high	high

S13/13

93. D

31 Two cells X and Y are connected in series with a resistor of resistance 9.0Ω, as shown.



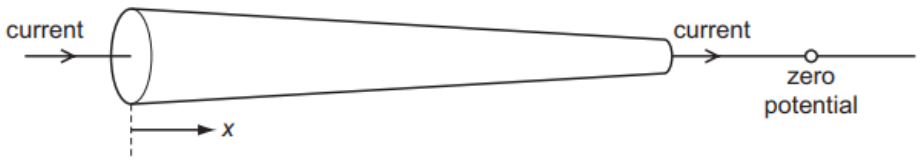
Cell X has an electromotive force (e.m.f.) of 1.0V and an internal resistance of 1.0Ω. Cell Y has an e.m.f. of 2.0V and an internal resistance of 2.0Ω.

What is the current in the circuit?

A 0.25A **B** 0.17A **C** 0.10A **D** 0.083A

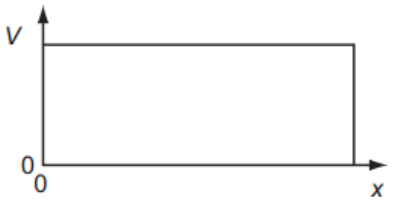
94. C

32 The circular cross-sectional area of a metal wire varies along its length. There is a current in the wire. The narrow end of the wire is at a reference potential of zero.

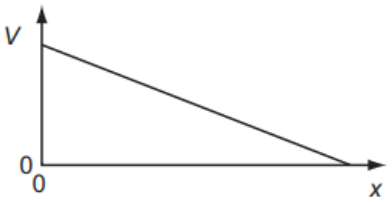


Which graph best represents the variation with distance x along the wire of the potential difference V relative to the reference zero?

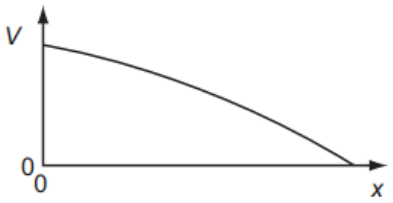
A



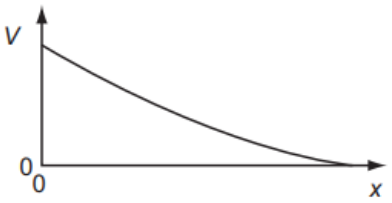
B



C

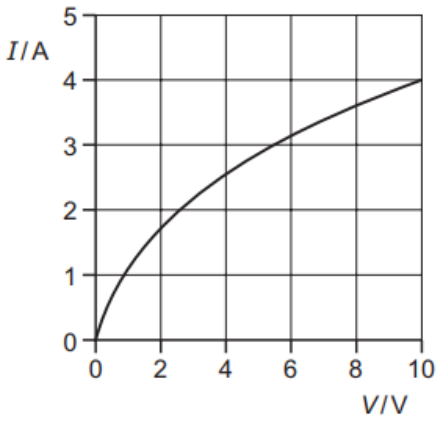


D



95. C

33 The graph shows how current I varies with voltage V for a filament lamp.



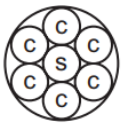
Since the graph is not a straight line, the resistance of the lamp varies with V.

Which row gives the correct resistance at the stated value of V?

	V/V	R/Ω
A	2.0	1.5
B	4.0	3.2
C	6.0	1.9
D	8.0	0.9

96. B

34 An electric power cable consists of six copper wires c surrounding a steel core s.



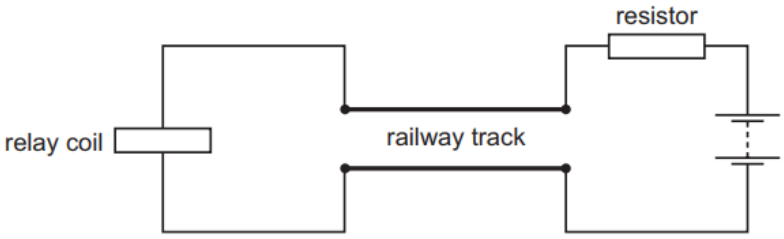
A length of 1.0 km of one of the copper wires has a resistance of 10 Ω and 1.0 km of the steel core has a resistance of 100 Ω.

What is the approximate resistance of a 1.0 km length of the power cable?

A 0.61 Ω **B** 1.6 Ω **C** 160 Ω **D** 610 Ω

97. C

35 The diagram shows a length of track from a model railway connected to a battery, a resistor and a relay coil.



With no train present, there is a current in the relay coil which operates a switch to turn on a light.

When a train occupies the section of track, most of the current flows through the wheels and axles of the train in preference to the relay coil. The switch in the relay turns off the light.

Why is a resistor placed between the battery and the track?

A to limit the heating of the wheels of the train

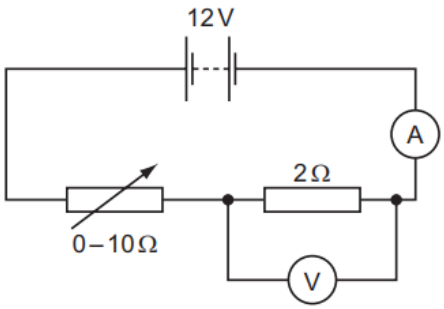
B to limit the energy lost in the relay coil when a train is present

C to prevent a short circuit of the battery when a train is present

D to protect the relay when a train is present

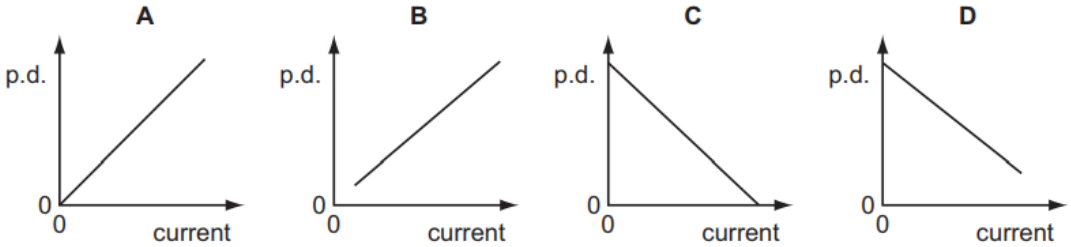
98. B

36 A 12 V battery is in series with an ammeter, a 2 Ω fixed resistor and a 0 – 10 Ω variable resistor. A high-resistance voltmeter is connected across the fixed resistor.



The resistance of the variable resistor is changed from zero to its maximum value.

Which graph shows how the potential difference (p.d.) measured by the voltmeter varies with the current measured by the ammeter?



W12/13

99. C

32 Which values of current and resistance will produce a rate of energy transfer of $16\,J\,s^{-1}$?

	current / A	resistance / Ω
A	1	4
B	2	8
C	4	1
D	16	1

100. B

34 Four statements about potential difference or electromotive force are listed.

1 It involves changing electrical energy into other forms.

2 It involves changing other energy forms into electrical energy.

3 It is the energy per unit charge to move charge right round a circuit.

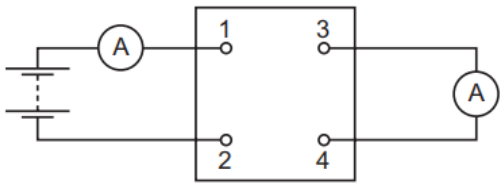
4 It is the work done per unit charge by the charge moving from one point to another.

Which statements apply to potential difference and which apply to electromotive force?

	potential difference	electromotive force
A	1 and 3	2 and 4
B	1 and 4	2 and 3
C	2 and 3	1 and 4
D	2 and 4	1 and 3

101. D

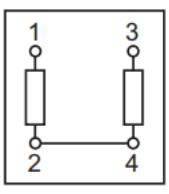
35 The diagram shows a four-terminal box connected to a battery and two ammeters.



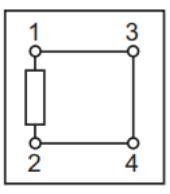
The currents in the two meters are identical.

Which circuit, within the box, will give this result?

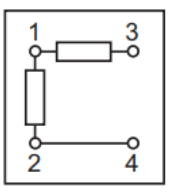
A



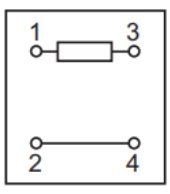
B



C

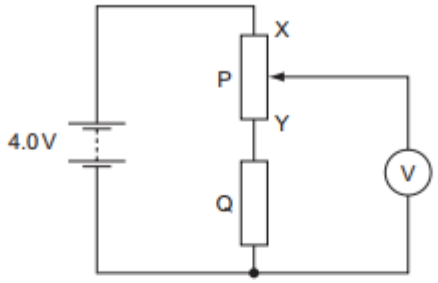


D



102. B

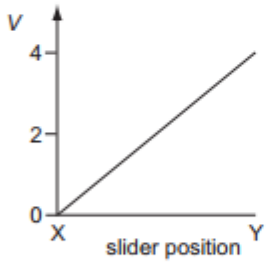
36 In the circuit below, P is a potentiometer of total resistance 10Ω and Q is a fixed resistor of resistance 10Ω. The battery has an e.m.f. of 4.0V and negligible internal resistance. The voltmeter has a very high resistance.



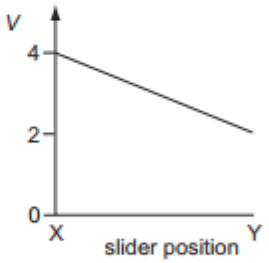
The slider on the potentiometer is moved from X to Y and a graph of voltmeter reading *V* is plotted against slider position.

Which graph is obtained?

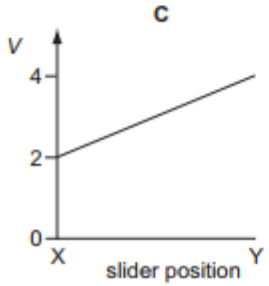
A



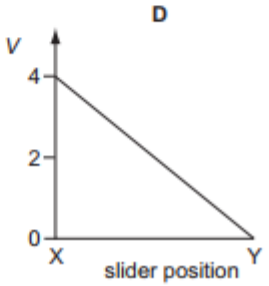
B



C

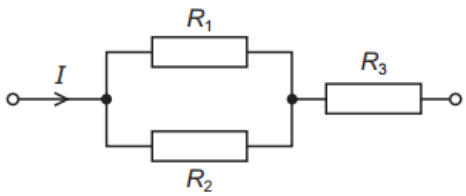


D



103. D

37 The diagram shows a resistor network. The potential difference across the network is V.



Is the equation shown below correct for the network?

$$V = I(1/R_1 + 1/R_2 + R_3)$$

A Yes, it correctly combines two series resistors with one parallel resistor, and correctly uses Ohm's Law.

B Yes, it correctly combines two parallel resistors with one series resistor, and correctly uses Ohm's Law.

C No, because it should read $V = I \div (1/R_1 + 1/R_2 + R_3)$.

D No, because the terms $1/R_2$ and R_3 have different units and cannot be added.

S12/11

104. C

33 There is a current of 10 mA in a conductor for half an hour.

How much charge passes a point in the conductor in this time?

A 0.3 C **B** 5 C **C** 18 C **D** 300 C

105. A

34 An iron wire has length 8.0 m and diameter 0.50 mm. The wire has resistance R.

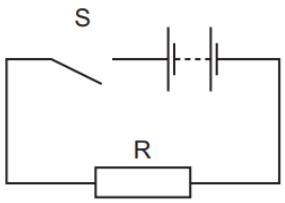
A second iron wire has length 2.0 m and diameter 1.0 mm.

What is the resistance of the second wire?

A $\frac{R}{16}$ **B** $\frac{R}{8}$ **C** $\frac{R}{2}$ **D** R

106. C

35 The diagram shows a simple circuit.



Which statement is correct?

A When switch S is closed, the electromotive force (e.m.f.) of the battery falls because work is done against the internal resistance of the battery.

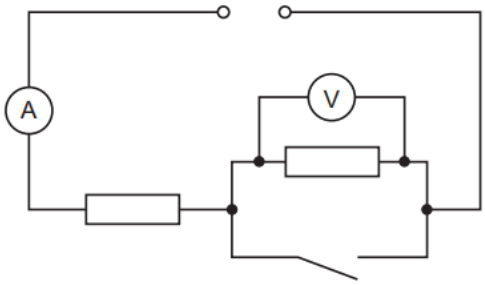
B When switch S is closed, the e.m.f. of the battery falls because work is done against the resistance R.

C When switch S is closed, the potential difference across the battery falls because work is done against the internal resistance of the battery.

D When switch S is closed, the potential difference across the battery falls because work is done against the resistance R.

107. B

36 In the circuit below, the ammeter reading is I and the voltmeter reading is V.

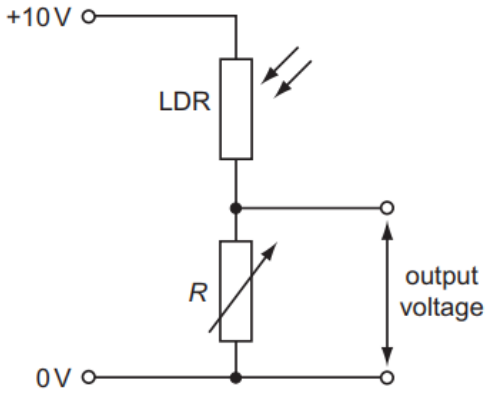


When the switch is closed, which row describes what happens to I and V?

	I	V
A	decreases	decreases to zero
B	increases	decreases to zero
C	increases	stays the same
D	stays the same	increases

108. A

37 A potential divider consists of a light-dependent resistor (LDR) in series with a variable resistor of resistance *R*. The resistance of the LDR decreases when the light level increases. The variable resistor can be set at either high resistance or low resistance.

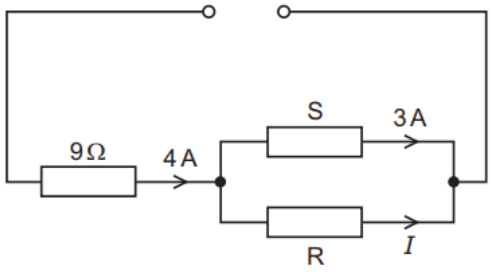


Which situation gives the largest output voltage?

	light level at LDR	*R*
A	high	high
B	high	low
C	low	high
D	low	low

109. C

38 The circuit below has a current I in the resistor R.



What must be known in order to determine the value of I?

