1: Skills for physics – Topic questions

The questions in this document have been compiled from a number of past papers, as indicated in the table below.

Use these questions to formatively assess your learners' understanding of this topic.

Question	Year	Series	Paper number
1	2017	June	21
1	2017	June	33
2	2017	June	33

The mark scheme for each question is provided at the end of the document.

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1 **(a)** Determine the SI base units of stress.
Show your working.

base units ....[2]

(b) A beam PQ is clamped so that the beam is horizontal. A mass *M* of 500 g is hung from end Q and the beam bends slightly, as illustrated in Fig. 1.1.

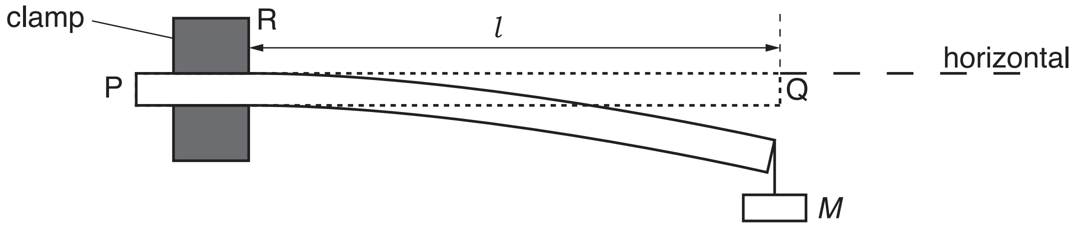

Fig. 1.1

The length l of the beam from the edge of the clamp R to end Q is 60.0 cm. The width *b* of the beam is 30.0 mm and the thickness *d* of the beam is 5.00 mm. The material of the beam has Young modulus *E*.

The mass *M* is made to oscillate vertically. The time period *T* of the oscillations is 0.58 s.

The period *T* is given by the expression

$$T = 2\pi\sqrt{\frac{4Ml^3}{Ebd^3}}.$$

(i) Determine *E* in GPa.

E = ...GPa [3]

1 In this experiment, you will investigate the motion of a chain of paper clips.

(a) You have been provided with a chain of fifteen paper clips with a sphere of modelling clay attached to one end of the chain.

Measure and record the length *L* of one paper clip as shown in Fig. 1.1.

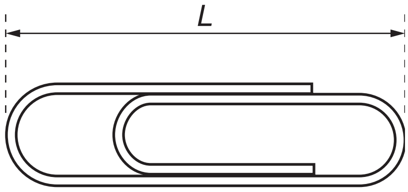

Fig. 1.1

L = ... [1]

(b) **(i)** Set up the apparatus as shown in Fig. 1.2.

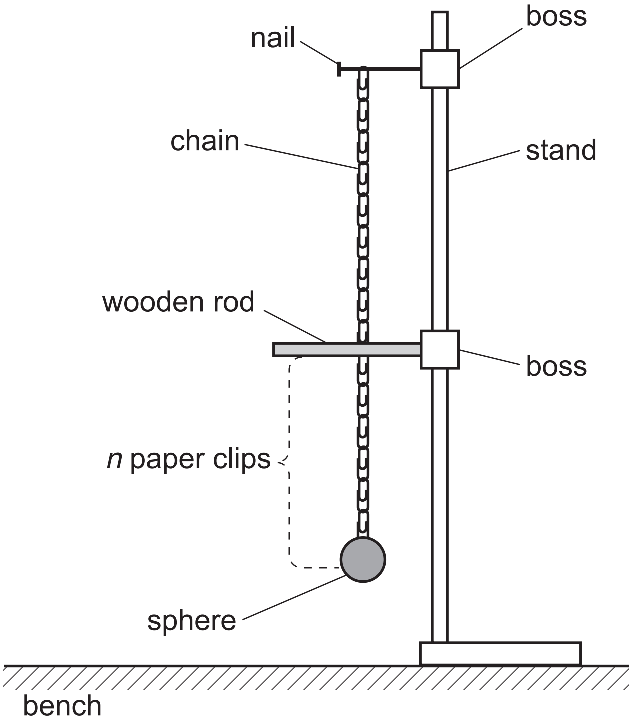

Fig. 1.2

The chain should be suspended from the nail.

The wooden rod should be positioned so that the chain, when hanging vertically, just touches the rod with 6 paper clips below the rod.

(ii) Record the number *n* of paper clips below the rod.

n = ...

(c) Move the sphere towards you through a distance of approximately 10 cm.
Release the sphere. The chain will oscillate and hit the rod during these oscillations.

Determine the period *T* of the oscillations.

T = ...[2]

(d) Change n by moving the wooden rod vertically and repeat **(b)(ii)** and **(c)** until you have six sets of values of n and T.

Record your results in a table. Include values of $\sqrt{n}$ to three significant figures in your table.

[8]

(e) **(i)** Plot a graph of T on the y-axis against $\sqrt{n}$ on the x-axis. [3]

(ii) Draw the straight line of best fit. [1]

(iii) Determine the gradient and y-intercept of this line.

gradient = ...

y-intercept = ...
[2]

(f) It is suggested that the quantities T and n are related by the equation

$$T = P\sqrt{n} + Q$$

where P and Q are constants.

Using your answers in **(e)(iii)**, determine the values of P and Q.
Give appropriate units.

P = ...

Q = ...
[2]

(g) Theory suggests that

$$P = \pi\sqrt{\frac{L}{g}}$$

where g is the acceleration of free fall.

Use your values in **(a)** and **(f)** to determine a value for g.
Give an appropriate unit.

g = ...[1]

[Total: 20]

2 In this experiment, you will investigate the equilibrium of a balanced metre rule and determine its mass.

(a) You have been provided with a metre rule with a hole close to each end as shown in Fig. 2.1.

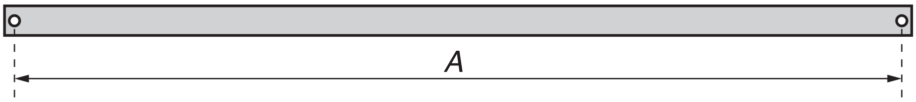

Fig. 2.1

The distance between the centres of the holes is *A*.

Measure and record *A*.

A = ... [1]

(b) (i) Set up the apparatus as shown in Fig. 2.2.

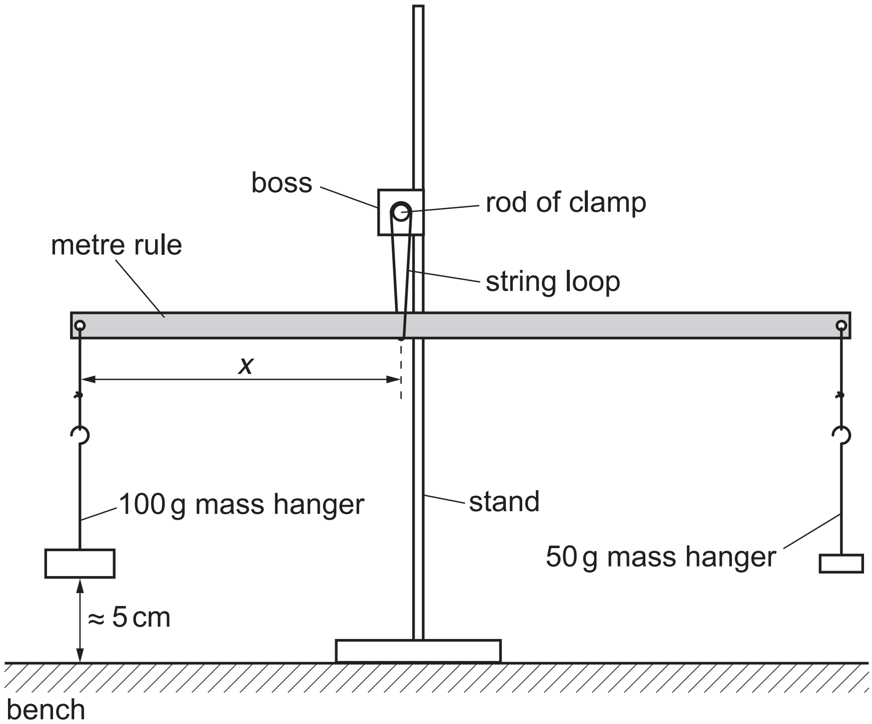

Fig. 2.2

Adjust the position of the rule until it is balanced.

The distance between the centre of the hole from which the 100 g mass hanger is supported and the position of the central string loop is *x*.

(ii) Measure and record *x*.

x = ... [1]

(c) **(i)** Add a 10 g slotted mass to each mass hanger.

(ii) Adjust the position of the rule until it is balanced.
The distance between the centre of the hole from which the 100 g mass hanger is supported and the position of the central string loop is now *y* as shown in Fig. 2.3.

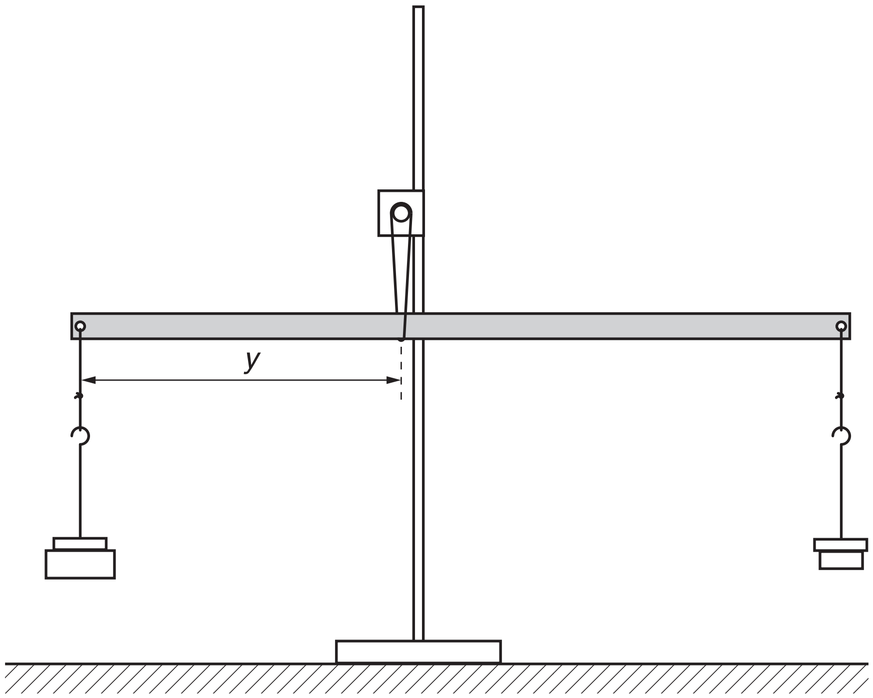

Fig. 2.3

(iii) Measure and record *y*.

y = ... [1]

(iv) Calculate ($y - x$).

($y - x$) = ... [1]

(v) Estimate the percentage uncertainty in your value of ($y - x$).

percentage uncertainty = ... [1]

(d) **(i)** Calculate $m(A-2y)$ where $m = 10.0\,\text{g}$.

$m(A-2y)$ = ... [1]

(ii) Justify the number of significant figures that you have given for your value of $m(A-2y)$.

....

....

.... [1]

(e) **(i)** Add another 10 g mass to each of the mass hangers and repeat **(c)(ii)**, **(c)(iii)** and **(c)(iv)**.

y = ...

$(y-x)$ = ...
[2]

(ii) Calculate $m(A-2y)$ where $m = 20.0\,\text{g}$.