A e.m.f. of the power supply

B resistance of resistor S

C Kirchhoff's first law

D Kirchhoff's second law

S12/12

110. C

32 When will 1 C of charge pass a point in an electrical circuit?

A when 1 A moves through a potential difference of 1 V

B when a power of 1 W is used for 1 s

C when the current is 5 mA for 200 s

D when the current is 10 A for 10 s

111. B

34 A power cable X has resistance R and carries current I.

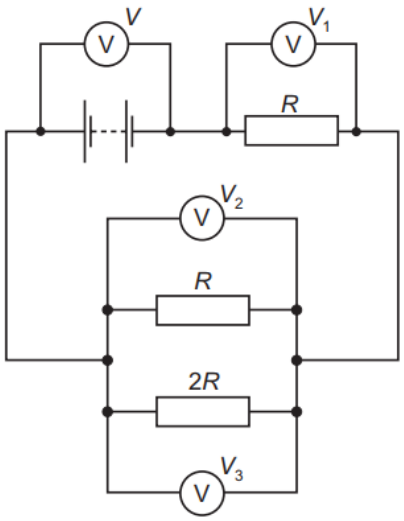
A second cable Y has resistance $2R$ and carries current $\frac{1}{2}I$.

What is the ratio $\frac{\text{power dissipated in Y}}{\text{power dissipated in X}}$?

A $\frac{1}{4}$ **B** $\frac{1}{2}$ **C** 2 **D** 4

112. D

35 The diagram shows a circuit with four voltmeter readings V, V_1, V_2 and V_3.



Which equation relating the voltmeter readings must be true?

A $V = V_1 + V_2 + V_3$

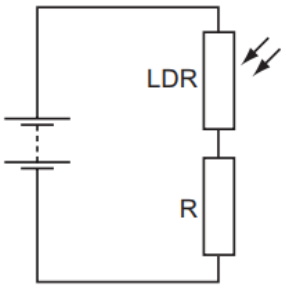
B $V + V_1 = V_2 + V_3$

C $V_3 = 2(V_2)$

D $V - V_1 = V_3$

113. D

36 A light-dependent resistor (LDR) is connected in series with a resistor R and a battery.



The resistance of the LDR is equal to the resistance of R when no light falls on the LDR.

When the light intensity falling on the LDR increases, which statement is correct?

A The current in R decreases.

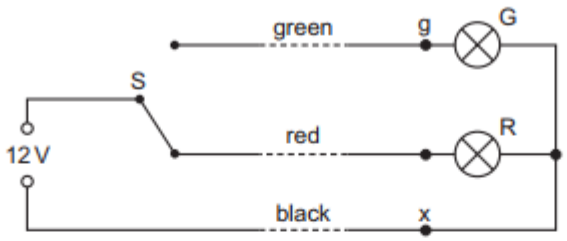
B The current in the LDR decreases.

C The p.d. across R decreases.

D The p.d. across the LDR decreases.

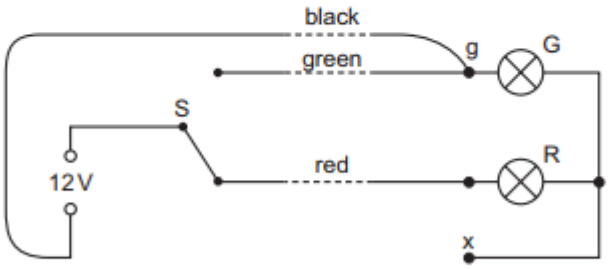
114. D

37 The diagram shows the circuit for a signal to display a green or a red light. It is controlled by the switch S.



The signal is some way from S to which it is connected by a cable with green, red and black wires. At the signal, the green and red wires are connected to the corresponding lamp and the black wire is connected to a terminal x to provide a common return. The arrangement is shown correctly connected and with the switch set to illuminate the red lamp.

During maintenance, the wires at the signal are disconnected and, when reconnected, the black wire is connected in error to the green lamp (terminal g) instead of terminal x. The red wire is connected correctly to its lamp and connections at S remain as in the diagram.



When the system is tested with the switch connection to the red wire, what does the signal show?

A the green lamp illuminated normally

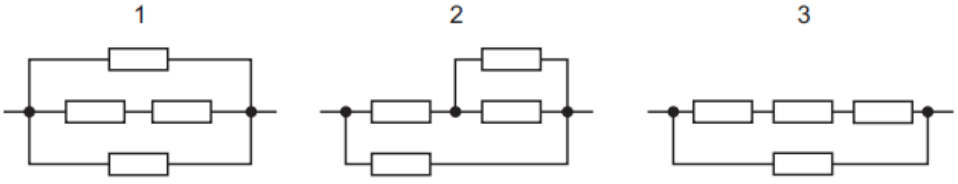
B the red lamp illuminated normally

C the red and green lamps both illuminated normally

D the red and green lamps both illuminated dimly

115. C

38 Four identical resistors are connected in the three networks below.



Which arrangement has the highest total resistance and which has the lowest?

	highest	lowest
A	1	2
B	1	3
C	3	1
D	3	2

W11/11

116. D

34 Which of the equations that link some of the following terms is correct?

potential difference (p.d.)	V
current	I
resistance	R
charge	Q
energy	E
power	P
time	t

A $P = \frac{Q^2R}{t}$

B $ER^2 = V^2t$

C $\frac{VI}{P} = t$

D $PQ = EI$

117. A

35 Which statement is **not** valid?

A Current is the speed of the charged particles that carry it.

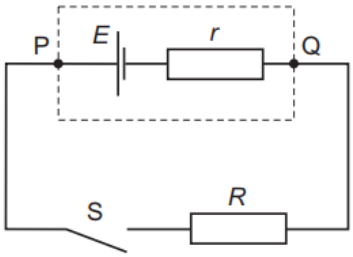
B Electromotive force (e.m.f.) is the energy converted to electrical energy from other forms, per unit charge.

C The potential difference (p.d.) between two points is the work done in moving unit charge from one point to the other.

D The resistance between two points is the p.d. between the two points, per unit current.

118. B

36 A cell of e.m.f. *E* and internal resistance *r* is connected in series with a switch S and an external resistor of resistance *R*.



The p.d. between P and Q is *V*.

When S is closed,

A *V* decreases because there is a p.d. across *R*.

B *V* decreases because there is a p.d. across *r*.

C *V* remains the same because the decrease of p.d. across *r* is balanced by the increase of p.d. across *R*.

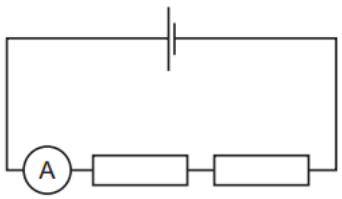
D *V* remains the same because the sum of the p.d.s across *r* and *R* is still equal to *E*.

119. D

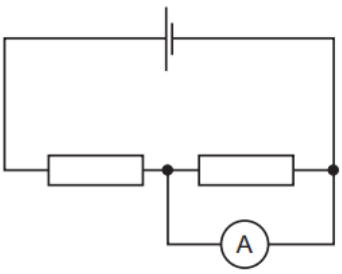
37 A cell, two resistors of equal resistance and an ammeter are used to construct four circuits. The resistors are the only parts of the circuits that have resistance.

In which circuit will the ammeter show the greatest reading?

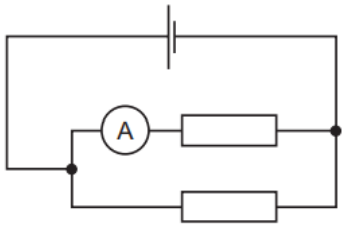
A



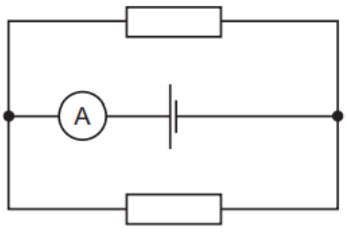
B



C

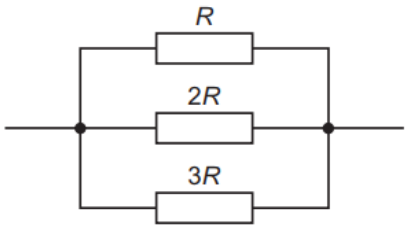


D



120. B

38 Three resistors of resistance R, $2R$ and $3R$ are connected in parallel.

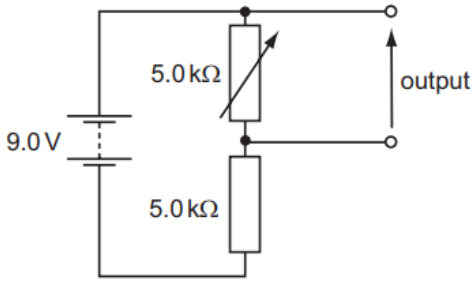


Using I to represent the current through the resistor of resistance R, which row represents the relationships between the currents through the resistors?

	resistor resistance		
	R	$2R$	$3R$
A	I	$\frac{1}{3}I$	$\frac{1}{2}I$
B	I	$\frac{1}{2}I$	$\frac{1}{3}I$
C	I	$\frac{2}{3}I$	$\frac{1}{3}I$
D	I	$2I$	$3I$

121. B

39 The diagram shows a potential divider circuit designed to provide a variable output p.d.



Which row gives the available range of output p.d.?

	maximum output	minimum output
A	3.0 V	0
B	4.5 V	0
C	9.0 V	0
D	9.0 V	4.5 V

W11/12

122. C

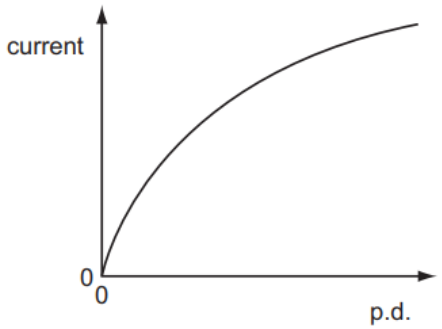
32 A charge of 8.0 C passes through a resistor of resistance 30 Ω at a constant rate in a time of 20 s.

What is the potential difference across the resistor?

A 0.40 V **B** 5.3 V **C** 12 V **D** 75 V

123. D

33 The graph shows the variation with potential difference (p.d.) of the current in a lamp filament.



Which statement explains the shape of this graph?

A As the filament temperature rises, electrons can pass more easily through the filament.

B It takes time for the filament to reach its working temperature.

C The power output of the filament is proportional to the square of the current in it.

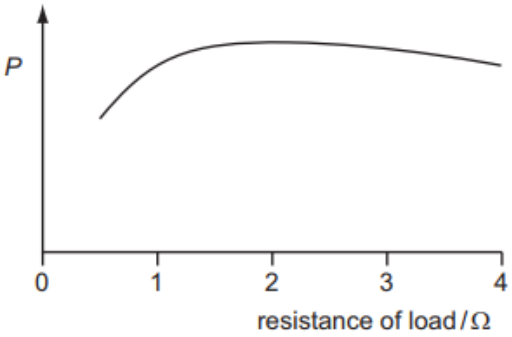
D The resistance of the filament increases with a rise in temperature.

124. A

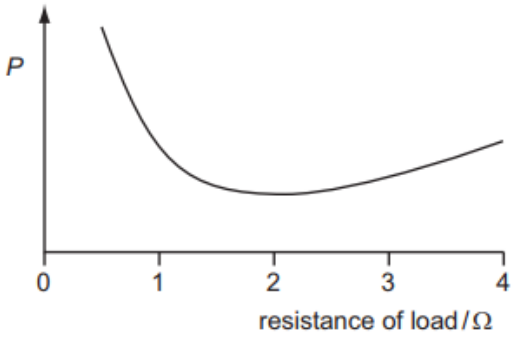
35 A power supply of electromotive force (e.m.f.) 12 V and internal resistance 2 Ω is connected in series with a load resistor. The value of the load resistor is varied from 0.5 Ω to 4 Ω.

Which graph shows how the power *P* dissipated in the load resistor varies with the resistance of the load resistor?

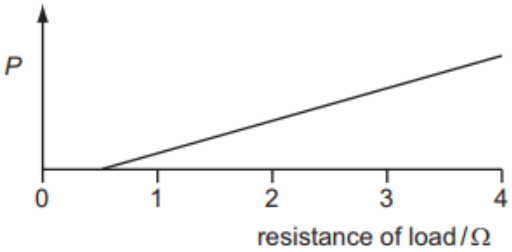
A



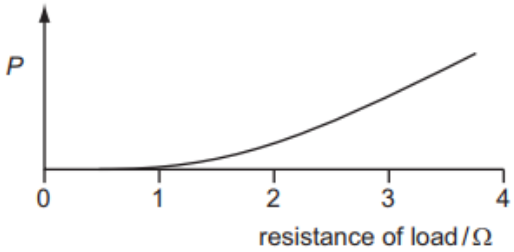
B



C



D



125. C

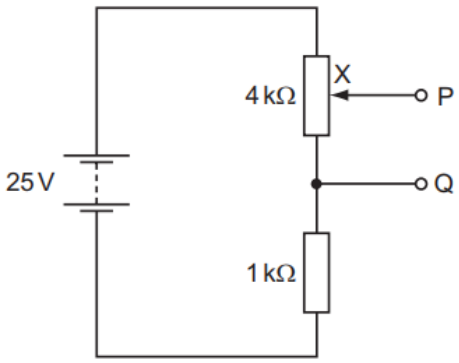
36 Each of Kirchhoff's laws is linked to the conservation of a physical quantity.

Which physical quantities are assumed to be conserved in the formulation of Kirchhoff's first law and of Kirchhoff's second law?

	Kirchhoff's first law	Kirchhoff's second law
A	energy	charge
B	energy	momentum
C	charge	energy
D	momentum	energy

126. B

37 The diagram shows a potential divider circuit which, by adjustment of the contact X, can be used to provide a variable potential difference between the terminals P and Q.

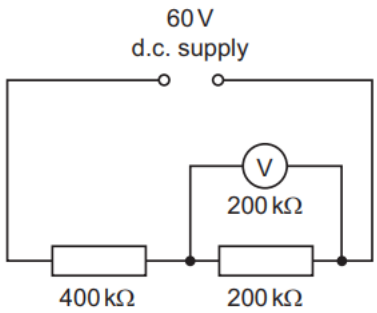


What are the limits of this potential difference?

A 0 and 5 V **B** 0 and 20 V **C** 0 and 25 V **D** 5 V and 25 V

127. A

38 A constant 60 V d.c. supply is connected across two resistors of resistance 400 kΩ and 200 kΩ.



What is the reading on a voltmeter, also of resistance 200 kΩ, when connected across the 200 kΩ resistor as shown in the diagram?

A 12 V **B** 15 V **C** 20 V **D** 30 V

S11/11

128. C

31 A copper wire of cross-sectional area 2.0 mm^2 carries a current of 10 A.

How many electrons pass through a given cross-section of the wire in one second?

A 1.0×10^{1} **B** 5.0×10^{6} **C** 6.3×10^{19} **D** 3.1×10^{25}

129. A

32 A battery is marked 9.0 V.

What does this mean?

A Each coulomb of charge from the battery supplies 9.0 J of electrical energy to the whole circuit.

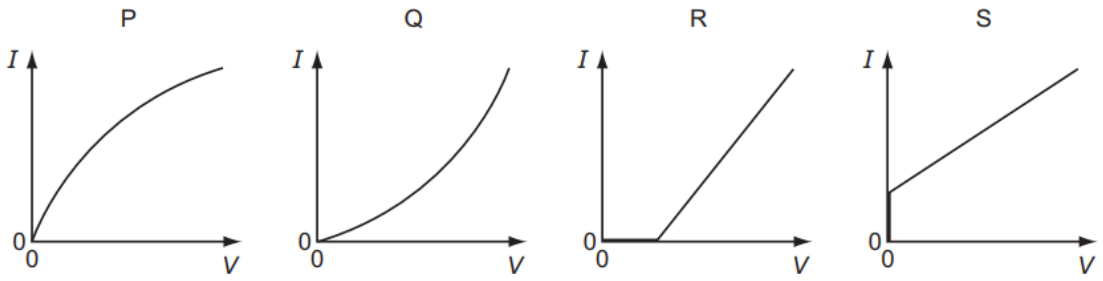
B The battery supplies 9.0 J to an external circuit for each coulomb of charge.

C The potential difference across any component connected to the battery will be 9.0 V.

D There will always be 9.0 V across the battery terminals.

130. A

33 The graphs show possible current-voltage (I-V) relationships for a filament lamp and for a semiconductor diode.

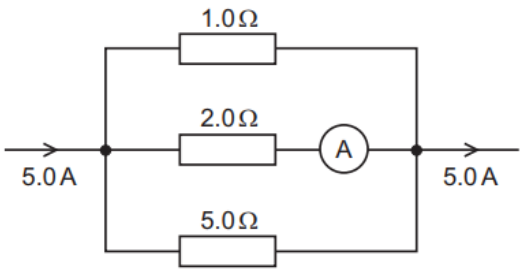


Which row best specifies the correct I-V graphs for the lamp and the diode?

	filament lamp	semiconductor diode
A	P	R
B	P	S
C	Q	R
D	Q	S

131. C

35 The diagram shows part of a current-carrying circuit. The ammeter has negligible internal resistance.

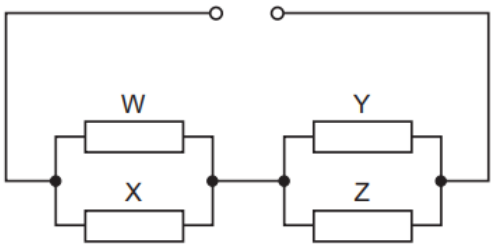


What is the reading on the ammeter?

A 0.7A **B** 1.3A **C** 1.5A **D** 1.7A

132. C

36 Four resistors of equal value are connected as shown.



How will the powers to the resistors change when resistor W is removed?

A The powers to X, Y and Z will all increase.

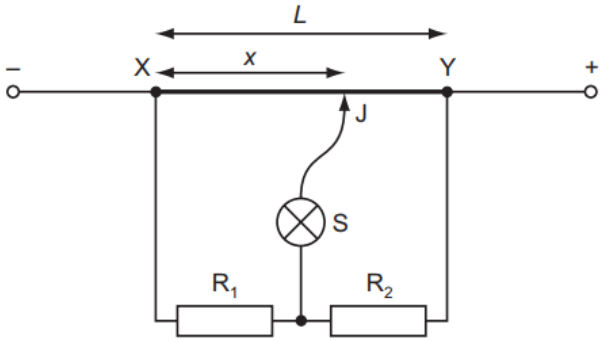
B The power to X will decrease and the powers to Y and Z will increase.

C The power to X will increase and the powers to Y and Z will decrease.

D The power to X will increase and the powers to Y and Z will remain unaltered.

133. D

37 In the circuit shown, XY is a length *L* of uniform resistance wire. R_1 and R_2 are unknown resistors. J is a sliding contact that joins the junction of R_1 and R_2 to points on XY through a small signal lamp S.



To determine the ratio $\frac{V_1}{V_2}$ of the potential differences across R_1 and R_2, a point is found on XY at which the lamp is off. This point is at a distance *x* from X.

What is the value of the ratio $\frac{V_1}{V_2}$?

A $\frac{L}{x}$ **B** $\frac{x}{L}$ **C** $\frac{L-x}{x}$ **D** $\frac{x}{L-x}$

S11/12

134. C

32 What describes the electric potential difference between two points in a wire that carries a current?

A the force required to move a unit positive charge between the points

B the ratio of the energy dissipated between the points to the current

C the ratio of the power dissipated between the points to the current

D the ratio of the power dissipated between the points to the charge moved

135. D

34 A source of electromotive force (e.m.f.) *E* has a constant internal resistance *r* and is connected to an external variable resistor of resistance *R*.

As *R* is increased from a value below *r* to a value above *r*, which statement is correct?

A The terminal potential difference remains constant.

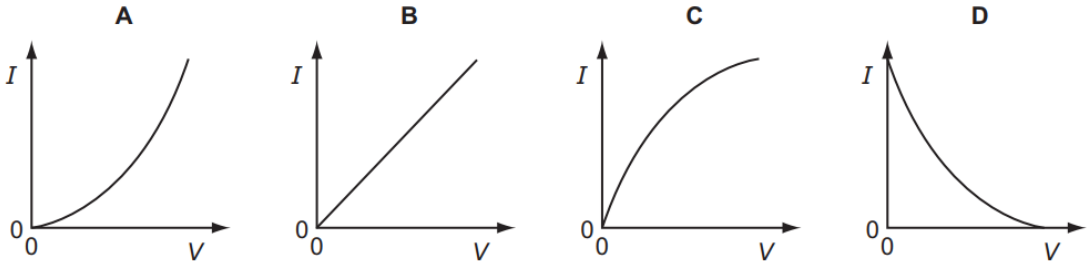
B The current in the circuit increases.

C The e.m.f. of the source increases.

D The largest output power is obtained when *R* reaches *r*.

136. A

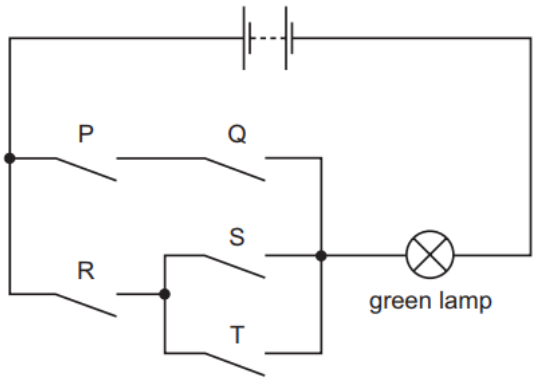
35 Which graph best represents the way in which the current I through a thermistor depends upon the potential difference V across it?



137. C

36 Safety on railways is increased by using several electrical switches.

In the diagram, switches P, Q, R, S and T control the current through a green lamp.

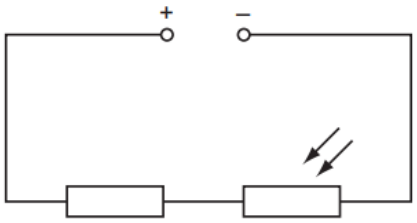


Which row does **not** allow the green lamp to light?

	P	Q	R	S	T
A	closed	closed	closed	open	closed
B	closed	open	closed	closed	open
C	closed	open	open	closed	closed
D	open	open	closed	open	closed

138. B

37 The diagram shows a fixed resistor and a light-dependent resistor (LDR) in series with a constant low-voltage supply.



When the LDR is in the dark, the fixed resistor and the LDR have the same value of resistance.

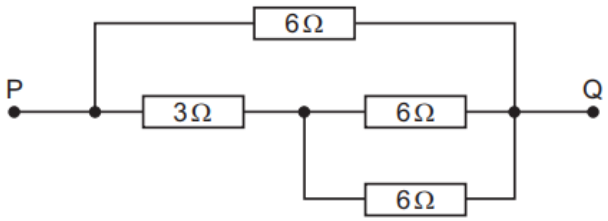
Light is shone on the LDR.

What happens to the potential differences across the two components?

	p.d. across resistor	p.d. across LDR
A	decreased	increased
B	increased	decreased
C	no change	increased
D	no change	decreased

139. C

38 The diagram shows a d.c. circuit.



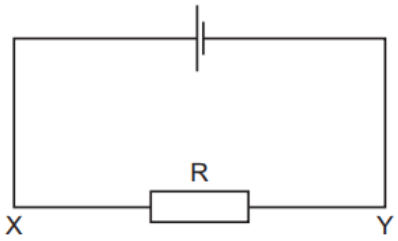
What is the resistance between the points P and Q due to the resistance network?

A 0.47Ω **B** 2.1Ω **C** 3.0Ω **D** 21Ω

W10/11

140. C

31 The current in the circuit shown is 4.8 A.

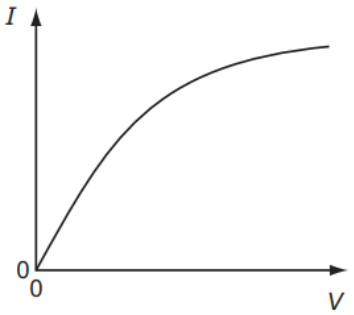


What is the direction of flow and the rate of flow of electrons through the resistor R?

	direction of flow	rate of flow
A	X to Y	$3.0 \times 10^{19}\,s^{-1}$
B	X to Y	$6.0 \times 10^{18}\,s^{-1}$
C	Y to X	$3.0 \times 10^{19}\,s^{-1}$
D	Y to X	$6.0 \times 10^{18}\,s^{-1}$

141. A

32 Which component has the *I*-*V* graph shown?



A filament lamp

B light-dependent resistor

C semiconductor diode

D thermistor

142. B

33 A copper wire is cylindrical and has resistance *R*.

What will be the resistance of a copper wire of twice the length and twice the radius?

A $\frac{R}{4}$ **B** $\frac{R}{2}$ **C** R **D** $2R$

143. C

34 A relay is required to operate 800 m from its power supply. The power supply has negligible internal resistance. The relay requires 16.0 V and a current of 0.60 A to operate.

A cable connects the relay to the power supply and two of the wires in the cable are used to supply power to the relay.

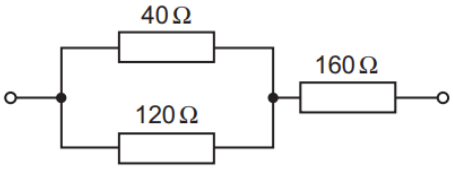
The resistance of each of these wires is 0.0050 Ω per metre.

What is the minimum output e.m.f. of the power supply?

A 16.6 V **B** 18.4 V **C** 20.8 V **D** 29.3 V

144. C

35 The diagram shows part of a circuit.

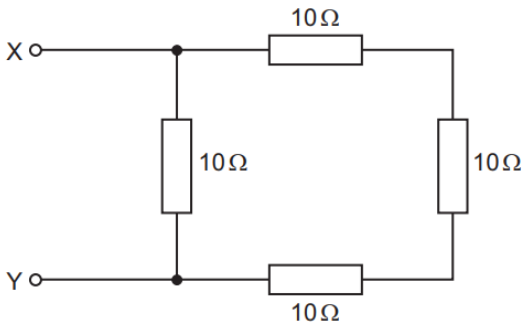


What is the total resistance of the combination of the three resistors?

A 320 Ω **B** 240 Ω **C** 190 Ω **D** 80 Ω

145. B

36 The diagram shows an arrangement of resistors.



What is the total electrical resistance between X and Y?

A less than 1 Ω

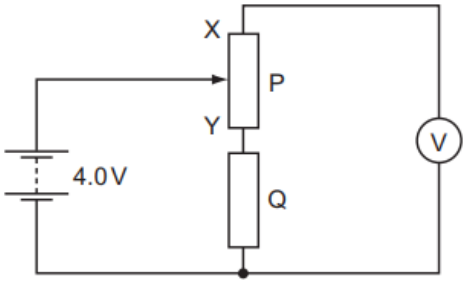
B between 1 Ω and 10 Ω

C between 10 Ω and 30 Ω

D 40 Ω

146. A

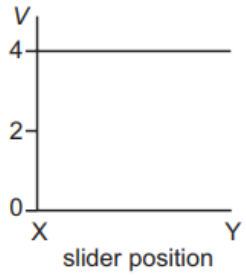
37 In the circuit below, P is a potentiometer of total resistance 10 Ω and Q is a fixed resistor of resistance 10 Ω. The battery has an e.m.f. of 4.0 V and negligible internal resistance. The voltmeter has a very high resistance.



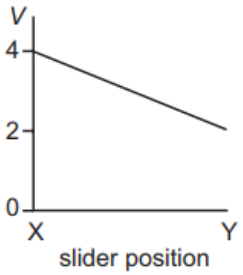
The slider on the potentiometer is moved from X to Y and a graph of voltmeter reading *V* is plotted against slider position.