$m(A-2y)$ = ...

(f) It is suggested that the relationship between y, x, m and A is

$$(y - x) = km(A - 2y)$$

where k is a constant.

(i) Using your data, calculate two values of k.

first value of k = ...

second value of k = ...
[1]

(ii) Explain whether your results in **(f)(i)** support the suggested relationship.

....

....

....

....[1]

(g) Using your second value of k, calculate the mass M of the metre rule using the relationship

$$k = \frac{1}{B + M}$$

where B = 150 g.

M = ... g [1]

(h) **(i)** Describe four sources of uncertainty or limitations of the procedure for this experiment.

1. ....

....

2. ....

....

3. ....

....

4. ....

....
[4]

(ii) Describe four improvements that could be made to this experiment. You may suggest the use of other apparatus or different procedures.

1. ....

....

2. ....

....

3. ....

....

4. ....

....
[4]

[Total: 20]

Question	Answer	Marks
1 (a)	(stress =) force / area **or** kg m s^{-2} / m^2	**1**
	= kg m^{-1} s^{-2}	**1**
1 (b) (i)	0.58 = $2\pi \times [(4 \times 0.500 \times 0.600^3) / (E \times 0.0300 \times 0.00500^3)]^{0.5}$	**1**
	$E = [4\pi^2 \times 4 \times 0.500 \times (0.600)^3] / [(0.58)^2 \times 0.0300 \times (0.00500)^3]$ = 1.35×10^{10} (Pa)	**1**
	= 14 (13.5) GPa	**1**
1 (b) (ii) 1.	(accuracy determined by) the closeness of the value(s)/measurement(s) to the true value	**1**
	(precision determined by) the range of the values/measurements	**1**
1 (b) (ii) 2.	l is (cubed so) 3 × (percentage/fractional) uncertainty **and** T is (squared so) 2 × (percentage / fractional) uncertainty **and** (so) l contributes more	**1**
		Total: 8
1 (a)	Value of L with unit to the nearest mm in the range 2.5–3.5 cm.	**1**
1 (c)	Value of T with unit in the range 0.7 s to 1.5 s.	**1**
	Evidence of repeated timings. Must see nT repeated where $n \geqslant 5$.	**1**
1 (d)	Six sets of readings of n (different values) and time with correct trend and without help from Supervisor scores 4 marks, five sets scores 3 marks etc.	**4**
	Range of $n \geqslant 9$.	**1**
	Column headings: Each column heading must contain a quantity and a unit where appropriate. The presentation of quantity and unit must conform to accepted scientific convention e.g. T / s. No unit for n or $\sqrt{n}$.	**1**
	Consistency: All values of raw time must be given to either 0.1 s or 0.01 s.	**1**
	Significant figures: All values of $\sqrt{n}$ must be given to 3 significant figures.	**1**
1 (e) (i)	Axes: Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions). Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions. Scales must be labelled with the quantity that is being plotted. Scale markings should be no more than three large squares apart.	**1**
	Plotting of points: All observations must be plotted on the grid. Diameter of plotted points must be $\leqslant$ half a small square (no "blobs"). Points must be plotted to an accuracy of half a small square.	**1**
	Quality: All points in the table must be plotted for this mark to be awarded. It must be possible to draw a straight line that is within ±□0.10 on the $\sqrt{n}$ axis of all plotted points.	**1**

Question	Answer	Marks
1 (e) (ii)	Line of best fit: Judge by balance of all points on the grid about the candidate's line (at least 5). There must be an even distribution of points either side of the line along the full length. Allow one anomalous point only if clearly indicated (i.e. circled or labelled) by the candidate. There must be at least five points left after the anomalous point is disregarded. Lines must not be kinked or thicker than half a small square.	**1**
	Gradient: The hypotenuse of the triangle used must be greater than half the length of the drawn line. Method of calculation must be correct. Do not allow Δx / Δy. Both read-offs must be accurate to half a small square in both x and y directions.	**1**
	y-intercept: Correct read-off from a point on the line substituted correctly into $y = mx + c$ or an equivalent expression. Read-off accurate to half a small square in both x and y directions. **or** Intercept read directly from the graph, with read-off at $x = 0$, accurate to half a small square in y direction.	**1**
1 (f)	Value of P = candidate's gradient **and** value of Q = candidate's intercept. The values must not be fractions.	**1**
	Units for P and Q both s.	**1**
1 (g)	Correct calculation of $g = L\pi^2 / P^2$ with consistent unit.	**1**
		Total: 20
2 (a)	Value(s) of A with unit in the range 97.5–99.5 cm.	**1**
2 (b) (ii)	Values of all raw x to nearest mm.	**1**
2 (c) (iii)	Value of $y > x$.	**1**
2 (c) (iv)	Correct calculation of $(y - x)$.	**1**
2 (c) (v)	Percentage uncertainty in $(y - x)$ based on absolute uncertainty of 2–5 mm. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown. Correct method of calculation to obtain percentage uncertainty.	**1**
2 (d) (i)	Correct calculation of $m(A - 2y)$.	**1**
2 (d) (ii)	Justification for s.f. in $m(A - 2y)$ linked to s.f. in A, y and m **or** $(A - 2y)$ and m.	**1**
2 (e) (i)	Second value of y.	**1**
	Quality: second value of y > first value of y.	**1**
2 (f) (i)	Two values of k calculated correctly.	**1**
2 (f) (ii)	Valid comment consistent with calculated values of k, testing against a criterion specified by the candidate.	**1**
2 (g)	Correct calculation of $M = 1 / k - B$.	**1**

Question	Answer	Marks
2 (h) (i)	A Two readings are not enough to draw a (valid) conclusion (**not** "not enough for accurate results", "few readings"). B Difficult to measure *x* or *y* with reason e.g. markings on rule obscured because of thickness of string / twist in string / ruler oscillating / ruler swinging / rule slides in loop / string not vertical. C Large (%) uncertainty in ($y – x$) **or** ($y – x$) is small. D Little difference in *y* values. E Difficult to balance rule. *1 mark for each point up to a maximum of 4.*	**4**
2 (h) (ii)	A Take more readings and plot a graph / take more readings and compare *k* values (**not** "repeat readings" on its own). B Use thinner string / tie a knot in loop / use two loops / use a hook / use longer loop / string. C Heavier (added/slotted) masses (**not** heavier hangers). D Use wider range of (added) masses. E Suspend rule from its top edge / balance on fulcrum / use thicker string with reason such as to make easier to balance / prevent rule from slipping. *1 mark for each point up to a maximum of 4.*	**4**
		Total: 20

Notes about the mark scheme are available separately.

2: Motion – Topic questions

The questions in this document have been compiled from a number of past papers, as indicated in the table below.

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Question	Year	Series	Paper number
2	2017	June	21
3	2017	March	22
5	2017	March	22

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2 **(a)** State the two conditions for a system to be in equilibrium.

1. ....

....

2. ....

....
[2]

(b) A paraglider P of mass 95 kg is pulled by a wire attached to a boat, as shown in Fig. 2.1.

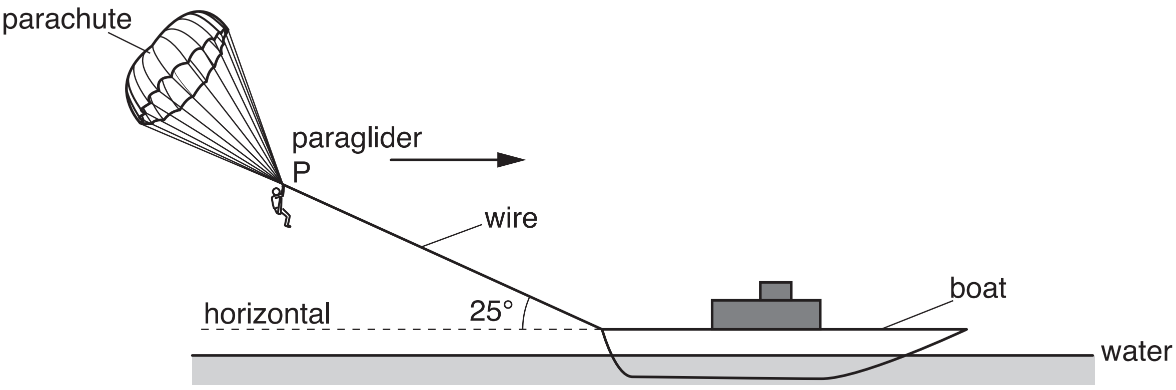
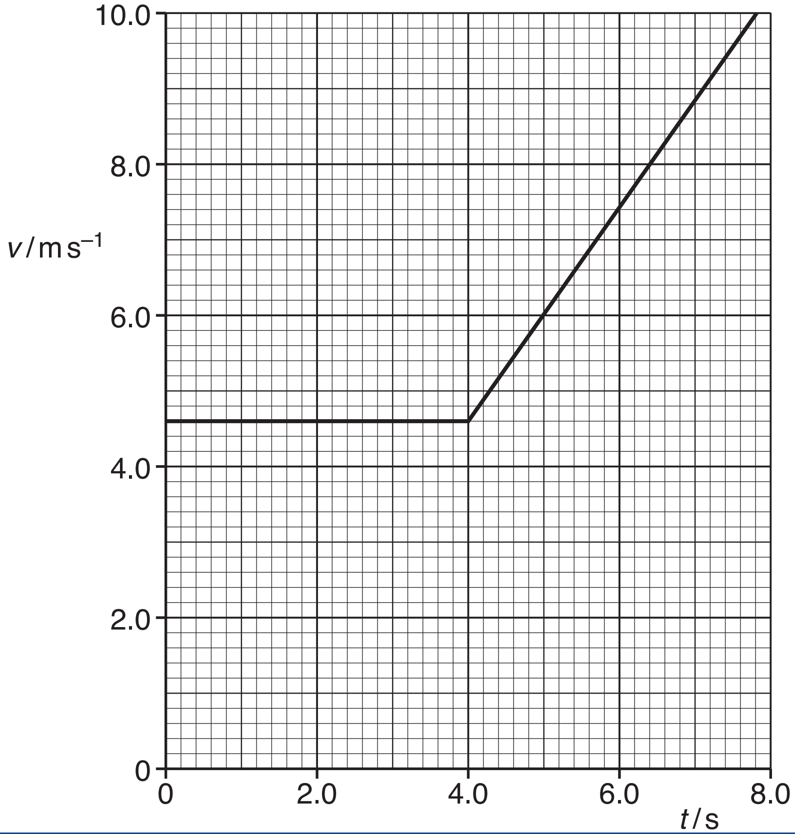


Fig. 2.1

The wire makes an angle of 25° with the horizontal water surface. P moves in a straight line parallel to the surface of the water.

The variation with time t of the velocity v of P is shown in Fig. 2.2.



(i) Show that the acceleration of P is $1.4\,m\,s^{-2}$ at time $t = 5.0\,s$.

[2]

(ii) Calculate the total distance moved by P from time $t = 0$ to $t = 7.0\,s$.

distance = ...m [2]

(iii) Calculate the change in kinetic energy of P from time $t = 0$ to $t = 7.0\,s$.

change in kinetic energy = ...J [2]

(iv) The tension in the wire at time $t = 5.0\,s$ is 280 N.

Calculate, for the horizontal motion,

1. the vertical lift force *F* supporting P,

F = ...N [3]

2. the force *R* due to air resistance acting on P in the horizontal direction.

R = ...N [3]

[Total: 14]

3 **(a)** Define *velocity*.

....

....[1]

(b) A car travels in a straight line up a slope, as shown in Fig. 3.1.

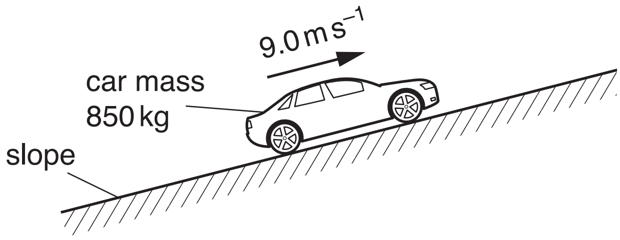


Fig. 3.1

The car has mass 850 kg and travels with a constant speed of 9.0 m s^{-1}. The car's engine exerts a force on the car of 2.0 kN up the slope.

A resistive force F_D, due to friction and air resistance, opposes the motion of the car.

The variation of F_D with the speed v of the car is shown in Fig. 3.2.

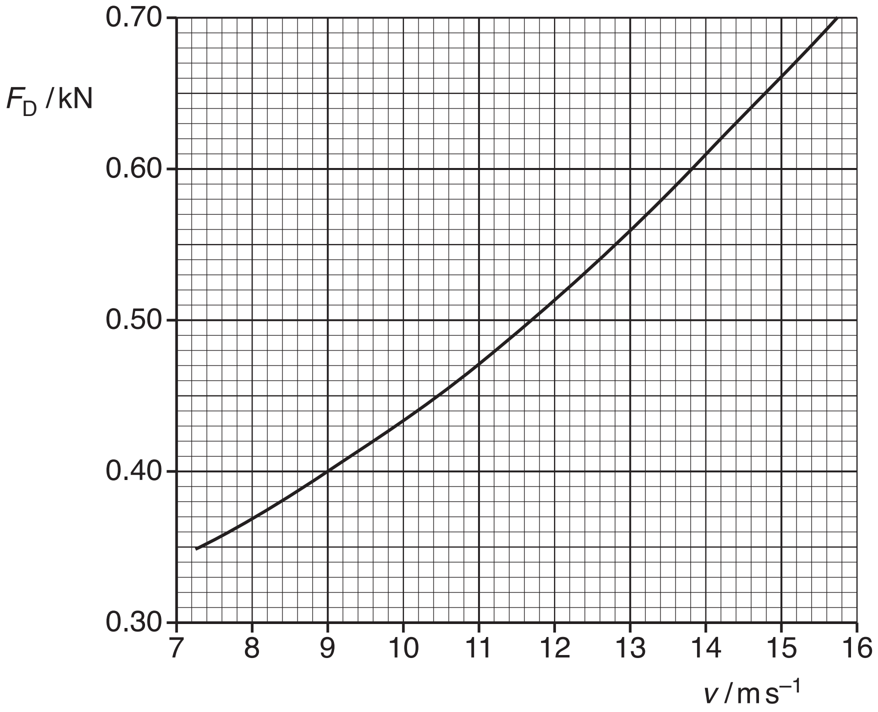


Fig. 3.2

(i) State and explain whether the car is in equilibrium as it moves up the slope.

....

....

....[2]

(ii) Consider the forces that act along the slope. Use data from Fig. 3.2 to determine the component of the weight of the car that acts down the slope.

component of weight = ... N [2]

(iii) Show that the power output of the car is 1.8×10^4 W.

[2]

(iv) The car now travels along horizontal ground. The output power of the car is maintained at 1.8×10^4 W. The variation of the resistive force F_D acting on the car is given in Fig. 3.2.

Calculate the acceleration of the car when its speed is $15\,m\,s^{-1}$.

acceleration = ... $m\,s^{-2}$ [3]

[Total: 10]

5 An electron is travelling in a straight line through a vacuum with a constant speed of $1.5 \times 10^7\,m\,s^{-1}$.

The electron enters a uniform electric field at point A, as shown in Fig. 5.1.

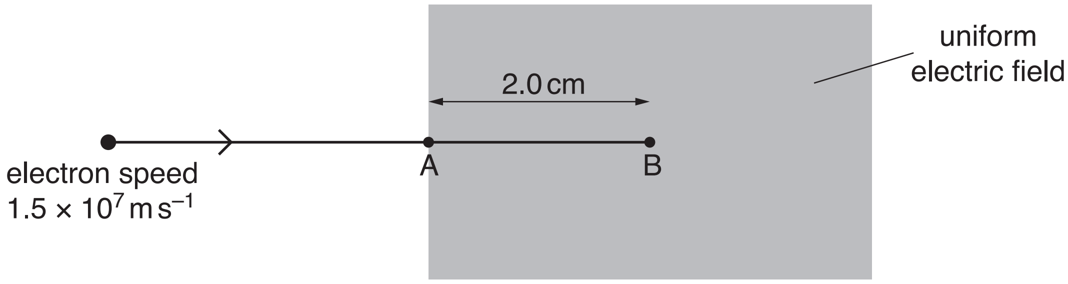


Fig. 5.1

The electron continues to move in the same direction until it is brought to rest by the electric field at point B. Distance AB is 2.0 cm.

(a) State the direction of the electric field.

....[1]

(b) Calculate the magnitude of the deceleration of the electron in the field.

deceleration = ... $m\,s^{-2}$ [2]

(c) Calculate the electric field strength.

electric field strength = ... $V\,m^{-1}$ [3]

(d) The electron is at point A at time $t = 0$.

On Fig. 5.2, sketch the variation with time t of the velocity v of the electron until it reaches point B. Numerical values of v and t do not need to be shown.

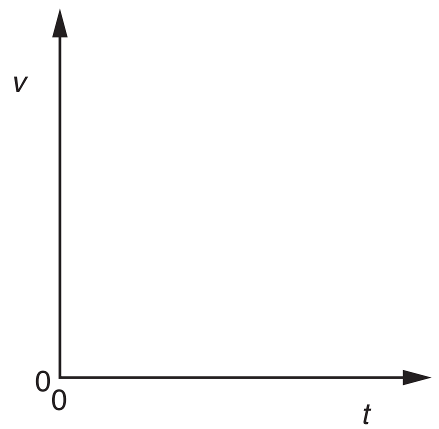


Fig. 5.2

[1]

[Total: 7]

Question	Answer	Marks
2 (a)	resultant force (in any direction) is zero	**1**
	resultant torque/moment (about any point) is zero	**1**
2 (b) (i)	$a = (v - u) / t$ **or** gradient **or** $\Delta v / (\Delta) t$	**1**
	e.g. a = (8.8 – 4.6) / (7.0 – 4.0) = 1.4 m s^{-2}	**1**
2 (b) (ii)	s = 4.6 × 4 + [(8.8 + 4.6) / 2] × 3	**1**
	= 18.4 + 20.1 = 39 (38.5) m	**1**
2 (b) (iii)	ΔE = ½ × 95 [$(8.8)^2 - (4.6)^2$]	**1**
	= 3678 – 1005 = 2700 (2673) J	**1**
2 (b) (iv) 1	weight = 95 × 9.81 (= 932 N)	**1**
	vertical tension force = 280 sin 25° **or** 280 cos 65° (=118.3 N)	**1**
	F = 932 + 118 = 1100 (1050) N	**1**
2 (b) (iv) 2	horizontal tension force = 280 cos 25° **or** 280 sin 65° (= 253.8 N)	**1**
	resultant force = 95 × 1.4 (= 133 N)	**1**
	133 = 253.8 – R R = 120 (120.8) N	**1**
		Total: 14
3 (a)	change of displacement / time (taken)	**1**
3 (b) (i)	constant velocity, so resultant force is zero	**1**
	(so car is) in (dynamic) equilibrium	**1**
3 (b) (ii)	F_D = 0.40 (kN) or 0.40 × 10^3 (N)	**1**
	component of weight = 2.0 × 10^3 – 0.40 × 10^3 = 1.6 × 10^3 N	**1**
3 (b) (iii)	$P = Fv$	**1**
	= 2.0 × 10^3 × 9.0 = 1.8 × 10^4 W	**1**
3 (b) (iv)	(driving) force = 1.8 × 10^4 / 15 (= 1.2 × 10^3)	**1**
	F_D = 0.66 (kN) or 0.66 × 10^3 (N)	**1**
	acceleration = (1.2 × 10^3 – 0.66 × 10^3) / 850 = 0.64 (0.635) m s^{-2}	**1**
		Total: 10

Question	Answer	Marks
5 (a)	to the right / from the left / from A to B / in the same direction as electron velocity	1
5 (b)	$v^2 = u^2 + 2as$ $a = (1.5 \times 10^7)^2 / (2 \times 2.0 \times 10^{-2})$ Other alternative calculations for this mark: e.g. $a = 1.5\times10^7 / 2.67\times10^{-9}$ e.g. $a = [(1.5\times10^7 \times 2.67\times10^{-9}) - 2.0\times10^{-2}] \times [2 / (2.67\times10^{-9})^2]$ e.g. $a = (2.0\times10^{-2} \times 2) / (2.67\times10^{-9})^2$	1
	$= 5.6 \times 10^{15}$ m s^{-2}	1
5 (c)	$E = F / Q$	1
	$= (9.1 \times 10^{-31} \times 5.6 \times 10^{15}) / 1.6 \times 10^{-19}$	1
	= 3.2 × 104 V m–1	1
5 (d)	straight line with negative gradient starting at an intercept on the *v*-axis and ending at an intercept on the *t*-axis.	1
		Total: 7

Notes about the mark scheme are available separately.

3: Forces, work and materials – Topic questions

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3	2017	June	21
1	2017	March	22
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3 **(a)** A cylinder is made from a material of density 2.7 g cm^{-3}. The cylinder has diameter 2.4 cm and length 5.0 cm.

Show that the cylinder has weight 0.60 N.

[3]

(b) The cylinder in **(a)** is hung from the end A of a non-uniform bar AB, as shown in Fig. 3.1.

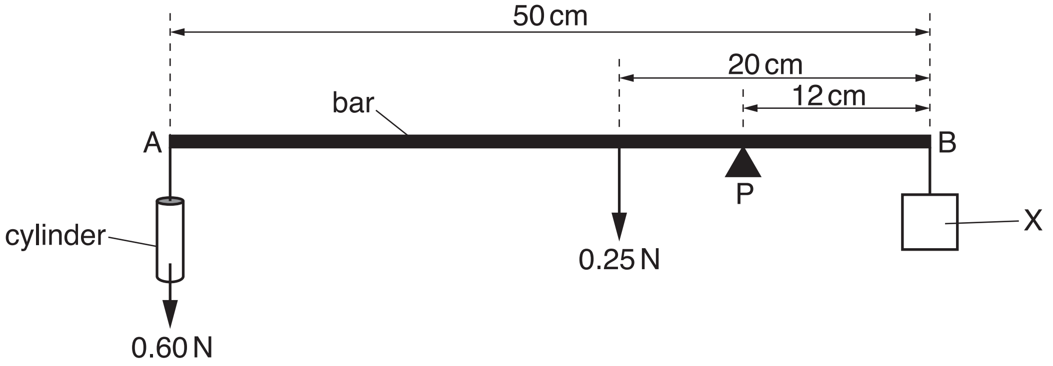


Fig. 3.1

The bar has length 50 cm and has weight 0.25 N. The centre of gravity of the bar is 20 cm from B. The bar is pivoted at P. The pivot is 12 cm from B.