Which graph would be obtained?

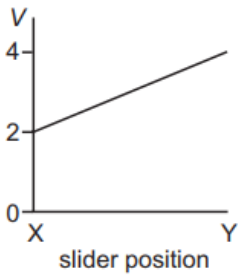
A



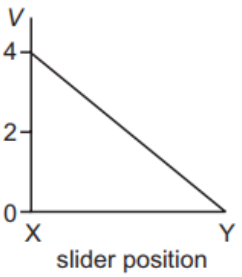
B



C



D



W10/12

147. D

30 Which electrical component is represented by the following symbol?

A a diode

B a potentiometer

C a resistor

D a thermistor

148. A

31 When there is **no current** in a wire, which statement about the conduction electrons in that wire is correct?

A Electrons in the wire are moving totally randomly within the wire.

B Equal numbers of electrons move at the same speed, but in opposite directions, along the wire.

C No current is flowing therefore the electrons in the wire are stationary.

D No current is flowing therefore the electrons in the wire are vibrating around a fixed point.

149. C

32 A high-resistance voltmeter connected across a battery reads 6.0 V.

When the battery is connected in series with a lamp of resistance of 10 Ω, the voltmeter reading falls to 5.6 V.

Which statement explains this observation?

A The electromotive force (e.m.f.) of the battery decreases because more work is done across its internal resistance.

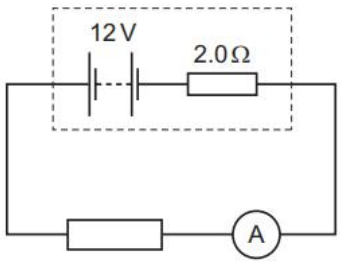
B The e.m.f. of the battery decreases because work is done across the lamp.

C The potential difference (p.d.) across the battery decreases because more work is done across its internal resistance.

D The p.d. across the battery decreases because work is done across the lamp.

150. D

33 A battery of e.m.f. 12 V and internal resistance 2.0 Ω is connected in series with an ammeter of negligible resistance and an external resistor. External resistors of various different values are used.

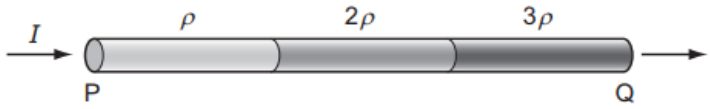


Which combination of current and resistor value is **not** correct?

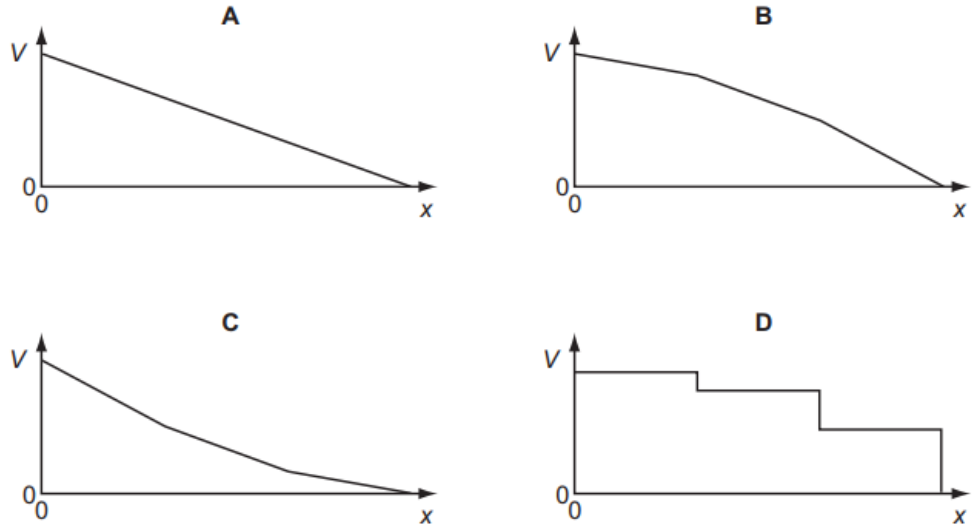
	current / A	external resistor value / Ω
A	1.0	10
B	1.2	8
C	1.5	6
D	1.8	4

151. B

34 A wire PQ is made of three different materials, with resistivities ρ, 2ρ and 3ρ. There is a current I in this composite wire, as shown.

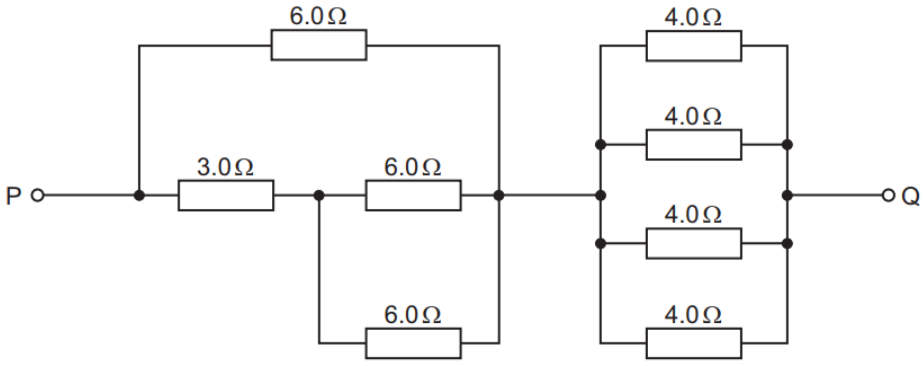


Which graph best shows how the potential V along the wire varies with distance x from P?



152. B

35 The diagram shows part of a circuit.

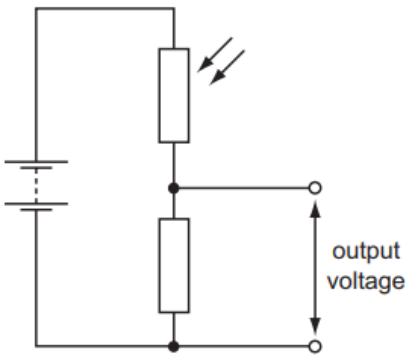


What is the resistance between the points P and Q due to the resistance network?

A 1.3Ω **B** 4.0Ω **C** 10Ω **D** 37Ω

153. B

36 The diagram shows a potential divider circuit.



The light level increases.

What is the effect on the resistance of the light-dependent resistor (LDR) and on the output voltage?

	resistance of the LDR	output voltage
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

154. B

37 Three resistors, with resistances R_1, R_2 and R_3, are connected in series and are found to have a combined resistance of 500 Ω. When connected in parallel, the combined resistance is found to be 50 Ω.

Which values will correspond to these results?

	R_1/Ω	R_2/Ω	R_3/Ω
A	160	160	80
B	200	200	100
C	225	225	50
D	230	230	40

S10/11

155. A

30 In terms of energy transfer W and charge q, what are the definitions of potential difference (p.d.) and electromotive force (e.m.f.)?

	p.d.	e.m.f.
A	$\frac{W}{q}$	$\frac{W}{q}$
B	$\frac{W}{q}$	Wq
C	Wq	$\frac{W}{q}$
D	Wq	Wq

156. D

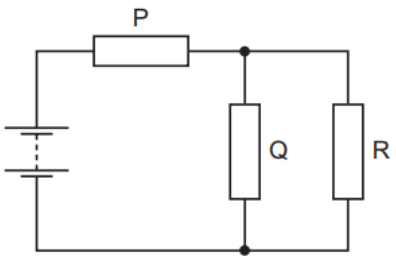
32 The resistance of a thermistor depends on its temperature, and the resistance of a light-dependent resistor (LDR) depends on the illumination.

Under which conditions will the resistance of both a thermistor and an LDR be highest?

	thermistor	LDR
A	highest temperature	highest illumination
B	highest temperature	lowest illumination
C	lowest temperature	highest illumination
D	lowest temperature	lowest illumination

157. A

33 The resistors P, Q and R in the circuit have equal resistance.



The battery, of negligible internal resistance, supplies a total power of 12W.

What is the power dissipated by heating in resistor R?

A 2W **B** 3W **C** 4W **D** 6W

158. A

34 In deriving a formula for the combined resistance of three different resistors in series, Kirchhoff's laws are used.

Which physics principle is involved in this derivation?

A the conservation of charge

B the direction of the flow of charge is from negative to positive

C the potential difference across each resistor is the same

D the current varies in each resistor, in proportion to the resistor value

159. A

35 A source of e.m.f. of 9.0 mV has an internal resistance of 6.0 Ω.

It is connected across a galvanometer of resistance 30 Ω.

What will be the current in the galvanometer?

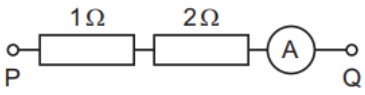
A 250 μA **B** 300 μA **C** 1.5 mA **D** 2.5 mA

160. D

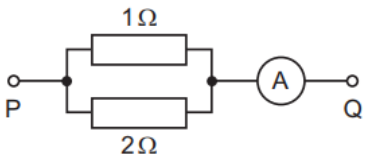
36 In each arrangement of resistors, the ammeter has a resistance of 2 Ω.

Which arrangement gives the largest reading on the ammeter when the same potential difference is applied between points P and Q?

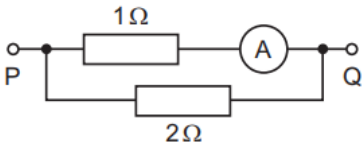
A



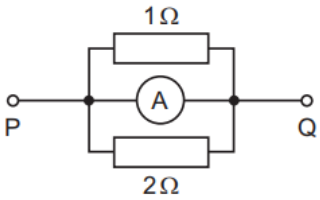
B



C



D



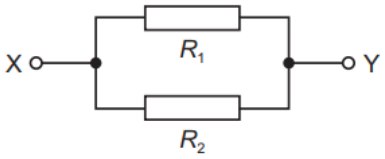
New Topic 11:

11. RESISTANCE AND RESISTIVITY

S16/11

1. B

36 Two resistors of resistances R_1 and R_2 are connected in parallel.



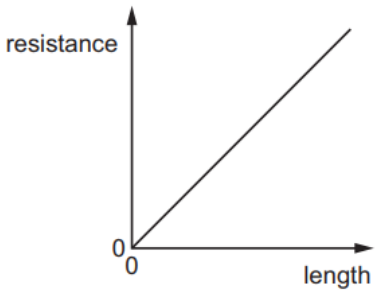
What is the combined resistance between X and Y?

A $R_1 + R_2$ **B** $\frac{R_1 R_2}{R_1 + R_2}$ **C** $\frac{R_1 + R_2}{R_1 R_2}$ **D** $\frac{R_1}{R_2}$

S16/13

2. A

32 The graph shows the variation with length of the resistance of a uniform metal wire.



The gradient of the graph is G.
The wire has cross-sectional area A.

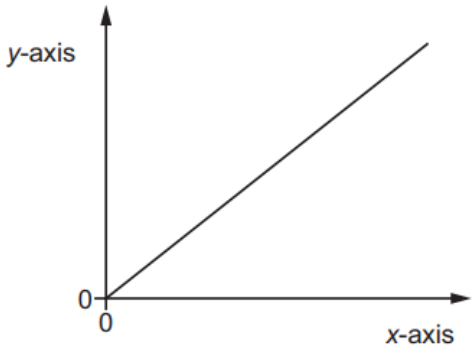
Which expression could be used to calculate the resistivity of the metal of the wire?

A $G \times A$ **B** $\frac{G}{A}$ **C** $\frac{A}{G}$ **D** $G \times A^2$

W15/11

3. C

31 The diagram shows a graph.



For a uniform metallic wire, what could the graph **not** represent?

	y-axis	*x*-axis
A	current	potential difference
B	resistance	length
C	resistance	temperature in °C
D	potential difference	current

4. A

32 An iron wire has length 8.0 m and diameter 0.50 mm. The wire has resistance R.

A second iron wire has length 2.0 m and diameter 1.0 mm.

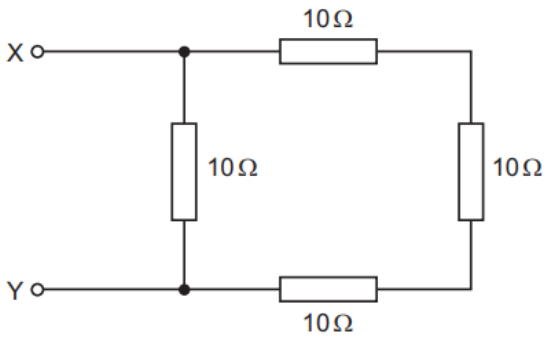
What is the resistance of the second wire?

A $\frac{R}{16}$ **B** $\frac{R}{8}$ **C** $\frac{R}{2}$ **D** R

W15/12

5. B

36 The diagram shows an arrangement of resistors.



What is the total electrical resistance between X and Y?

A less than 1Ω

B between 1Ω and 10Ω

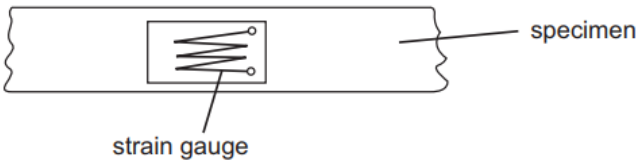
C between 10Ω and 30Ω

D 40Ω

W15/13

6. D

33 Tensile strain may be measured by the change in electrical resistance of a device called a strain gauge. A strain gauge consists of folded fine metal wire mounted on a flexible insulating backing sheet. The strain gauge is firmly attached to the specimen.



When the strain in the specimen is increased, what happens to the resistance of the wire?

A It decreases, because the length decreases and the cross-sectional area increases.

B It decreases, because the length increases and the cross-sectional area decreases.

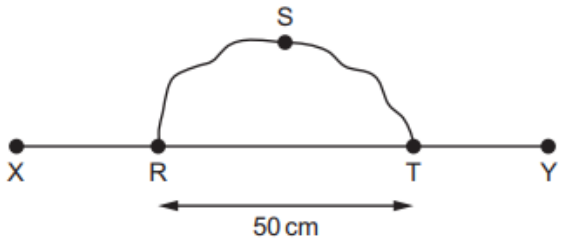
C It increases, because the length decreases and the cross-sectional area increases.

D It increases, because the length increases and the cross-sectional area decreases.

S15/11

7. C

38 A wire RST is connected to another wire XY as shown.



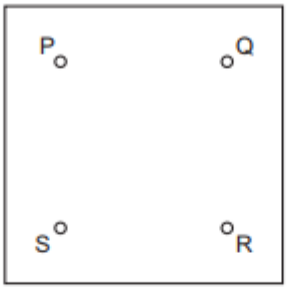
Each wire is 100 cm long with a resistance per unit length of $10\,\Omega\,m^{-1}$.

What is the total resistance between X and Y?

A 3.3Ω **B** 5.0Ω **C** 8.3Ω **D** 13.3Ω

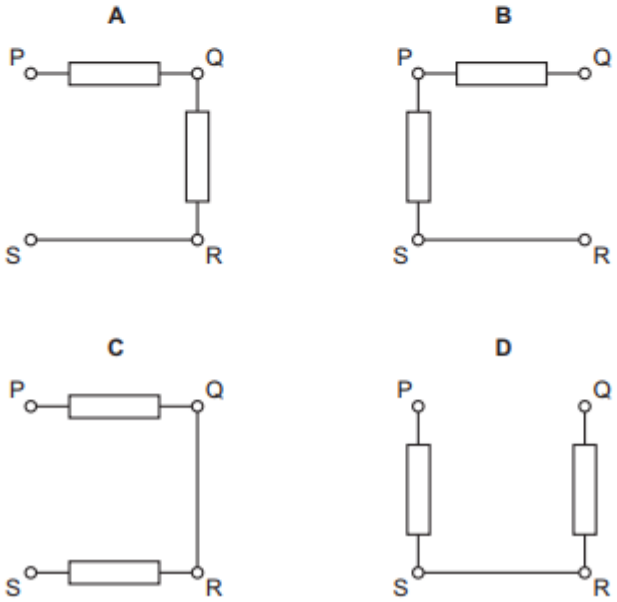
S15/13

36 A box with four terminals P, Q, R and S contains two identical resistors.



When a battery of electromotive force (e.m.f.) E and negligible internal resistance is connected across PS, a high-resistance voltmeter connected across QR reads $\frac{E}{2}$.

Which diagram shows the correct arrangement of the two resistors inside the box?



8. A

W14/11

9. C

32 A pencil is used to draw a line of length 30 cm and width 1.2 mm. The resistivity of the material in the pencil is $2.0 \times 10^{-5}\,\Omega\,m$ and the resistance of the line is $40\,k\Omega$.

What is the thickness of the line?

A $1.25 \times 10^{-10}\,m$

B $1.25 \times 10^{-8}\,m$

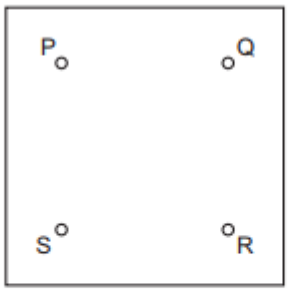
C $1.25 \times 10^{-7}\,m$

D $1.25 \times 10^{-5}\,m$

S15/13

10. A

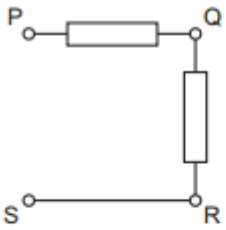
36 A box with four terminals P, Q, R and S contains two identical resistors.



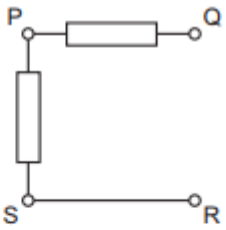
When a battery of electromotive force (e.m.f.) E and negligible internal resistance is connected across PS, a high-resistance voltmeter connected across QR reads $\frac{E}{2}$.

Which diagram shows the correct arrangement of the two resistors inside the box?

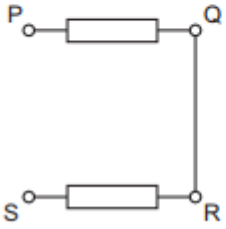
A



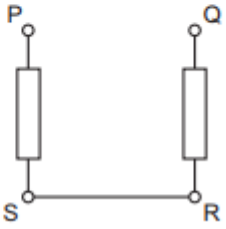
B



C



D



W14/11

11. C

32 A pencil is used to draw a line of length 30 cm and width 1.2 mm. The resistivity of the material in the pencil is $2.0 \times 10^{-5}\,\Omega$m and the resistance of the line is 40 kΩ.

What is the thickness of the line?

A 1.25×10^{-10} m

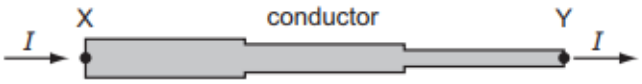
B 1.25×10^{-8} m

C 1.25×10^{-7} m

D 1.25×10^{-5} m

12. A

33 A conductor consists of three wires connected in series. The wires are all made of the same metal but have different cross-sectional areas. There is a current I in the conductor.



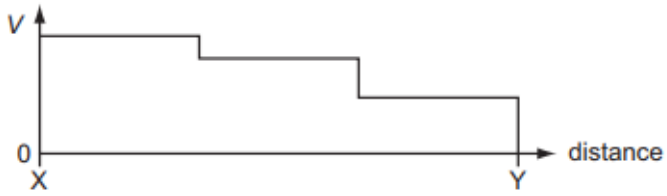
Point Y on the conductor is at zero potential.

Which graph best shows the variation of potential V with distance along the conductor?

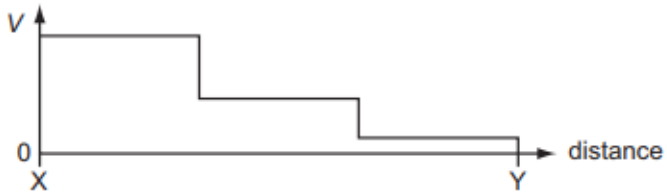
A

B

C



D



13. D

33 A metal wire of length 0.50 m has a resistance of 12 Ω.

What is the resistance of a wire of length 2.0 m and made of the same material, but with half the diameter?

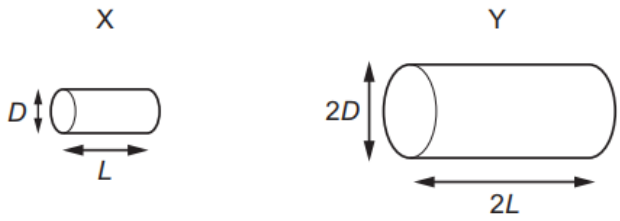
A 12 Ω **B** 48 Ω **C** 96 Ω **D** 192 Ω

S14/11

14. A

30 Two electrically-conducting cylinders X and Y are made from the same material.

Their dimensions are as shown.



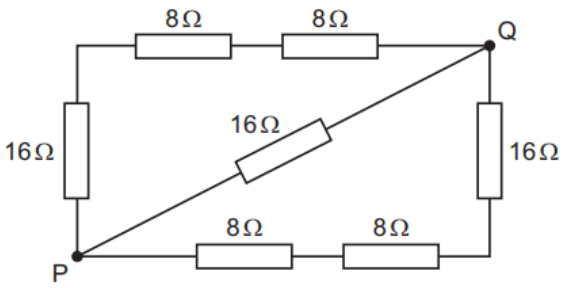
The resistance between the ends of each cylinder is measured.

What is the ratio $\frac{\text{resistance of X}}{\text{resistance of Y}}$?

A $\frac{2}{1}$ **B** $\frac{1}{1}$ **C** $\frac{1}{2}$ **D** $\frac{1}{4}$

15. A

36 What is the total resistance between points P and Q in this network of resistors?



A 8 Ω **B** 16 Ω **C** 24 Ω **D** 32 Ω

S14/13

16. D

33 Two wires P and Q made of the same material and of the same length are connected in parallel to the same voltage supply. Wire P has diameter 2 mm and wire Q has diameter 1 mm.

What is the ratio $\frac{\text{current in P}}{\text{current in Q}}$?

A $\frac{1}{4}$ **B** $\frac{1}{2}$ **C** $\frac{2}{1}$ **D** $\frac{4}{1}$

W13/11

17. B

35 The wire of a heating element has resistance R. The wire breaks and is replaced by a different wire.

Data for the original wire and the replacement wire are shown in the table.

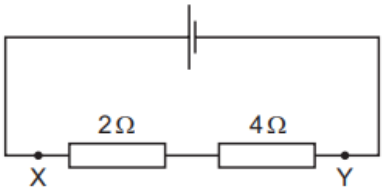
	length	diameter	resistivity of metal
original wire	l	d	ρ
replacement wire	l	$2d$	2ρ

What is the resistance of the replacement wire?

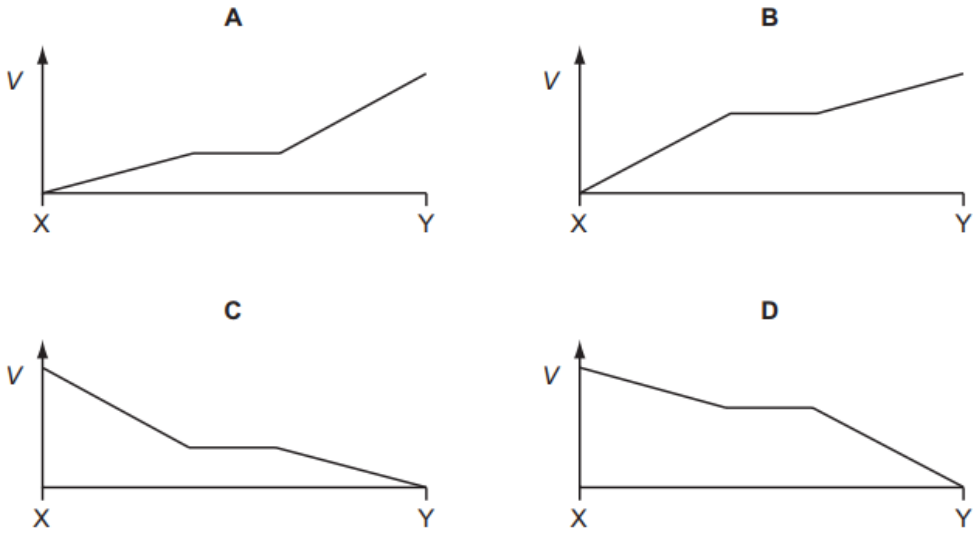
A $\frac{R}{4}$ **B** $\frac{R}{2}$ **C** R **D** $2R$

18. D

37 A 2Ω resistor and a 4Ω resistor are connected to a cell.



Which graph shows how the potential *V* varies with distance between X and Y?



W13/13

19. C

35 A copper wire is cylindrical and has resistance *R*.

What will be the resistance of a copper wire of twice the length and twice the radius?

A $\frac{R}{4}$ **B** $\frac{R}{2}$ **C** R **D** $2R$

S13/12

20. C

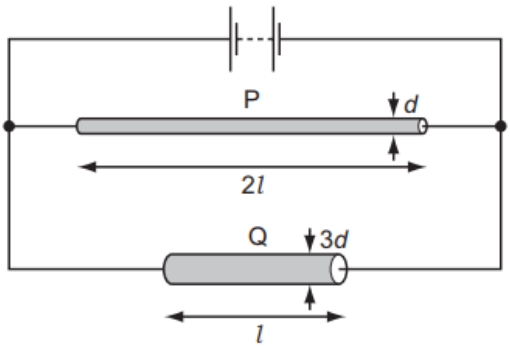
32 A power cable has length 2000 m. The cable is made of twelve parallel strands of copper wire, each with diameter 0.51 mm.

What is the resistance of the cable? (resistivity of copper = $1.7 \times 10^{-8}\,\Omega$m)

A 0.014Ω **B** 3.5Ω **C** 14Ω **D** 166Ω

21. D

35 Two wires P and Q made of the same material are connected to the same electrical supply. P has twice the length of Q and one-third of the diameter of Q, as shown in the diagram.



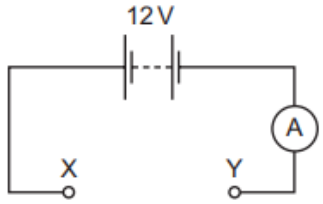
What is the ratio $\frac{\text{current in P}}{\text{current in Q}}$?

A $\frac{2}{3}$ **B** $\frac{2}{9}$ **C** $\frac{1}{6}$ **D** $\frac{1}{18}$

S13/13

22. C

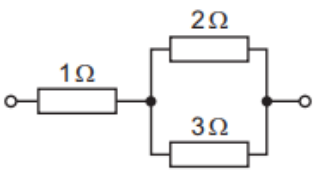
37 In the circuit shown, the battery and ammeter each have negligible resistance.



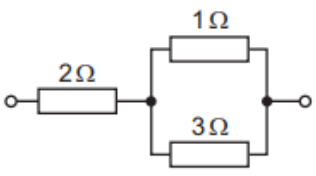
The following combinations of resistors are placed in turn between the terminals X and Y of the circuit.

Which combination would give an ammeter reading of 8 A?

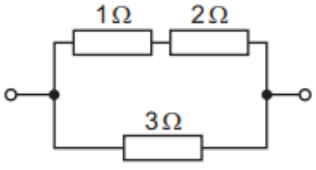
A



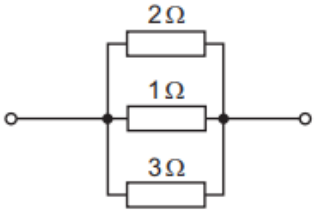
B



C



D



W12/11

23. C

33 A cylindrical wire of length 10 m and diameter 2.0 mm has a resistance of 0.050 Ω.

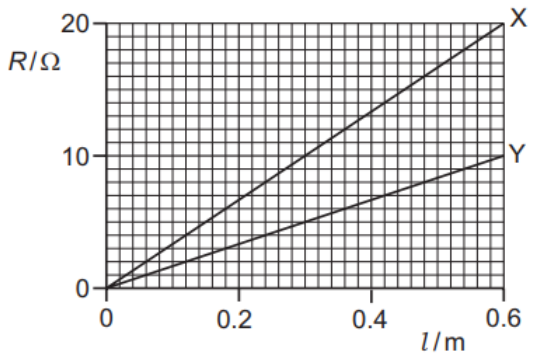
From which material is the wire made?

	material	resistivity / Ω m
A	bronze	1.6×10^{-7}
B	nichrome	1.6×10^{-6}
C	silver	1.6×10^{-8}
D	zinc	6.3×10^{-8}

W12/12

24. C

34 The graph shows the variation with length l of resistance R for two wires X and Y made from the same material.



What does the graph show?