An object X is hung from end B. The weight of X is adjusted until the bar is horizontal and in equilibrium.

(i) Explain what is meant by *centre of gravity*.

....

....[1]

(ii) Calculate the weight of X.

weight of X = ... N [3]

(c) The cylinder is now immersed in water, as illustrated in Fig. 3.2.

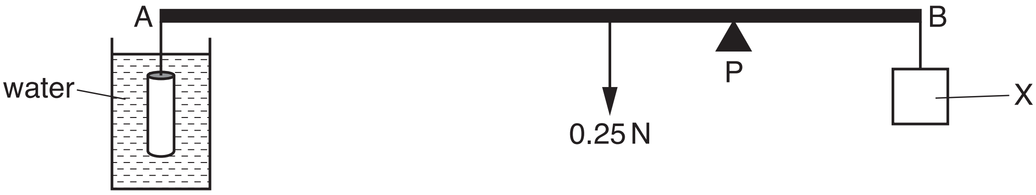


Fig. 3.2

An upthrust acts on the cylinder and the bar is not in equilibrium.

(i) Explain the origin of the upthrust.

....

....

....

....[2]

(ii) Explain why the weight of X must be reduced in order to obtain equilibrium for AB.

....

....

....[1]

[Total: 10]

1 **(a)** Complete Fig. 1.1 by putting a tick (✓) in the appropriate column to indicate whether the listed quantities are scalars or vectors.

quantity	scalar	vector
acceleration		
force		
kinetic energy		
momentum		
power		
work		

Fig. 1.1

[2]

(b) A floating sphere is attached by a cable to the bottom of a river, as shown in Fig. 1.2.

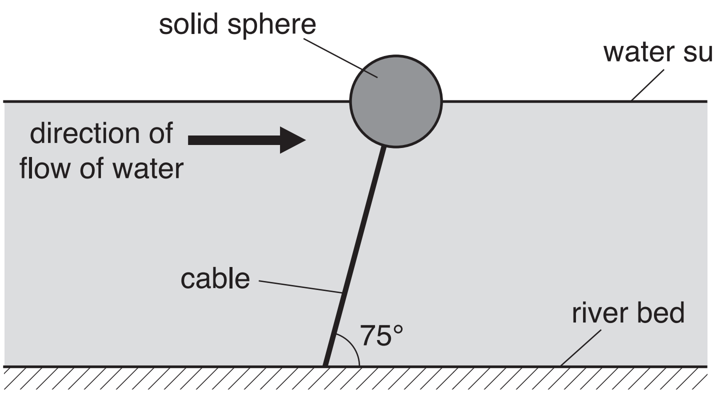


Fig. 1.2

The sphere is in equilibrium, with the cable at an angle of 75° to the horizontal. Assume that the force on the sphere due to the water flow is in the horizontal direction.

The radius of the sphere is 23 cm. The sphere is solid and is made from a material of density 82 kg m^{-3}.

(i) Show that the weight of the sphere is 41 N.

[2]

(ii) The tension in the cable is 290 N.

Determine the upthrust acting on the sphere.

upthrust = ... N [2]

(iii) Explain the origin of the upthrust acting on the sphere.

....

....

....[1]

[Total: 7]

2 **(a)** State the *principle of conservation of momentum*.

....

....

....[2]

(b) Two blocks, A and B, are on a horizontal frictionless surface. The blocks are joined together by a spring, as shown in Fig. 2.1.

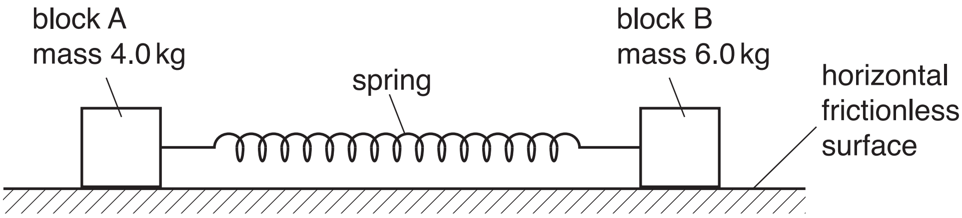


Fig. 2.1

Block A has mass 4.0 kg and block B has mass 6.0 kg.

The variation of the tension *F* with the extension *x* of the spring is shown in Fig. 2.2.

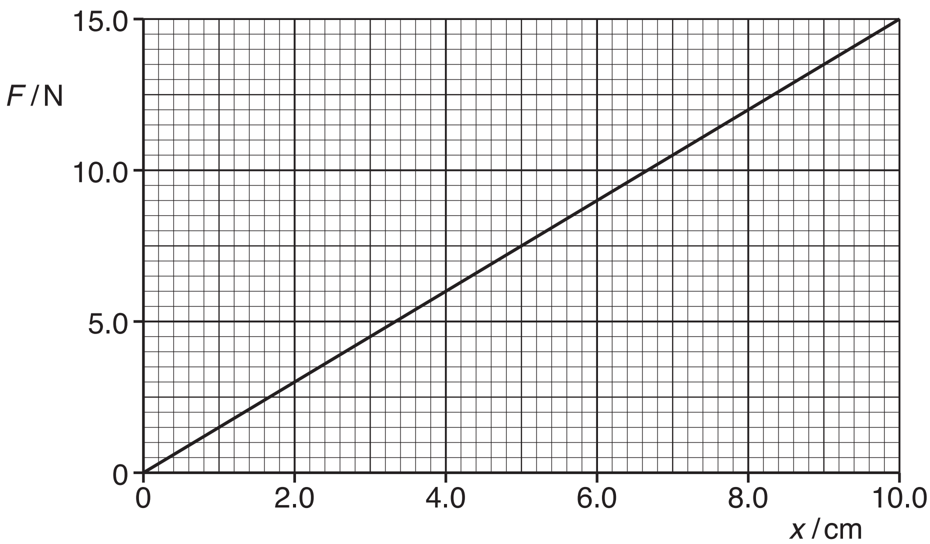


Fig. 2.2

The two blocks are held apart so that the spring has an extension of 8.0 cm.

(i) Show that the elastic potential energy of the spring at an extension of 8.0 cm is 0.48 J.

[2]

(ii) The blocks are released from rest at the same instant. When the extension of the spring becomes zero, block A has speed v_A and block B has speed v_B.

For the instant when the extension of the spring becomes zero,

1. use conservation of momentum to show that

$$\frac{\text{kinetic energy of block A}}{\text{kinetic energy of block B}} = 1.5$$

[3]

2. use the information in **(b)(i)** and **(b)(ii)1** to determine the kinetic energy of block A. It may be assumed that the spring has negligible kinetic energy and that air resistance is negligible.

kinetic energy of block A = ...J [2]

(iii) The blocks are released at time $t = 0$.

On Fig. 2.3, sketch a graph to show how the momentum of block A varies with time t until the extension of the spring becomes zero.
Numerical values of momentum and time are not required.

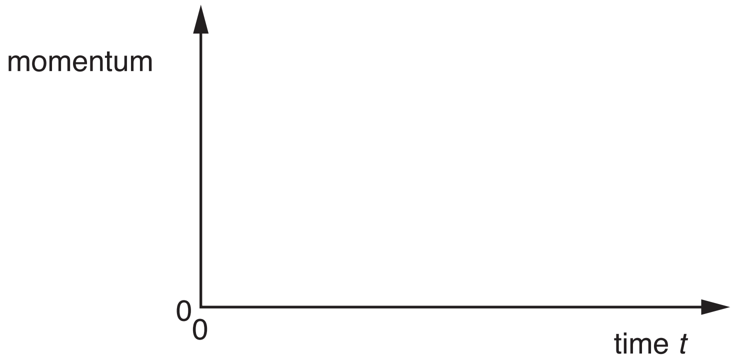


Fig. 2.3

[2]

[Total: 11]

Question	Answer	Marks
3 (a)	$\rho = m / V$	**1**
	$V = \pi d^2 L / 4$ **or** $\pi r^2 L$	**1**
	weight = $2.7 \times 10^3 \times \pi (1.2 \times 10^{-2})^2 \times 5.0 \times 10^{-2} \times 9.81 = 0.60$ N	**1**
3 (b) (i)	the point from where (all) the weight (of a body) seems to act	**1**
3 (b) (ii)	$W \times 12$	**1**
	$(0.25 \times 8) + (0.6 \times 38)$	**1**
	$W = (2 + 22.8) / 12$ $= 2.1\ (2.07)$ N	**1**
3 (c) (i)	pressure changes with depth (in water) **or** pressure on bottom (of cylinder) different from pressure on top	**1**
	pressure on bottom of cylinder greater than pressure on top **or** force (up) on bottom of cylinder greater than force (down) on top	**1**
3 (c) (ii)	anticlockwise moment reduced and reducing the weight of X reduces clockwise moment **or** anticlockwise moment reduced so clockwise moment now greater than (total) anticlockwise moment	**1**
		Total: 10
1 (a)	scalars: kinetic energy, power, work	**1**
	vectors: acceleration, force, momentum	**1**
1 (b) (i)	mass = volume × density *or* $m = V \times \rho$ $= 4/3\ \pi\ (23 \times 10^{-2})^3 \times 82$	**1**
	weight = $4/3\ \pi\ (23 \times 10^{-2})^3 \times 82 \times 9.8 = 41$ N	**1**
1 (b) (ii)	vertical component of tension = 290 sin75° or 290 cos15° (= 280)	**1**
	upthrust = 290 sin75°+ 41 = 320 (321) N	**1**
1 (b) (iii)	the water pressure is greater than the air pressure *or* the pressure on lower surface (of sphere) is greater than the pressure on upper surface (of sphere)	**1**
		Total: 7

Question	Answer	Marks
2 (a)	sum / total momentum of bodies is constant *or* sum / total momentum of bodies before = sum / total momentum of bodies after	**1**
	for an isolated / closed system / no (resultant) external force	**1**
2 (b) (i)	EPE = area under graph or ½Fx or ½kx^2 and $F = kx$	**1**
	energy = ½ × 12.0 × 8.0 × 10^{-2} = 0.48 J *or* energy = ½ × 150 × (8.0 × $10^{-2})^2$ = 0.48 J	**1**
2 (b) (ii) 1	4.0 v_A = 6.0 v_B	**1**
	$E_K = ½mv^2$	**1**
	ratio = $\frac{0.50 \times 4.0}{0.50 \times 6.0} \left(\frac{6.0}{4.0}\right)^2$ = 1.5 *or* = ratio = $\frac{1}{1.5} \times (1.5)^2 = 1.5$	**1**
2 (b) (ii) 2	0.48 = E_K of A + E_K of B = E_K of A + (E_K of A / 1.5) = 5/3 × E_K of A	**1**
	E_K of A = 0.29 (0.288) J	**1**
2 (b) (iii)	curve starts from origin and has decreasing gradient	**1**
	final gradient of graph line is zero	**1**
		Total: 11

Notes about the mark scheme are available separately.

Cambridge Assessment International Education

Cambridge International AS & A Level

5: Electrical circuits – Topic questions

The questions in this document have been compiled from a number of past papers, as indicated in the table below.

Use these questions to formatively assess your learners' understanding of this topic.

Question	Year	Series	Paper number
6	2017	June	21
6	2017	March	22
7	2017	June	22

The mark scheme for each question is provided at the end of the document.