A cross-sectional area of X = 2 × cross-sectional area of Y

B resistivity of X = 2 × resistivity of Y

C when equal lengths of X and Y are connected in series to a battery, power in X = 2 × power in Y

D when equal lengths of X and Y are connected in parallel to a battery, current in X = 2 × current in Y

W12/13

25. D

33 A copper wire is stretched so that its diameter is reduced from 1.0 mm to a uniform 0.5 mm.

The resistance of the unstretched copper wire is 0.2 Ω.

What will be the resistance of the stretched wire?

A 0.4 Ω **B** 0.8 Ω **C** 1.6 Ω **D** 3.2 Ω

W11/11

26. A

33 Which statement about electrical resistivity is correct?

A The resistivity of a material is numerically equal to the resistance in ohms of a cube of that material, the cube being of side length one metre and the resistance being measured between opposite faces.

B The resistivity of a material is numerically equal to the resistance in ohms of a one metre length of wire of that material, the area of cross-section of the wire being one square millimetre and the resistance being measured between the ends of the wire.

C The resistivity of a material is proportional to the cross-sectional area of the sample of the material used in the measurement.

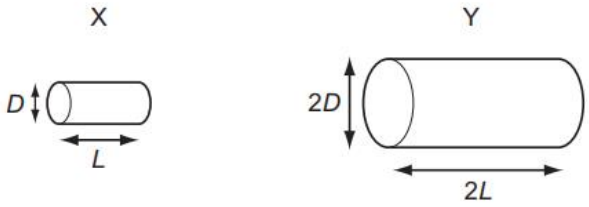
D The resistivity of a material is proportional to the length of the sample of the material used in the measurement.

W11/12

27. A

34 Two electrically-conducting cylinders X and Y are made from the same material.

Their dimensions are as shown.



The resistance of each cylinder is measured between its ends.

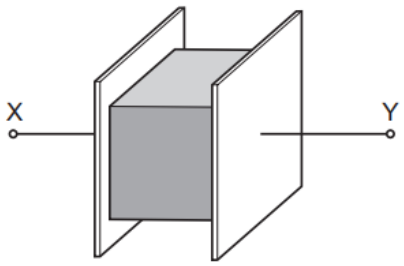
What is the ratio $\frac{\text{resistance of X}}{\text{resistance of Y}}$?

A $\frac{2}{1}$ **B** $\frac{1}{1}$ **C** $\frac{1}{2}$ **D** $\frac{1}{4}$

S11/11

28. C

34 The resistance of a metal cube is measured by placing it between two parallel plates, as shown.



The cube has volume V and is made of a material with resistivity ρ. The connections to the cube have negligible resistance.

Which expression gives the electrical resistance of the metal cube between X and Y?

A $\rho V^{\frac{1}{3}}$ **B** $\rho V^{\frac{2}{3}}$ **C** $\frac{\rho}{V^{\frac{1}{3}}}$ **D** $\frac{\rho}{V^{\frac{2}{3}}}$

S11/12

29. D

33 A cylindrical piece of a soft, electrically-conducting material has resistance R. It is rolled out so that its length is doubled but its volume stays constant.

What is its new resistance?

A $\frac{R}{2}$ **B** R **C** $2R$ **D** $4R$

W10/11

30. B

33 A copper wire is cylindrical and has resistance R.

What will be the resistance of a copper wire of twice the length and twice the radius?

A $\frac{R}{4}$ **B** $\frac{R}{2}$ **C** R **D** $2R$

S10/11

31. D

31 What is the unit of resistivity?

A Ωm^{-2} **B** Ωm^{-1} **C** Ω **D** Ωm

New Topic 12:

12. RADIOACTIVITY

S16/11

1. A

38 Which statement describes β^- decay in terms of a simple quark model?

A A down quark changes to an up quark and emits an electron and an electron antineutrino.

B A down quark changes to an up quark and emits a positron and an electron neutrino.

C An up quark changes to a down quark and emits an electron and an electron antineutrino.

D An up quark changes to a down quark and emits a positron and an electron neutrino.

2. D

39 Which word equation represents β^+ decay?

A proton → neutron + electron + electron antineutrino

B proton → neutron + electron + electron neutrino

C proton → neutron + positron + electron antineutrino

D proton → neutron + positron + electron neutrino

3. A

40 Which statement about the alpha-particle scattering experiment provides evidence for the existence of the nucleus?

A A tiny proportion of the alpha-particles are deflected through large angles.

B Slower alpha-particles are deflected through larger angles.

C The kinetic energies of the deflected alpha-particles are unchanged.

D The number of alpha-particles deflected depends on the thickness of the foil.

S16/12

4. C

38 The gold nucleus $^{185}_{79}Au$ undergoes alpha decay.

What are the nucleon number and proton number of the nucleus formed by this decay?

	nucleon number	proton number
A	183	79
B	183	77
C	181	77
D	181	75

5. B

39 Which row gives the correct classification of protons, electrons and neutrinos?

	protons	electrons	neutrinos
A	hadrons	leptons	hadrons
B	hadrons	leptons	leptons
C	leptons	hadrons	hadrons
D	leptons	hadrons	leptons

6. D

40 Which equation represents β^+ decay?

A neutron → proton + positron + antineutrino

B neutron → proton + positron + neutrino

C proton → neutron + positron + antineutrino

D proton → neutron + positron + neutrino

S16/13

7. D

38 A nitrogen-13 nucleus $^{13}_{7}N$ undergoes beta decay.

In the equations below, ν and $\bar{\nu}$ represent a neutrino and antineutrino respectively and γ represents a photon of gamma radiation.

Which equation represents this decay?

A $^{13}_{7}N \rightarrow {}^{13}_{6}C + \beta^- + \bar{\nu} + \gamma$

B $^{13}_{7}N \rightarrow {}^{13}_{6}C + \beta^- + \nu + \gamma$

C $^{13}_{7}N \rightarrow {}^{13}_{6}C + \beta^+ + \bar{\nu} + \gamma$

D $^{13}_{7}N \rightarrow {}^{13}_{6}C + \beta^+ + \nu + \gamma$

8. B

39 Radon $^{222}_{86}Rn$ is the start of a decay chain that forms bismuth $^{214}_{83}Bi$ by α and β^- emission.

For the decay of each nucleus of radon, how many α particles and β^- particles are emitted?

	α particles	β^- particles
A	1	1
B	2	1
C	1	2
D	2	2

9. C

40 The magnitude of the charge on the proton may be regarded as +1 unit. On this basis, the charges on the up (u) quark, down (d) quark and their antiquarks ($\bar{u}$ and $\bar{d}$) are not whole units.

Which row in the table shows the correct values for the charges on the u, d, $\bar{u}$ and $\bar{d}$ quarks?

	u	d	$\bar{u}$	$\bar{d}$
A	$+\frac{2}{3}$	$-\frac{1}{3}$	$+\frac{2}{3}$	$-\frac{1}{3}$
B	$-\frac{2}{3}$	$+\frac{1}{3}$	$+\frac{2}{3}$	$-\frac{1}{3}$
C	$+\frac{2}{3}$	$-\frac{1}{3}$	$-\frac{2}{3}$	$+\frac{1}{3}$
D	$-\frac{2}{3}$	$+\frac{1}{3}$	$-\frac{2}{3}$	$+\frac{1}{3}$

W15/11

10. D

37 Radioactive decay is random.

What is meant by the term *random*?

A The decay of a nucleus can be predicted.

B The decay of a nucleus is unaffected by pressure.

C The decay of a nucleus is unaffected by temperature.

D The nucleus has a constant probability of decay per unit time.

11. D

38 The nuclei of the isotopes of an element all contain the same number of a certain particle.

What is this particle?

A electron

B neutron

C nucleon

D proton

12. D

39 Which statement about nuclei is correct?

A Different isotopic nuclei have different proton numbers.

B For some nuclei, the nucleon number can be less than the proton number.

C In some nuclear processes, mass-energy is not conserved.

D Nucleon numbers of nuclei are unchanged by the emission of β-particles.

13. B

40 The diagram shows part of a radioactive decay chain in which the nuclide thorium-232 decays by α-emission into radium-228. This nuclide is also unstable and decays by β-emission into a nuclide of actinium. This process continues.

$$^{232}_{90}\text{Th} \xrightarrow{\alpha} {}^{228}_{88}\text{Ra} \xrightarrow{\beta} {}^{X}_{89}\text{Ac} \xrightarrow{Y} {}^{228}_{90}\text{Th} \xrightarrow{\alpha} {}^{224}\text{Z} \longrightarrow$$

What are X, Y and Z?

	X	Y	Z
A	228	α	Th
B	228	β	Ra
C	232	α	Th
D	232	β	Ra

W15/12

14. C

39 A material contains a radioactive isotope that disintegrates solely by the emission of α-particles at a rate of $100\,s^{-1}$.

Which statement about this material is correct?

A The number of atoms in the material diminishes at a rate of $100\,s^{-1}$.

B The number of neutrons in the material diminishes at a rate of $100\,s^{-1}$.

C The number of nucleons in the material diminishes at a rate of $400\,s^{-1}$.

D The number of protons in the material diminishes at a rate of $100\,s^{-1}$.

15. D

40 A radioactive nucleus emits an α-particle or a β-particle, creating a product nucleus.

Which decay process could create the product nucleus stated?

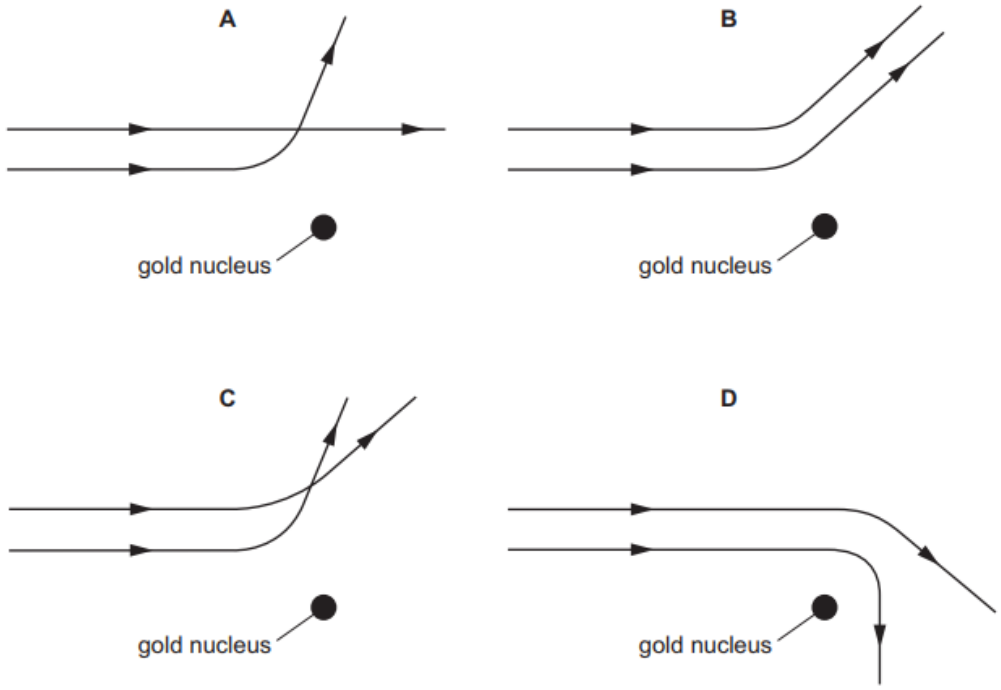
	radioactive nucleus	decay	product nucleus
A	$^{226}_{88}Ra$	α	$^{224}_{86}Rn$
B	$^{238}_{92}U$	α	$^{242}_{94}Pu$
C	$^{228}_{88}Ra$	β	$^{228}_{87}Fr$
D	$^{231}_{90}Th$	β	$^{231}_{91}Pa$

W15/13

16. C

38 Two α-particles with equal energies are fired towards the nucleus of a gold atom.

Which diagram best represents their paths?



17. C

39 When a nucleus emits an α-particle, how do the proton number and the nucleon number of the original nucleus change?

	proton number	nucleon number
A	–4	–2
B	–2	–2
C	–2	–4
D	+1	no change

18. D

40 A simple theory of α-particle scattering by a thin metal foil uses the four assumptions given below.

Which assumption is exact and is **not** an approximation?

A Each α-particle interacts with just one nucleus.

B The α-particles lose no kinetic energy when they are deflected.

C The metal nuclei do not recoil.

D Total momentum is conserved.

S15/11

19. C

39 When α-particles are directed at gold leaf

1 almost all α-particles pass through without deflection,

2 a few α-particles are deviated through large angles.

What are the reasons for these effects?

	1	2
A	most α-particles have enough energy to pass right through the gold leaf	gold is very dense so a few low energy α-particles bounce back from the gold surface
B	most α-particles miss all gold atoms	a few α-particles bounce off gold atoms
C	the gold nucleus is very small so most α-particles miss all nuclei	occasionally the path of an α-particle is close to a nucleus
D	the positive charge in an atom is not concentrated enough to deflect an α-particle	occasionally an α-particle experiences many small deflections in the same direction

20. B

40 The nuclide $^{222}_{86}Rn$ decays in a sequence of stages to form the nuclide $^{206}_{82}Pb$.

Four of the nuclides formed in the sequence are α-particle emitters. The others are β-particle emitters.

How many nuclides formed in the decay sequence are β-particle emitters?

A 2 **B** 4 **C** 8 **D** 12

S15/12

21. A

38 An experiment in which α-particles were deflected by a gold foil produced new insights into the structure of the atom.