You can find the complete question papers and the complete mark schemes (with additional notes where available) on the School Support Hub at www.cambridgeinternational.org/support

6 **(a)** Define the *ohm*.

....

....[1]

(b) A cell X of electromotive force (e.m.f.) 1.5 V and negligible internal resistance is connected in series to three resistors A, B and C, as shown in Fig. 6.1.

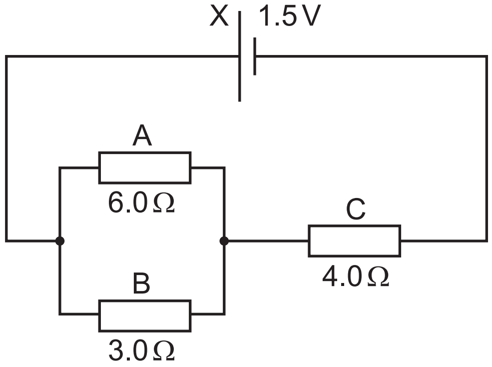


Fig. 6.1

Resistors A and B have resistances 6.0 Ω and 3.0 Ω respectively and are connected in parallel. Resistor C has resistance 4.0 Ω and is connected in series with the parallel combination.

Calculate

(i) the current in the circuit,

current = ...A [3]

(ii) the current in resistor B,

current = ...A [1]

(iii) the ratio

$$\frac{\text{power dissipated in resistor B}}{\text{power dissipated in resistor C}}.$$

ratio = ...[2]

(c) The resistors A, B and C in **(b)** are wires of the same material and have the same length.

(i) Explain how the resistors may be made with different resistance values.

....[1]

(ii) Calculate the ratio

$$\frac{\text{average drift speed of the charge carriers in resistor B}}{\text{average drift speed of the charge carriers in resistor C}}.$$

ratio = ...[2]

(d) A cell of e.m.f. 1.5V and negligible internal resistance is connected in parallel with cell X in Fig. 6.1 with their positive terminals together.

State the change, if any, to the current in

(i) cell X,

....[1]

(ii) resistor C.

....[1]

[Total: 12]

6 **(a)** Three resistors of resistances R_1, R_2 and R_3 are connected as shown in Fig. 6.1.

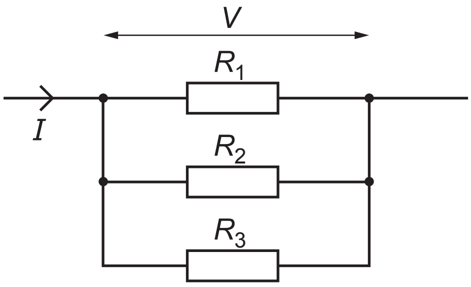


Fig. 6.1

The total current in the combination of resistors is I and the potential difference across the combination is V.

Show that the total resistance R of the combination is given by the equation

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}.$$

[2]

(b) A battery of electromotive force (e.m.f.) 6.0 V and internal resistance r is connected to a resistor of resistance 12 Ω and a variable resistor X, as shown in Fig. 6.2.

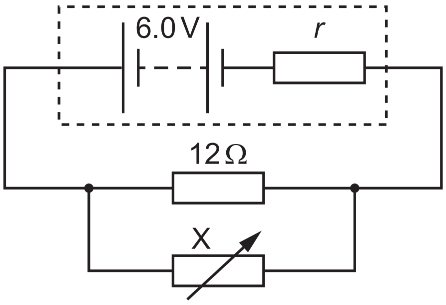


Fig. 6.2

(i) By considering energy, explain why the potential difference across the battery's terminals is less than the e.m.f. of the battery.

....

....

....

....[2]

(ii) A charge of 2.5 kC passes through the battery.

Calculate

1. the total energy transformed by the battery,

energy = ...J [2]

2. the number of electrons that pass through the battery.

number = ...[1]

(iii) The combined resistance of the two resistors connected in parallel is 4.8 Ω.

Calculate the resistance of X.

resistance of X = ...Ω [1]

(iv) Use your answer in **(b)(iii)** to determine the ratio

$$\frac{\text{power dissipated in X}}{\text{power dissipated in 12}\,\Omega\text{ resistor}}.$$

ratio = ...[2]

(v) The resistance of X is now decreased. Explain why the power produced by the battery is increased.

....

....

....[1]

[Total: 11]

7 **(a)** Define *electromotive force* (e.m.f.) of a cell.

....

....[1]

(b) A cell C of e.m.f. 1.50 V and internal resistance 0.200 Ω is connected in series with resistors X and Y, as shown in Fig. 7.1.

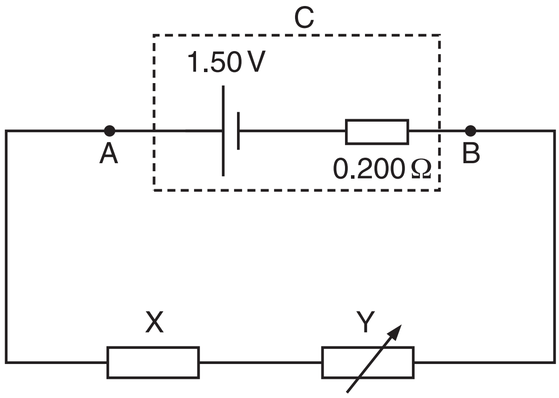


Fig. 7.1

The resistance of X is constant and the resistance of Y can be varied.

(i) The resistance of Y is varied from 0 to 8.00 Ω.

State and explain the variation in the potential difference (p.d.) between points A and B (terminal p.d. across C). Numerical values are not required.

....

....

....

....[3]

(ii) The resistance of Y is set at 6.00 Ω. The current in the circuit is 0.180 A.

Calculate

1. the resistance of X,

resistance = ... Ω [2]

2. the p.d. between points A and B,

p.d. = ... V [2]

3. the efficiency of the cell.

efficiency = ...[2]

[Total: 10]

Question	Answer	Marks
6 (a)	volt / ampere	1
6 (b) (i)	$R_T = [1 / 3.0 + 1 / 6.0]^{-1} + 4.0$ (= 6.0 Ω)	1
	$I = 1.5 / 6.0$	1
	= 0.25 A	1
6 (b) (ii)	$V_B = 0.5$ V $I = 0.5 / 3.0$ = 0.17 (0.167) A	1
6 (b) (iii)	$P = I^2R$ **or** VI **or** V^2/ R	1
	ratio = $(0.167^2 \times 3.0) / (0.25^2 \times 4.0)$ = 0.33	1
6 (c) (i)	vary/change/different radius/diameter/cross-sectional area (of wire)	1
6 (c) (ii)	$v = I / Ane$ ratio = $\frac{(I_B/A_B)}{(I_C/A_C)}$ or $\frac{I_B}{I_C} \times \frac{A_C}{A_B}$	1
	($R \propto 1/A$ so) ratio = $\frac{I_B}{I_C} \times \frac{A_C}{A_B} = \frac{0.167}{0.25} \times \frac{3.0}{4.0}$ = 0.50	1
6 (d) (i)	0.25 A to 0.13 (0.125) A **or** halved	1
6 (d) (ii)	no change	1
		Total: 12
6 (a)	$I = I_1 + I_2 + I_3$	1
	$(V/R) = (V/R_1) + (V/R_2) + (V/R_3)$ *or* $(I/V) = (I_1 /V) + (I_2 /V) + (I_3 /V)$ and (so) $1/R = 1/R_1 + 1/R_2 + 1/R_3$	1
6 (b) (i)	e.m.f. is total energy available per unit charge	1
	energy is dissipated in the internal resistance / resistor / r	1
6 (b) (ii) 1	Energy = EQ	1
	$= 6.0 \times 2.5 \times 10^3$ $= 1.5 \times 10^4$ J	1
6 (b) (ii) 2	number = $2.5 \times 10^3 / 1.6 \times 10^{-19}$ $= 1.6 \times 10^{22}$ (1.56×10^{22})	1
6 (b) (iii)	$1 / 4.8 = 1 / 12 + 1 / R_X$ $R_X = 8.0$ Ω	1
6 (b) (iv)	$P = V^2/ R$ *or* $P = VI$ <u>and</u> $V = IR$	1
	ratio = $(V^2/ 8) / (V^2/ 12) = 12 / 8 = 1.5$	1
6 (b) (v)	(total) current, *or* I, increases and $P = EI$ *or* $P = 6I$ *or* $P \propto I$ *or* total (circuit) resistance decreases and $P = E2/R$ *or* $P = 36/R$ or $P \propto 1/R$	1
		Total: 11

Question	Answer	Marks
7 (a)	energy transformed from chemical to electrical / unit charge (driven around a complete circuit)	**1**
7 (b) (i)	the current decreases (as resistance of Y increases)	**1**
	lost volts go down (as resistance of Y increases)	**1**
	p.d. AB increases (as resistance of Y increases)	**1**
7 (b) (i) 1	$1.50 = 0.180 \times (6.00 + 0.200 + R_X)$	**1**
	$R_X = 2.1(3)\ \Omega$	**1**
7 (b) (ii) 2	p.d. AB = 1.5 − (0.180 × 0.200) **or** 0.18 × (2.13 + 6.00)	**1**
	= 1.46(4) V	**1**
7 (b) (ii) 3	efficiency = (useful) power output / (total) power input **or** IV / IE	**1**
	(= 1.46 / 1.5) = 0.97 [0.98 if full figures used]	**1**
		Total: 10

Notes about the mark scheme are available separately.

4: Waves – Topic questions

The questions in this document have been compiled from a number of past papers, as indicated in the table below.

Use these questions to formatively assess your learners' understanding of this topic.

Question	Year	Series	Paper number
4	2017	June	21
5	2017	June	21
4	2017	March	22

The mark scheme for each question is provided at the end of the document.

You can find the complete question papers and the complete mark schemes (with additional notes where available) on the School Support Hub at www.cambridgeinternational.org/support

4 **(a)** State the conditions required for the formation of stationary waves.

....

....

....[2]

(b) One end of a string is attached to a vibrator. The string is stretched by passing the other end over a pulley and attaching a load, as illustrated in Fig. 4.1.

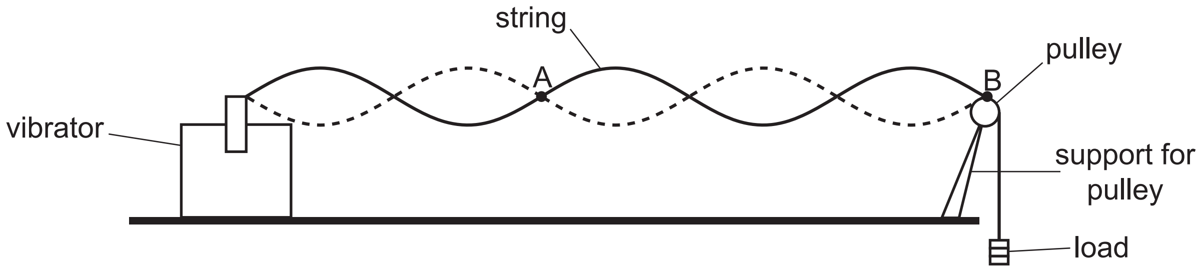


Fig. 4.1

The frequency of vibration of the vibrator is adjusted to 250 Hz and a transverse wave travels along the string with a speed of 12 m s^{-1}. The wave is reflected at the pulley and a stationary wave forms on the string.

Fig. 4.2 shows the string between points A and B at time $t = t_1$.