Which conclusion can be drawn from the results of the experiment?

A Atomic nuclei occupy a very small fraction of the volume of an atom.

B Electrons orbit the atomic nucleus.

C Some atoms of the same element contain different numbers of neutrons.

D The atomic nucleus contains protons and neutrons.

22. C

39 A radioactive substance contains a number of identical nuclei that emit β-particles.

Which property of these nuclei remains unaltered by the emission?

A charge

B neutron number

C nucleon number

D proton number

23. C

40 A uranium-238 nucleus, $^{238}_{92}U$, undergoes nuclear decays to form uranium-234, $^{234}_{92}U$.

Which series of decays could give this result?

A emission of four β-particles

B emission of four γ-rays

C emission of one α-particle and two β-particles

D emission of two α-particles and eight β-particles

S15/13

24. D

38 Nucleus P decays in two stages to produce nucleus Q.

Which decay sequence will result in the highest number of neutrons in nucleus Q?

A an α-particle followed by a β-particle

B an α-particle followed by a γ-ray

C a β-particle followed by another β-particle

D a β-particle followed by a γ-ray

25. A

39 A neutral atom has a nucleus given by the symbol $^{133}_{55}Cs$.

How many protons, neutrons and electrons are in this atom?

	protons	neutrons	electrons
A	55	78	55
B	55	133	55
C	78	55	78
D	133	55	133

26. C

40 The nuclear equation for a fission reaction is shown below.

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{93}_{X}Rb + {}^{141}_{55}Cs + Y\,{}^{1}_{0}n$$

What are the values of X and Y?

	X	Y
A	37	0
B	37	1
C	37	2
D	38	2

W14/11

27. D

38 Which statement about α-particles is correct?

A α-particles emitted from a single radioactive isotope have a continuous distribution of energies.

B α-particles have less ionising power than β-particles.

C The charge of an α-particle is $+1.60 \times 10^{-19}$ C.

D The speeds of α-particles can be as high as $1.5 \times 10^{7}\,m\,s^{-1}$.

28. B

39 The isotope $^{222}_{86}Rn$ decays in a sequence of emissions to form the isotope $^{206}_{82}Pb$. At each stage of the decay sequence, it emits either an α-particle or a β-particle.

What is the number of stages in the decay sequence?

A 4 **B** 8 **C** 16 **D** 20

29. C

40 What is the approximate mass of a nucleus of uranium?

A 10^{-15} kg **B** 10^{-20} kg **C** 10^{-25} kg **D** 10^{-30} kg

W14/13

30. A

38 The nucleus of a radioactive isotope of an element emits an alpha particle. The daughter nucleus then emits a beta particle and then the daughter nucleus of that reaction emits another beta particle.

Which statement describes the final nuclide that is formed?

A It is a different isotope of the original element.

B It is a nuclide of a different element of higher proton number.

C It is a nuclide of the same element but with different proton number.

D It is identical to the original nuclide.

31. C

39 A nuclear reaction is shown.

$$^{238}_{92}U + {}^{4}_{2}He \rightarrow {}^{241}_{94}Pu + X$$

What is product X?

A an alpha particle

B an electron

C a neutron

D a proton

32. C

40 Alpha, beta and gamma radiations

1 are absorbed to different extents in solids,

2 behave differently in an electric field,

3 behave differently in a magnetic field.

The diagrams illustrate these behaviours.

diagram 1

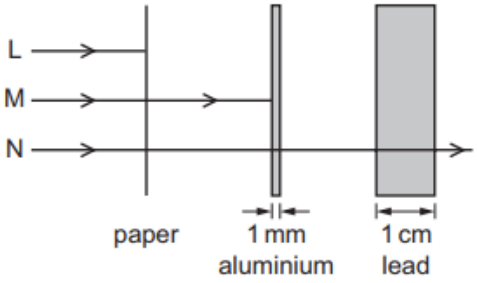


diagram 2

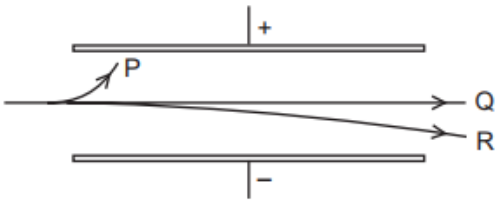
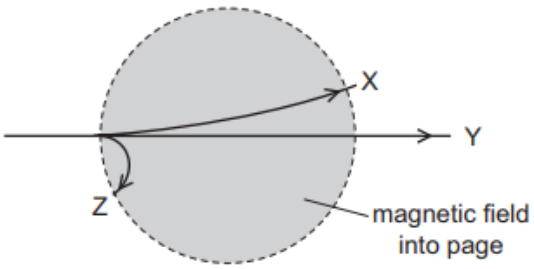


diagram 3



Which three labels on these diagrams refer to the **same** kind of radiation?

A L, P, X **B** L, P, Z **C** M, P, Z **D** N, Q, X

S14/11

33. C

37 Alpha, beta and gamma radiations have various depths of penetration in matter and different charges.

Which row best summarises the penetration and charge of each radiation?

	alpha	beta	gamma
A	absorbed by a sheet of card negative charge	absorbed by several mm of aluminium no charge	not fully absorbed by several cm of lead no charge
B	absorbed by a sheet of card negative charge	absorbed by several mm of aluminium positive charge	not fully absorbed by several cm of lead no charge
C	absorbed by a sheet of card positive charge	absorbed by several mm of aluminium negative charge	not fully absorbed by several cm of lead no charge
D	absorbed by several mm of aluminium positive charge	not fully absorbed by several cm of lead negative charge	absorbed by a sheet of card no charge

34. B

38 In 2002, two-proton radioactive decay of an isotope of iron, $^{45}_{26}Fe$, was observed.

What could be the resulting product?

A $^{43}_{26}Fe$ **B** $^{43}_{24}Cr$ **C** $^{45}_{24}Cr$ **D** $^{47}_{28}Ni$

35. B

39 U^{++} is a doubly-ionised uranium atom. The uranium atom has a nucleon number of 235 and a proton number of 92.

In a simple model of the atom, how many particles are in this ionised atom?

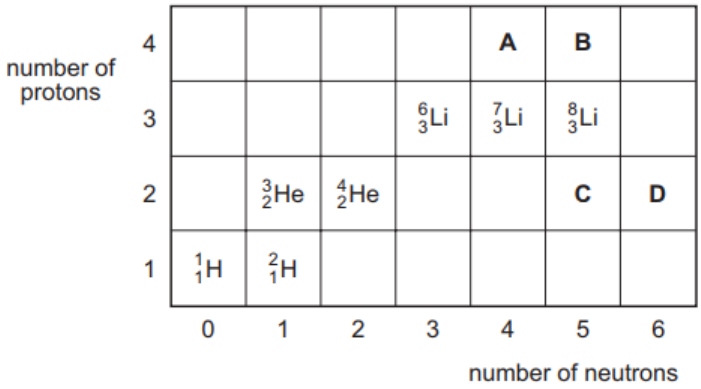
A 235 **B** 325 **C** 327 **D** 329

36. A

40 The grid shows a number of nuclides arranged according to the number of protons and the number of neutrons in each.

A nucleus of the nuclide $^{8}_{3}\text{Li}$ decays by emitting a β-particle.

What is the resulting nuclide?



S14/13

37. C

39 An isotope of thorium has a nucleon number of 232 and a proton number of 90. It decays to form another isotope of thorium with a nucleon number of 228.

How many alpha particles and beta particles are emitted by a nucleus of thorium during this decay?

	alpha particles	beta particles
A	0	4
B	1	0
C	1	2
D	2	1

38. D

40 Four nuclei are represented below.

$^{28}_{14}\text{E}$ $^{25}_{15}\text{G}$ $^{25}_{12}\text{M}$ $^{24}_{13}\text{Q}$

Which statement about these nuclei is correct?

A An uncharged atom of element Q has 24 orbital electrons.

B Nucleus M could transform into Q by emitting a beta particle.

C Nuclei G and M are isotopes of the same element.

D When E absorbs a neutron and then emits an alpha particle, nucleus E transforms into M.

W13/11

39. C

39 When α-particles are fired at a thin metal foil, most of the particles pass straight through but a few are deflected by a large angle.

Which change would increase the **proportion** of α-particles deflected by a large angle?

A using α-particles with greater kinetic energy

B using a foil made of a metal with fewer protons in its nuclei

C using a double thickness foil

D using an alpha source with a higher activity

40. A

40 Plutonium-239 ($^{239}_{94}Pu$) decays by emitting α-radiation.

Which nuclide is formed from one of these decay reactions? (The product nuclides are represented by X.)

A $^{235}_{92}X$ **B** $^{237}_{92}X$ **C** $^{239}_{93}X$ **D** $^{239}_{95}X$

W13/13

41. D

39 A nucleus of the nuclide $^{228}_{89}Ac$ decays by emitting a beta particle. The nuclear equation below represents this decay.

$$^{228}_{89}Ac \rightarrow {}^{X}_{Y}Th + \beta$$

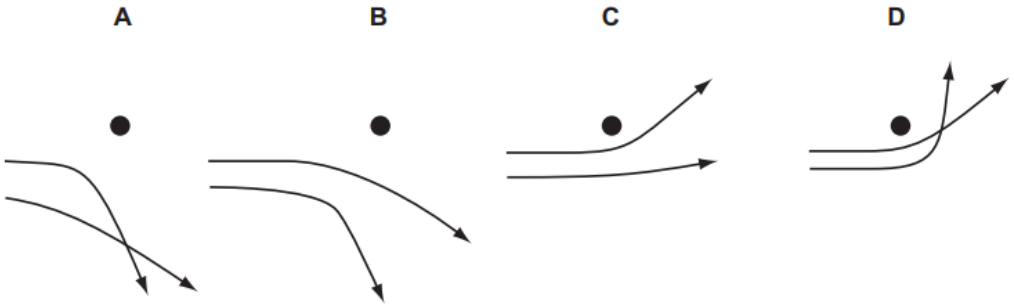
Which pair of values of X and Y is correct?

	X	Y
A	224	87
B	224	89
C	228	88
D	228	90

42. A

40 Two α-particles with equal energies are deflected by a large nucleus.

Which diagram best represents their paths?



S13/11

43. C

38 A nickel nucleus $^{59}_{28}Ni$ can be transformed by a process termed K-capture. In this process the nucleus absorbs an orbital electron.

If no other process is involved, what is the resulting nucleus?

A $^{58}_{28}Ni$ **B** $^{58}_{27}Co$ **C** $^{59}_{27}Co$ **D** $^{59}_{29}Cu$

44. A

39 It was once thought that the mass of an atom is spread uniformly through the volume of the atom. When α-particles are directed at a piece of gold foil, the results led scientists to believe instead that nearly all the mass of the gold atom is concentrated at a point inside the atom.

Which effect is possible **only** if nearly all the mass of the gold atom is concentrated at a point?

A a few α-particles bounce back

B most α-particles are only slightly deflected

C some α-particles pass through without any deflection

D some α-particles are absorbed

45. B

40 Which pair of nuclei are isotopes of one another?

	nucleon number	number of neutrons
A	186 180	112 118
B	186 182	112 108
C	184 187	110 110
D	186 186	110 112

S13/12

46. B

39 What is the approximate mass of an alpha particle?

A 10^{-28} kg

B 10^{-26} kg

C 10^{-24} kg

D 10^{-22} kg

47. B

40 An actinium nucleus has a nucleon number of 227 and a proton number of 89. It decays to form a radium nucleus, emitting a beta particle and an alpha particle in the process.

What are the nucleon number and the proton number of this radium nucleus?

	nucleon number	proton number
A	223	87
B	223	88
C	224	87
D	225	86

S13/13

48. C

38 Scientists investigating the count rate from a radioactive source observed that the count rate fluctuates.

What do these fluctuations imply about the nature of radioactive decay?

A It involves atomic nuclei.

B It is predictable.

C It is random.

D It is spontaneous.

49. D

39 The decay of a nucleus of neptunium is accompanied by the emission of a β-particle and γ-radiation.

What effect (if any) does this decay have on the proton number and on the nucleon number of the nucleus?

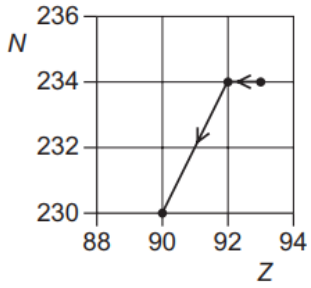
	proton number	nucleon number
A	increases	decreases
B	decreases	increases
C	unchanged	decreases
D	increases	unchanged

50. B

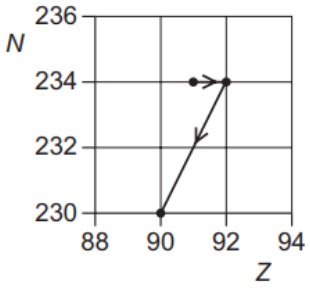
40 A radioactive nucleus is formed by β-decay. This nucleus then decays by α-emission.

Which graph of nucleon number *N* plotted against proton number *Z* shows the β-decay followed by the α-emission?