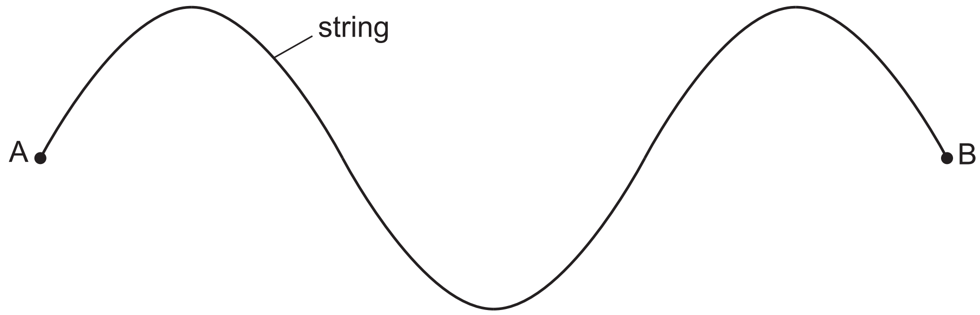


Fig. 4.2

At time $t = t_1$ the string has maximum displacement.

(i) Calculate the distance AB.

distance = ...m [2]

(ii) On Fig. 4.2, sketch the position of the string between A and B at times

1. $t = t_1 + 2.0\,\text{ms}$ (label this line P),

2. $t = t_1 + 5.0\,\text{ms}$ (label this line Q).

[3]

[Total: 7]

5 **(a)** Describe the Doppler effect.

....

....

....[1]

(b) A car travels with a constant velocity along a straight road. The car horn with a frequency of 400 Hz is sounded continuously. A stationary observer on the roadside hears the sound from the horn at a frequency of 360 Hz.
The speed of sound is 340 $m s^{-1}$.

Determine the magnitude *v*, and the direction, of the velocity of the car relative to the observer.

v = ... $m s^{-1}$

direction ....

[3]

[Total: 4]

4 **(a)** State what is meant by the *Doppler effect*.

....

....

....[2]

(b) A child sits on a rotating horizontal platform in a playground. The child moves with a constant speed along a circular path, as illustrated in Fig. 4.1.

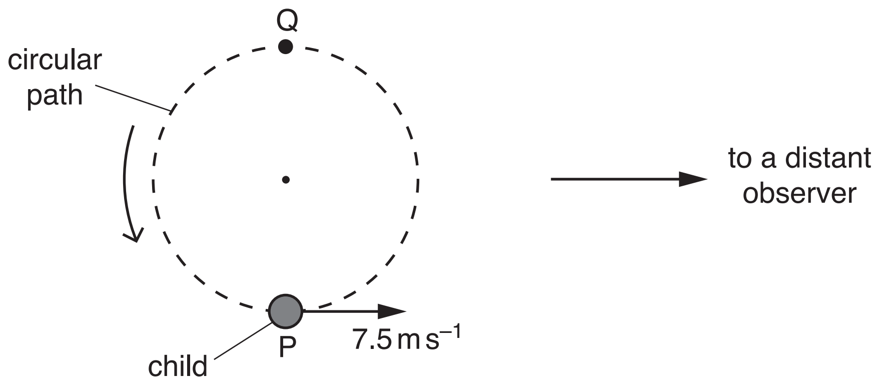


Fig. 4.1

An observer is standing a long distance away from the child. During one particular revolution, the child, moving at a speed of $7.5\,m\,s^{-1}$, starts blowing a whistle at point P and stops blowing it at point Q on the circular path.

The whistle emits sound of frequency 950 Hz. The speed of sound in air is $330\,m\,s^{-1}$.

(i) Determine the maximum frequency of the sound heard by the distant observer.

maximum frequency = ... Hz [2]

(ii) Describe the variation in the frequency of the sound heard by the distant observer.

....

....

....

....[2]

[Total: 6]

Question	Answer	Marks
4 (a)	(two) waves travelling (at same speed) in opposite directions overlap	**1**
	waves (are same type and) have same frequency/wavelength	**1**
4 (b) (i)	λ = 12 / 250 (= 0.048 m)	**1**
	distance = 1.5 × 0.048 = 0.072 m	**1**
4 (b) (ii)	*T* = 1 / 250 = 0.004 (s) or 4 (ms)	**1**
	1. curve drawn is mirror image of that in Fig. 4.2 and labelled P	**1**
	2. horizontal line drawn between A and B and labelled Q	**1**
		Total: 7
5 (a)	observed frequency is different to source frequency when source moves relative to observer	**1**
5 (b)	360 = (400 × 340) / (340 ± *v*)	**1**
	v = 38 (37.8) m s^{-1}	**1**
	away (from the observer)	**1**
		Total: 5
4 (a)	change in frequency when source moves relative to observer	**1**
	refers to 'change in observed / apparent frequency'	**1**
4 (b) (i)	*f* = (950 × 330) / (330 – 7.5)	**1**
	= 970 (972) Hz	**1**
4 (b) (ii)	frequency decreases	**1**
	from greater than 950 Hz / from 970 (972) Hz / to less than 950 Hz / to 930 (929) Hz / by 40 (43) Hz	**1**
		Total: 6

Notes about the mark scheme are available separately.

6: Particle physics – Topic questions

The questions in this document have been compiled from a number of past papers, as indicated in the table below.

Use these questions to formatively assess your learners' understanding of this topic.

Question	Year	Series	Paper number
7	2017	June	21
7	2017	March	22
8	2017	June	22

The mark scheme for each question is provided at the end of the document.

You can find the complete question papers and the complete mark schemes (with additional notes where available) on the School Support Hub at www.cambridgeinternational.org/support

7 **(a)** Use the quark model to show that

(i) the charge on a proton is +*e*,

....[1]

(ii) the charge on a neutron is zero.

....[1]

(b) A nucleus of $^{90}_{38}Sr$ decays by the emission of a β^- particle. A nucleus of $^{64}_{29}Cu$ decays by the emission of a β^+ particle.

(i) In Fig. 7.1, state the nucleon number and proton number for the nucleus produced in each of these decay processes.

	nucleus formed by β^- decay	nucleus formed by β^+ decay
nucleon number		
proton number		

Fig. 7.1 [1]

(ii) State the name of the force responsible for β decay.

....[1]

(iii) State the names of the leptons produced in each of the decay processes.

β^- decay: ....

β^+ decay: ....
[1]

[Total: 5]

7 A nucleus of bismuth-212 ($^{212}_{83}\text{Bi}$) decays by the emission of an α-particle and γ-radiation.

(a) State the number of protons and the number of neutrons in the nucleus of bismuth-212.

number of protons = ...

number of neutrons = ...
[1]

(b) The γ-radiation emitted from the nucleus has a wavelength of 3.8 pm.

Calculate the frequency of this radiation.

frequency = ... Hz [3]

(c) Explain how a single beam of α-particles and γ-radiation may be separated into a beam of α-particles and a beam of γ-radiation.

....

....

....

....[2]

(d) The α-particle emitted from the bismuth nucleus has an initial kinetic energy of 9.3×10^{-13} J. As the α-particle moves through air it causes the removal of electrons from atoms. The α-particle loses energy and is stopped after removing 1.8×10^{5} electrons as it moved through the air.

Determine the energy, in eV, needed to remove one electron.

energy = ... eV [2]

[Total: 8]

8 **(a)** Describe **two** differences between the decay of a nucleus that emits a β^- particle and the decay of a nucleus that emits a β^+ particle.

1. ....

....

2. ....

....
[2]

(b) In a simple quark model there are three types of quark. State the composition of the proton and of the neutron in terms of these three quarks.

proton: ....

neutron: ....
[1]

[Total: 3]

Question	Answer	Marks
7 (a) (i)	(proton is uud so) (2 / 3)*e* + (2 / 3)*e* – (1 / 3)*e* = *e*	**1**
7 (a) (ii)	(neutron is udd so) (2 / 3)*e* – (1 / 3)*e* –(1 / 3)*e* = 0	**1**
7 (b) (i)	<table><tr><td></td><td>β⁻</td><td>β⁺</td></tr><tr><td>nucleon number</td><td>90</td><td>64</td></tr><tr><td>proton number</td><td>39</td><td>28</td></tr></table> all correct	**1**
7 (b) (ii)	weak (nuclear force/interaction)	**1**
7 (b) (iii)	β^- decay: electron and (electron) antineutrino β^+ decay: positron and (electron) neutrino *all correct*	**1**
		Total: 5
7 (a)	number of protons = 83 and number of neutrons = 129	**1**
7 (b)	$\lambda = 3.8 \times 10^{-12}$	**1**
	$f = 3.0 \times 10^{8} / 3.8 \times 10^{-12}$	**1**
	$f = 7.9 \times 10^{19}$ (7.89×10^{19}) Hz	**1**
7 (c)	use an electric field (at an angle to the beam)	**1**
	α is deflected and γ is undeflected	**1**
7 (d)	*either*	
	energy = $9.3 \times 10^{-13} / 1.8 \times 10^{5}$ (= 5.17×10^{-18} J)	**1**
	= $5.17 \times 10^{-18} / 1.6 \times 10^{-19}$ = 32 (32.3) eV	**1**
	or	
	energy = $9.3 \times 10^{-13} / 1.6 \times 10^{-19}$ (= 5.81×10^{6} eV)	**(1)**
	= $5.81 \times 10^{6} / 1.8 \times 10^{5}$ = 32 (32.3) eV	**(1)**
		Total: 8
8 (a)	β^- emission: neutron changes to proton (+ beta$_-$/electron) **and** β^+ emission: proton changes to neutron (+ beta$_+$/positron)	**1**
	β^- emission: (electron) antineutrino also emitted **and** β^+ emission: (electron) neutrino also emitted	**1**
8 (b)	proton: up up down (and zero strange) neutron: up down down (and zero strange)	**1**
		Total: 3

Notes about the mark scheme are available separately.

7: Further mechanics – Topic questions

The questions in this document have been compiled from a number of past papers, as indicated in the table below.

Use these questions to formatively assess your learners' understanding of this topic.

Question	Year	Series	Paper number
1	2017	June	41
2	2017	June	41
1	2017	March	42

The mark scheme for each question is provided at the end of the document.

You can find the complete question papers and the complete mark schemes (with additional notes where available) on the School Support Hub at www.cambridgeinternational.org/support

1 **(a)** Explain how a satellite may be in a circular orbit around a planet.

....

....

....[2]

(b) The Earth and the Moon may be considered to be uniform spheres that are isolated in space. The Earth has radius R and mean density ρ. The Moon, mass m, is in a circular orbit about the Earth with radius nR, as illustrated in Fig. 1.1.