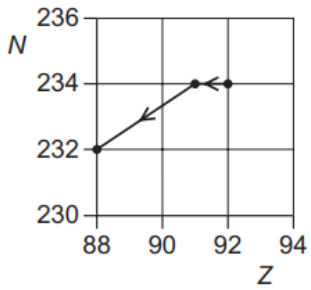
A



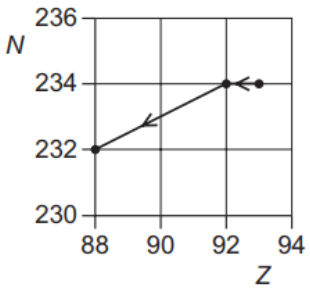
B



C



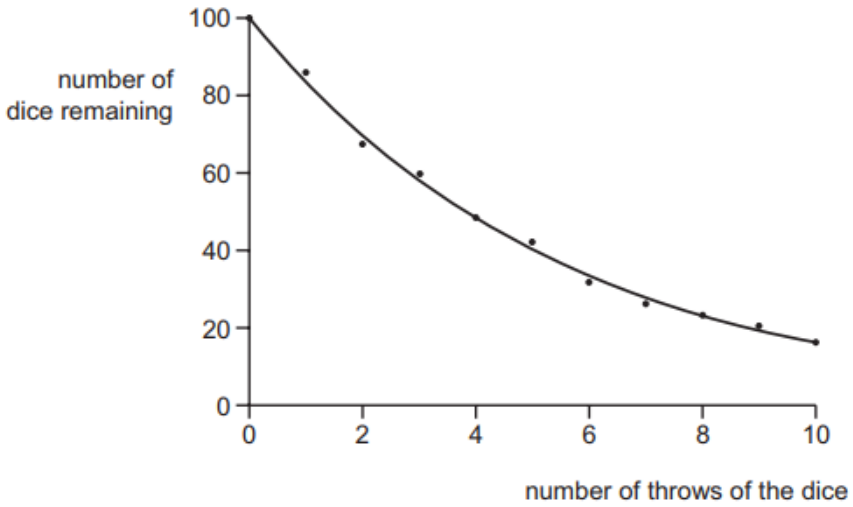
D



W12/11

51. C

38 A class of students used dice to simulate radioactive decay. After each throw, those dice showing a '6' were removed. The graph shows the results.



What could the scatter of points about the best-fit curve represent for actual radioactive decay?

A background count not being taken into account

B more than one type of radiation being present

C the random nature of radioactive decay

D the spontaneous nature of radioactive decay

52. A

39 Which statement about alpha, beta and gamma radiation is correct?

A Alpha radiation has the greatest ionising power.

B Beta radiation has the greatest ionising power.

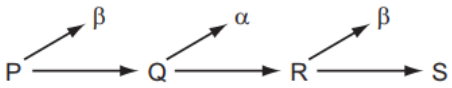
C Gamma radiation has the greatest ionising power.

D Alpha, beta and gamma radiation have nearly equal ionising powers.

53. B

40 In a radioactive decay series, three successive decays each result in a particle being emitted.

The first decay results in the emission of a β-particle. The second decay results in the emission of an α-particle. The third decay results in the emission of another β-particle.



Nuclides P and S are compared.

Which statement is correct?

A P and S are identical in all respects.

B P and S are isotopes of the same element.

C S is a different element of lower atomic number.

D S is a different element of reduced mass.

W12/12

54. C

39 A material contains a radioactive isotope that disintegrates solely by the emission of α-particles at a rate of $100\,s^{-1}$.

Which statement about this material is correct?

A The number of atoms in the material diminishes at a rate of $100\,s^{-1}$.

B The number of neutrons in the material diminishes at a rate of $100\,s^{-1}$.

C The number of nucleons in the material diminishes at a rate of $400\,s^{-1}$.

D The number of protons in the material diminishes at a rate of $100\,s^{-1}$.

55. D

40 A different nucleus can be formed by bombarding a stable nucleus with an energetic α-particle.

$^{23}_{11}Na$ is bombarded with an energetic α-particle.

What could be the products of this nuclear reaction?

A $^{25}_{10}Ne$ + neutron

B $^{25}_{11}Na$ + proton

C $^{26}_{12}Mg + \beta$

D $^{27}_{13}Al + \gamma$

W12/13

56. A

38 A nuclear isotope emits radiation which is detected by a Geiger-Müller tube held at a distance of about 10 cm from the radioactive source. The radiation is stopped completely by a 2 mm thick sheet of lead.

What can be deduced from this information about the emission from the isotope?

A It could be alpha and beta radiation, but not gamma radiation.

B It could be alpha and gamma radiation, but not beta radiation.

C It could be beta and gamma radiation, but not alpha radiation.

D It could be alpha, beta and gamma radiation.

57. C

39 What remains constant during β-emission from a number of identical nuclei in a substance?

A energy of the β-particles

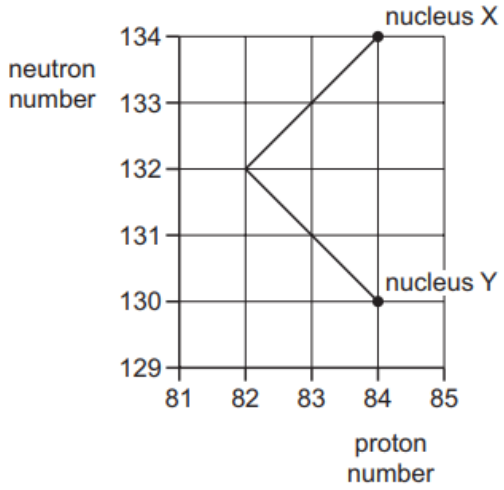
B neutron number of the nuclei

C nucleon number of the nuclei

D proton number of the nuclei

58. B

40 The graph of neutron number against proton number represents a sequence of radioactive decays.



Nucleus X is at the start of the sequence and, after the decays have occurred, nucleus Y is formed.

What is emitted during the sequence of decays?

A one α-particle followed by one β-particle

B one α-particle followed by two β-particles

C two α-particles followed by two β-particles

D two β-particles followed by one α-particle

S12/11

59. A

39 An experiment in which α-particles were deflected by a gold foil produced new insights into the structure of the atom.

Which conclusion can be drawn from the results of the experiment?

A Atomic nuclei occupy a very small fraction of the volume of an atom.

B Electrons orbit the atomic nucleus.

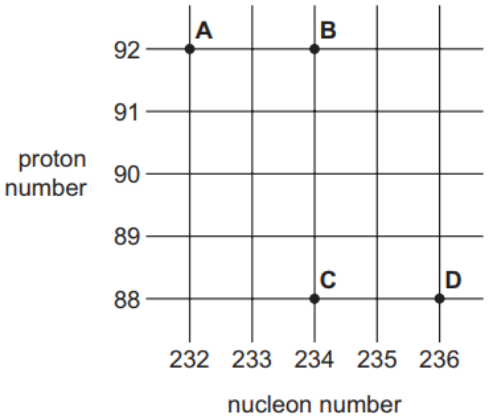
C Some atoms of the same element contain different numbers of neutrons.

D The atomic nucleus contains protons and neutrons.

60. B

40 Thorium-234 ($^{234}_{90}$Th) decays by β-emission into a daughter product which in turn decays by further β-emission into a granddaughter product.

Which letter in the diagram represents the granddaughter product?



S12/12

61. B

39 Nuclear decay is both spontaneous and random in nature.

Which row gives the correct experimental evidence for these properties?

	spontaneous nature of decay	random nature of decay
A	the decay rate is not affected by pressure	the decay rate is not affected by temperature
B	the decay rate is not affected by pressure	the rate at which radiation is received at a counter fluctuates
C	the decay rate is not affected by temperature	the decay rate is not affected by pressure
D	the rate at which radiation is received at a counter fluctuates	the decay rate is not affected by pressure

62. B

40 Radon $^{222}_{86}$Rn is the start of a decay chain that forms bismuth $^{214}_{83}$Bi by alpha and beta emission.

For the decay of each nucleus of radon, how many α–particles and β–particles are emitted?

	α–particles	β–particles
A	1	1
B	2	1
C	1	2
D	2	2

W11/11

63. D

40 An atomic nucleus emits a β-particle.

What change does this cause to the proton number and the nucleon number of the nucleus?

	proton number	nucleon number
A	–1	+1
B	0	–1
C	+1	–1
D	+1	0

W11/12

64. C

39 Which statement concerning α-particles is correct?

A An α-particle has charge +4*e*.

B An α-particle is a helium atom.

C When α-particles travel through air, they cause ionisation.

D When α-particles travel through a sheet of gold foil, they make the gold radioactive.

65. C

40 A nucleus of the nuclide $^{241}_{94}Pu$ decays by emission of a β-particle followed by the emission of an α-particle.

Which nucleus is formed?

A $^{239}_{93}Np$ **B** $^{239}_{91}Pa$ **C** $^{237}_{93}Np$ **D** $^{237}_{92}U$

S11/11

66. D

38 The first artificial radioactive substance was made by bombarding aluminium, $^{27}_{13}Al$, with α-particles. This produced an unstable isotope of phosphorus, $^{30}_{15}P$.

What was the by-product of this reaction?

A an α-particle

B a β-particle

C a γ-ray

D a neutron

67. B

39 Uranium-238, $^{238}_{92}U$, decays by α-emission into a daughter product which in turn decays by β-emission into a grand-daughter product.

What is the grand-daughter product?

A $^{234}_{90}Th$ **B** $^{234}_{91}Pa$ **C** $^{234}_{92}U$ **D** $^{230}_{90}Th$

68. D

40 Which statement about nuclei is correct?

A Different isotopic nuclei have different proton numbers.

B For some nuclei, the nucleon number can be less than the proton number.

C In some nuclear processes, mass-energy is not conserved.

D Nucleon numbers of nuclei are unchanged by the emission of β-particles.

S11/12

69. C

39 The uranium nucleus $^{238}_{92}U$ undergoes α-decay, producing nucleus X.

Nucleus X undergoes β-decay, producing nucleus Y.

For nucleus Y, what are the values of the proton number and nucleon number?

	proton number	nucleon number
A	89	234
B	89	236
C	91	234
D	91	236

70. B

40 Radon-220 is radioactive and decays to polonium-216 with the emission of an α-particle. The equation for the radioactive decay is shown.

$$^{220}_{86}Rn \rightarrow {}^{216}_{84}Po + {}^{4}_{2}He$$

How many neutrons are in the radon and polonium nuclei?

	Rn	Po
A	86	84
B	134	132
C	220	212
D	220	216

W10/11

71. C

38 Uranium-235 may be represented by the symbol $^{235}_{92}U$.

Which row shows the numbers of nucleons, protons and neutrons in a $^{235}_{92}U$ nucleus?

	nucleons	protons	neutrons
A	92	235	143
B	143	92	235
C	235	92	143
D	235	143	92

72. D

39 When a magnesium nucleus $^{25}_{12}Mg$ is hit by a gamma ray, a sodium nucleus $^{24}_{11}Na$ is formed and another particle is emitted.

What are the nucleon number (mass number) and proton number (atomic number) of the other particle produced in this nuclear reaction?

	nucleon number	proton number
A	0	–1
B	0	1
C	1	–1
D	1	1

73. C

40 Which nuclear equation shows the beta decay of a nucleus of argon (Ar) into potassium (K)?

A $^{44}_{21}Ar \rightarrow {}^{40}_{19}K + {}^{4}_{2}He$

B $^{40}_{20}Ar \rightarrow {}^{40}_{19}K + {}^{0}_{1}e$

C $^{40}_{18}Ar \rightarrow {}^{40}_{19}K + {}^{0}_{-1}e$

D $^{40}_{19}Ar \rightarrow {}^{40}_{19}K + {}^{0}_{0}\gamma$

W10/12

74. D

38 In the Rutherford scattering experiment, α-particles were fired at a thin gold foil. A small proportion of the α-particles were deflected through large angles.

Which statement gives the correct conclusion that could be drawn directly from these results?

A The atom is made up of electrons, protons and neutrons.

B The nucleus is at the centre of the atom.

C The nucleus is made up of protons and neutrons.

D The atom contains a very small, charged nucleus.

75. C

39 Which statement about the nuclei of the atoms of an element is correct?

A Every nucleus of an element contains an equal number of neutrons and protons.

B Every nucleus of an element contains the same number of neutrons as all others of that element, but the number of protons may differ.

C Every nucleus of an element contains the same number of protons as all others of that element, but the number of neutrons may differ.

D The number of protons in a nucleus differs from isotope to isotope of an element, as do the number of neutrons.

76. B

40 A counter recording radioactive decays from a radioactive source gives the following counts in equal intervals of time.

time / min	counts
0–10	424
10–20	395
20–30	413
30–40	363
40–50	366
50–60	294
60–70	301
70–80	253
80–90	212

What can be deduced from these readings?

A that radioactivity is random and that the half-life is 90 minutes

B that radioactivity is random and that the half-life is uncertain

C that radioactivity is spontaneous and that the half-life is 90 minutes

D that radioactivity is spontaneous and that the half-life is uncertain

S10/11

77. C

37 What are the correct descriptions of a γ-ray and a β-particle?

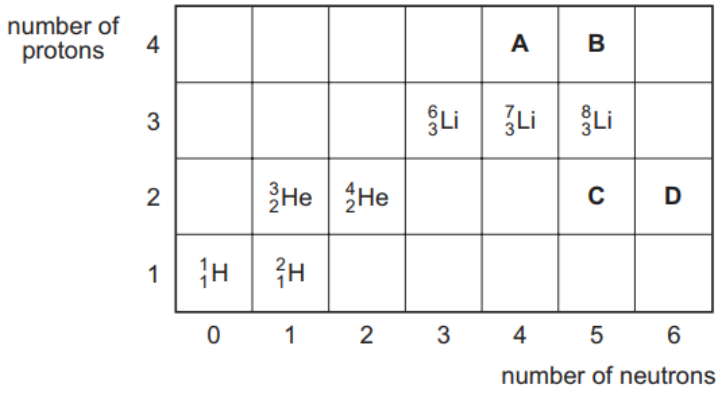
	γ-ray	β-particle
A	high-speed electron	electromagnetic radiation
B	electromagnetic radiation	helium-4 nucleus
C	electromagnetic radiation	high-speed electron
D	high-speed electron	helium-4 nucleus

78. A

38 The grid shows a number of nuclides arranged according to the number of protons and the number of neutrons in each.

A nucleus of the nuclide $^{8}_{3}\mathrm{Li}$ decays by emitting a β-particle.

What is the resulting nuclide?



79. C

39 What is **not** conserved in nuclear processes?

A charge

B momentum

C the total number of neutrons

D the total number of nucleons

80. C

40 The following represents a sequence of radioactive decays involving two α-particles and one β-particle.

$$^{217}_{85}\text{At} \xrightarrow{\alpha} \text{V} \xrightarrow{\alpha} \text{W} \xrightarrow{\beta} \text{X}$$

What is the nuclide X?

A $^{213}_{85}\text{At}$ **B** $^{215}_{77}\text{Ir}$ **C** $^{209}_{82}\text{Pb}$ **D** $^{217}_{81}\text{Tl}$