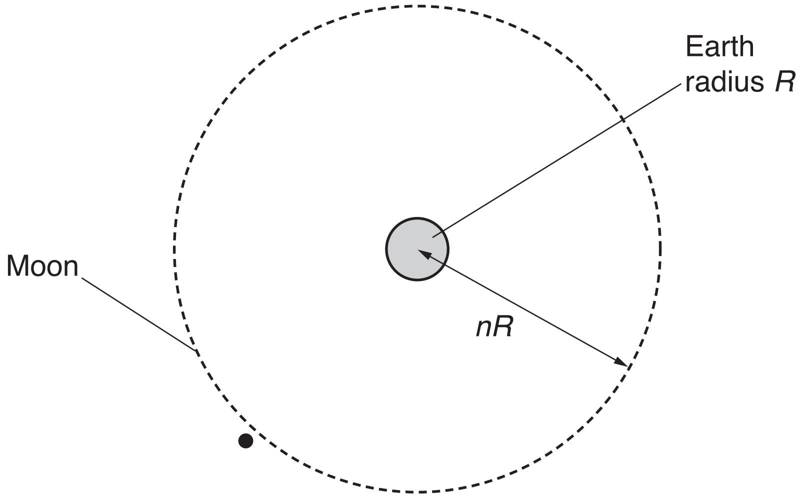


Fig. 1.1

The Moon makes one complete orbit of the Earth in time T.
Show that the mean density ρ of the Earth is given by the expression

$$\rho = \frac{3\pi n^3}{GT^2}.$$

[4]

(c) The radius R of the Earth is 6.38×10^3 km and the distance between the centre of the Earth and the centre of the Moon is 3.84×10^5 km.
The period T of the orbit of the Moon about the Earth is 27.3 days.
Use the expression in **(b)** to calculate ρ.

ρ = ... $kg\,m^{-3}$ [3]

[Total: 9]

2 A bar magnet of mass 180 g is suspended from the free end of a spring, as illustrated in Fig. 2.1.

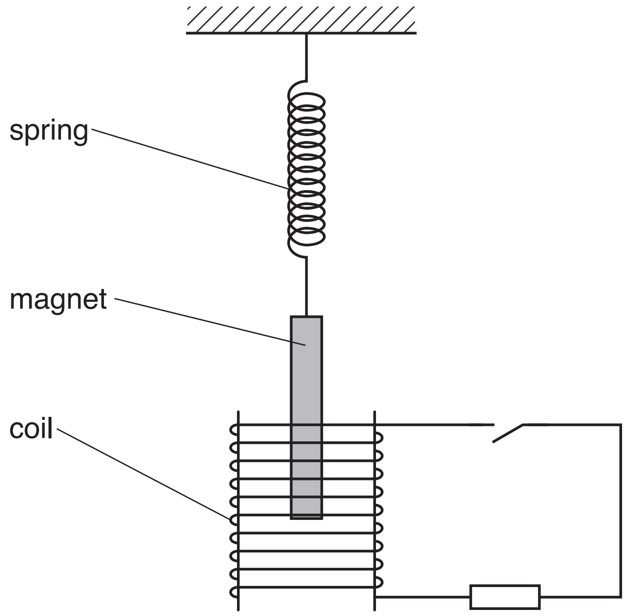


Fig. 2.1

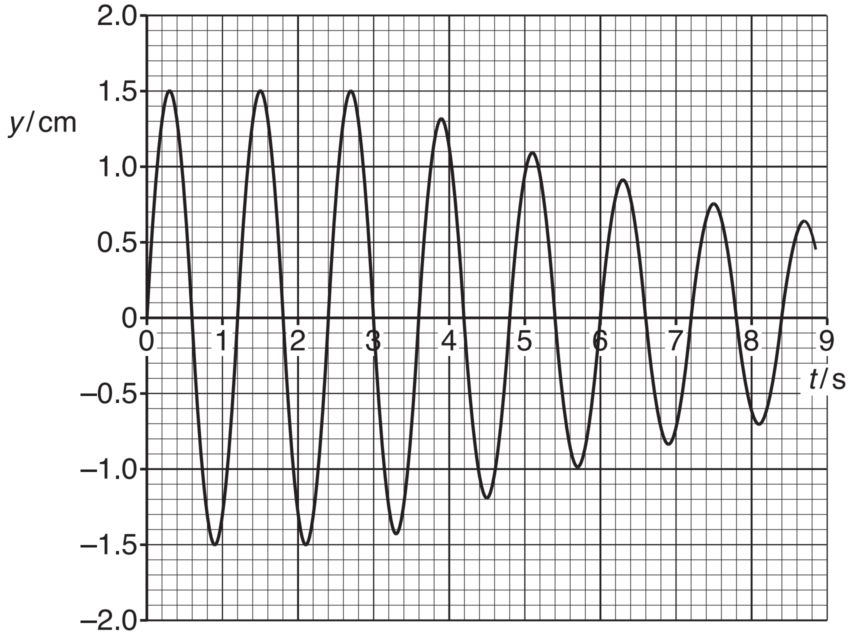
The magnet hangs so that one pole is near the centre of a coil of wire.

The coil is connected in series with a resistor and a switch. The switch is open.

The magnet is displaced vertically and then allowed to oscillate with one pole remaining inside the coil. The other pole remains outside the coil.

At time $t = 0$, the magnet is oscillating freely as it passes through its equilibrium position. At time $t = 3.0$ s, the switch in the circuit is closed.

The variation with time t of the vertical displacement y of the magnet is shown in Fig. 2.2.



(a) Determine, to two significant figures, the frequency of oscillation of the magnet.

frequency = ... Hz [2]

(b) State whether the closing of the switch gives rise to light, heavy or critical damping.

....[1]

(c) Calculate the change in the energy ΔE of oscillation of the magnet between time $t = 2.7$ s and time $t = 7.5$ s. Explain your working.

ΔE = ... J [6]

[Total: 9]

1 **(a)** Define *gravitational potential* at a point.

....

....

....[2]

(b) A rocket is launched from the surface of a planet and moves along a radial path, as shown in Fig. 1.1.

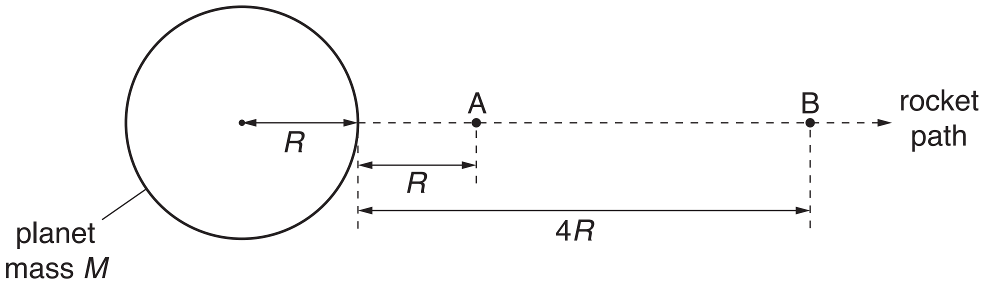


Fig. 1.1

The planet may be considered to be an isolated sphere of radius R with all of its mass M concentrated at its centre. Point A is a distance R from the surface of the planet. Point B is a distance $4R$ from the surface.

(i) Show that the difference in gravitational potential $\Delta\phi$ between points A and B is given by the expression

$$\Delta\phi = \frac{3GM}{10R}$$

where G is the gravitational constant.

[1]

(ii) The rocket motor is switched off at point A. During the journey from A to B, the rocket has a constant mass of 4.7×10^4 kg and its kinetic energy changes from 1.70 TJ to 0.88 TJ.

For the planet, the product *GM* is 4.0×10^{14} N m^2 kg^{-1}. It may be assumed that resistive forces to the motion of the rocket are negligible.

Use the expression in **(b)(i)** to determine the distance from A to B.

distance = ...m [3]

[Total: 6]

Question	Answer	Marks
1 (a)	gravitational force (of attraction between satellite and planet)	**1**
	provides / is centripetal force (on satellite about the planet)	**1**
1 (b)	$M = (4/3) \times \pi R3\rho$	**1**
	$\omega = 2\pi / T$ **or** $v = 2\pi nR / T$	**1**
	$GM / (nR)^2 = nR\omega^2$ **or** v^2 / nR	**1**
	substitution clear to give $\rho = 3\pi n^3 / GT^2$	**1**
1 (c)	$n = (3.84 \times 10^5) / (6.38 \times 10^3) = 60.19$ or 60.2	**1**
	$\rho = 3\pi \times 60.19^3 / [(6.67 \times 10^{-11}) \times (27.3 \times 24 \times 3600)^2]$	**1**
	$\rho = 5.54 \times 10^3$ kg m^{-3}	**1**
		Total: 9
2 (a)	e.g. period = 3 / 2.5	**1**
	frequency = 0.83 Hz	**1**
2 (b)	light (damping)	**1**
2 (c)	at 2.7 s, $A0 = 1.5$ (cm)	**1**
	energy = $\frac{1}{2} m \times 4\pi^2 f^2 A_0^2$	**1**
	$= \frac{1}{2} \times 0.18 \times 4\pi^2 \times 0.83^2 \times (1.5 \times 10^{-2})^2$ $= 5.51 \times 10^{-4}$ (J)	**1**
	at 7.5 s, $A_0 = 0.75$ (cm)	**1**
	energy = $\frac{1}{4} \times 5.51 \times 10^{-4}$ **or** energy = $\frac{1}{2} \times 0.18 \times 4\pi^2 \times 0.83^2 \times (0.75 \times 10^{-2})^2$	**1**
	energy = 1.38×10^{-4} (J) change = $(5.51 \times 10^{-4} - 1.38 \times 10^{-4}) = 4.13$ J	**1**
		Total: 9
1 (a)	work done per unit mass	**1**
	bringing (small test) mass from infinity (qto the point)	**1**
1 (b) (i)	$\Delta\phi = (GM / 2R) - (GM / 5R) = 3GM / 10R$	**1**
1 (b) (ii)	change in GPE = $(3 \times 4.0 \times 10^{14} / 10\ R) \times 4.7 \times 10^4$	**1**
	$(3 \times 4.0 \times 10^{14} / 10\ R) \times 4.7 \times 10^4 = (1.70 - 0.88) \times 10^{12}$ $R = 6.88 \times 10^6$	**1**
	distance = $3 \times 6.88 \times 10^6$ $= 2.1 \times 10^7$ m	**1**
		Total: 6

Notes about the mark scheme are available separately.

Cambridge Assessment International Education

Cambridge International AS & A Level

8: Thermodynamics – Topic questions

The questions in this document have been compiled from a number of past papers, as indicated in the table below.

Use these questions to formatively assess your learners' understanding of this topic.

Question	Year	Series	Paper number
4	2017	June	41
2	2017	March	42
2	2016	March	42

The mark scheme for each question is provided at the end of the document.

You can find the complete question papers and the complete mark schemes (with additional notes where available) on the School Support Hub at www.cambridgeinternational.org/support

4 **(a)** Describe the motion of molecules in a gas, according to the kinetic theory of gases.

....

....

....[2]

(b) Describe what is observed when viewing Brownian motion that provides evidence for your answer in **(a)**.

....

....

....[2]

(c) At a pressure of 1.05×10^5 Pa and a temperature of 27 °C, 1.00 mol of helium gas has a volume of $0.0240\,m^3$.
The mass of 1.00 mol of helium gas, assumed to be an ideal gas, is 4.00 g.

(i) Calculate the root-mean-square (r.m.s.) speed of an atom of helium gas for a temperature of 27 °C.

r.m.s. speed = ... $m\,s^{-1}$ [3]

(ii) Using your answer in **(i)**, calculate the r.m.s. speed of the atoms at 177 °C.

r.m.s. speed = ... $m\,s^{-1}$ [3]

[Total: 10]

2 **(a)** The first law of thermodynamics can be represented by the expression

$$\Delta U = q + w.$$

State what is meant by the symbols in the expression.

$+\Delta U$ ....

$+q$ ....

$+w$ ....
[2]

(b) A fixed mass of an ideal gas undergoes a cycle ABCA of changes, as shown in Fig. 2.1.

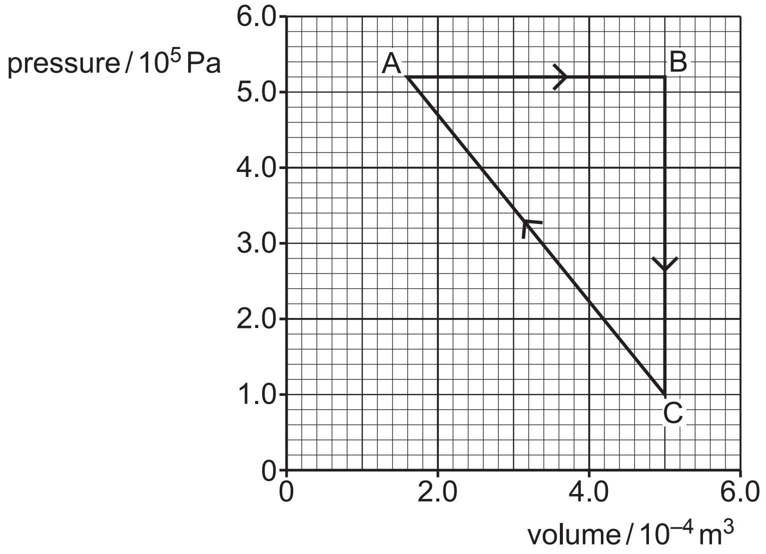


Fig. 2.1

(i) During the change from A to B, the energy supplied to the gas by heating is 442 J.

Use the first law of thermodynamics to show that the internal energy of the gas increases by 265 J.

[2]

(ii) During the change from B to C, the internal energy of the gas decreases by 313 J.

By considering molecular energy, state and explain qualitatively the change, if any, in the temperature of the gas.

....

....

....

....

....[3]

(iii) For the change from C to A, use the data in **(b)(i)** and **(b)(ii)** to calculate the change in internal energy.

change in internal energy = ... J [1]

(iv) The temperature of the gas at point A is 227 °C. Calculate the number of molecules in the fixed mass of the gas.

number = ...[2]

[Total: 10]

2 **(a)** State

(i) what is meant by *internal energy*,

....

....

.... [2]

(ii) the basic assumption of the kinetic theory of gases that leads to the conclusion that there is zero potential energy between the molecules of an ideal gas.

....

.... [1]

(b) The pressure p and volume V of an ideal gas are related by

$$pV = \frac{1}{3} Nm\langle c^2 \rangle$$

where N is the number of molecules, m is the mass of a molecule and $\langle c^2 \rangle$ is the mean-square speed of the molecules.

Use this equation to show that the mean kinetic energy $\langle E_K \rangle$ of a molecule is given by

$$\langle E_K \rangle = \frac{3}{2} kT$$

where k is the Boltzmann constant and T is the thermodynamic temperature.

[3]

(c) A cylinder contains 17 g of oxygen gas at a temperature of 12 °C. The mass of 1.0 mol of oxygen gas is 32 g. It may be assumed that the oxygen behaves as an ideal gas.

Calculate, for the oxygen gas in the cylinder,

(i) the mean kinetic energy of a molecule,

mean kinetic energy = ...J [2]

(ii) the number of molecules,

number = ...[2]

(iii) the total internal energy.

internal energy = ...J [1]

[Total: 11]

Question	Answer	Marks
4 (a)	random/haphazard	**1**
	constant velocity **or** speed in a straight line between collisions **or** distribution of speeds/different directions	**1**
4 (b)	(small) specks of light/bright specks/pollen grains/dust particles/smoke particles	**1**
	moving haphazardly/randomly/jerky/in a zigzag fashion	**1**
4 (c) (i)	$pV = ⅓ Nm\langle c^2 \rangle$ $1.05 \times 10^5 \times 0.0240 = ⅓ \times 4.00 \times 10^{-3} \times \langle c^2 \rangle$	**1**
	$\langle c2 \rangle = 1.89 \times 10^6$	**1**
	or	
	$½\, m\langle c^2 \rangle = (3 / 2)\, kT$ $0.5 \times (4.00 \times 10^{-3} / 6.02 \times 10^{23}) \times \langle c^2 \rangle = 1.5 \times 1.38 \times 10^{-23} \times 300$	**(1)**
	$\langle c^2 \rangle = 1.87 \times 10^6$	**(1)**
	or	
	$nRT = ⅓ Nm\langle c^2 \rangle$ $1.00 \times 8.31 \times 300 = ⅓ \times 4.00 \times 10^{-3} \times \langle c^2 \rangle$	**(1)**
	$\langle c^2 \rangle = 1.87 \times 10^6$	**(1)**
	$c_{r.m.s.} = 1.37 \times 10^3$ m s–1	**1**
4 (c) (ii)	$\langle c^2 \rangle \propto T$	**1**
	$\langle c^2 \rangle$ at 177 °C = $1.89 \times 10^6 \times (450 / 300)$	**1**
	$c_{r.m.s.}$ at 177 °C = 1.68×10^3 m s–1	**1**
		Total: 10
2 (a)	$+\Delta U$ increase in internal energy $+q$ heat (energy) transferred to the system / heating of system $+w$ work done on system	**1**
2 (b) (i)	$W = p\Delta V$ $= 5.2 \times 10^5 \times (5.0 – 1.6) \times 10^{-4}$ (=177 J)	**1**
	$\Delta U = q + w$ = 442 – 177 = 265 J	**1**
2 (b) (ii)	no (molecular) potential energy	**1**
	internal energy decreases so (total molecular) kinetic energy decreases	**1**
	(mean molecular) kinetic energy decreases so temperature decreases	**1**
2 (b) (iii)	ΔU + 265 – 313 = 0 ΔU = 48 J	**1**

Question	Answer	Marks
2 (b) (iv)	$pV = NkT$ or $pV = nRT$ and $N = nN_A$	**1**
	$5.2 \times 10^5 \times 1.6 \times 10^{-4} = N \times 1.38 \times 10^{-23} \times (273 + 227)$ *or* $5.2 \times 10^5 \times 1.6 \times 10^{-4} = n \times 8.31 \times (273 + 227)$ and $n = N / 6.02 \times 10^{23}$ $N = 1.2 \times 10^{22}$	**1**
		Total: 9
2 (a) (i)	sum of kinetic and potential energy of atoms/molecules	**1**
	reference to random (distribution)	**1**
2 (a) (ii)	no forces (of attraction or repulsion) between molecules	**1**
2 (b)	$pV = NkT$ or $pV = nRT$ and $R = kN_A$, $n = N / N_A$	**1**
	$⅓ Nm \langle c^2 \rangle = NkT$ or $⅓ Nm \langle c^2 \rangle = kT$	**1**
	$\langle E_K \rangle = ½ m \langle c^2 \rangle$ <u>so</u> $\langle E_K \rangle = 3/2\ kT$	**1**
2 (c) (i)	$\langle E_K \rangle = 3/2 \times 1.38 \times 10^{-23} \times (273 + 12)$	**1**
	$= 5.9\ (5.90) \times 10^{-21}$ J	**1**
	(use of T = 12 K not T = 285 K scores 0 / 2)	
2 (c) (ii)	number $= (17 / 32) \times 6.02 \times 10^{23}$	**1**
	$= 3.2\ (3.20) \times 10^{23}$	**1**
2 (c) (iii)	internal energy $= 5.9 \times 10^{-21} \times 3.2 \times 10^{23}$ $= 1900\ (1890)$ J	**1**
		Total: 11

Notes about the mark scheme are available separately.

9: Electricity and electronics – Topic questions

The questions in this document have been compiled from a number of past papers, as indicated in the table below.

Use these questions to formatively assess your learners' understanding of this topic.

Question	Year	Series	Paper number
3	2017	June	41
5	2017	June	41
6	2017	June	41

The mark scheme for each question is provided at the end of the document.

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3 The digital transmission of speech may be illustrated using the block diagram of Fig. 3.1.

Fig. 3.1

(a) (i) State what is meant by a *digital signal*.

....

....[1]

(ii) State the names of the components labelled X and Y on Fig. 3.1.

X: ....

Y: ....
[2]

(iii) Describe the function of the ADC.

....

....

....[2]

(b) The optic fibre has length 84 km and the attenuation per unit length in the fibre is 0.19 dB km^{-1}.

The input power to the optic fibre is 9.7 mW. At the output from the optic fibre, the signal-to-noise ratio is 28 dB.

Calculate

(i) in dB, the ratio

$$\frac{\text{input power to optic fibre}}{\text{noise power at output of optic fibre}},$$

ratio = ... dB [2]

(ii) the noise power at the output of the optic fibre.

noise power = ... W [3]

[Total: 10]

5 An α-particle is travelling in a vacuum towards the centre of a gold nucleus, as illustrated in Fig. 5.1.

Fig. 5.1

The gold nucleus has charge 79*e*.
The gold nucleus and the α-particle may be assumed to behave as point charges.
At a large distance from the gold nucleus, the α-particle has energy 7.7×10^{-13} J.

(a) The α-particle does not collide with the gold nucleus. Show that the radius of the gold nucleus must be less than 4.7×10^{-14} m.

[3]

(b) Determine the acceleration of the α-particle for a separation of 4.7×10^{-14} m between the centres of the gold nucleus and of the α-particle.

acceleration = ... $m\,s^{-2}$ [3]

(c) In an α-particle scattering experiment, the beam of α-particles is incident on a very thin gold foil.
Suggest why the gold foil must be very thin.

....

....[1]

[Total: 7]

6 A comparator circuit is designed to switch on a mains lamp when the ambient light level reaches a set value.
An incomplete diagram of the circuit is shown in Fig. 6.1.

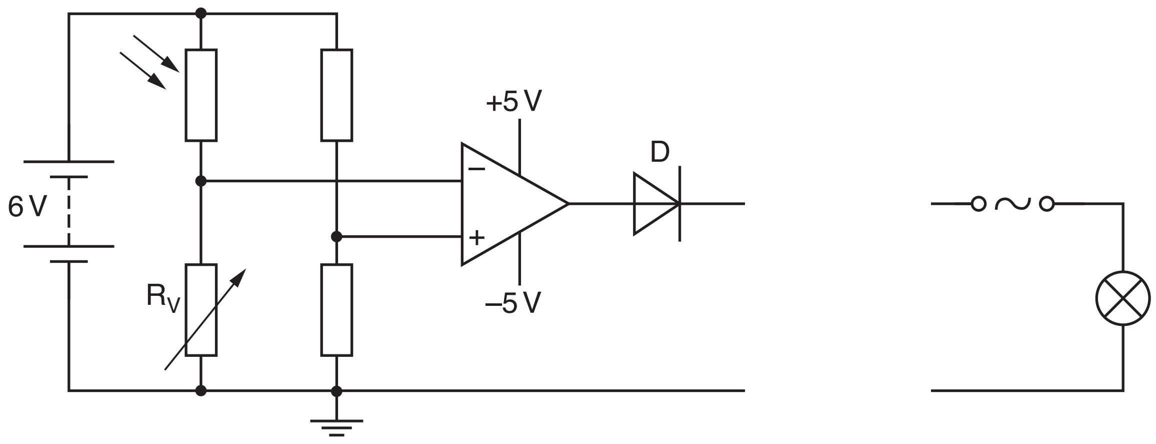

Fig. 6.1

(a) **(i)** A relay is required as part of the output device. This is not shown in Fig. 6.1. Explain why a relay is required.

....

....

....[2]

(ii) On Fig. 6.1, draw the symbol for a relay connected in the circuit as part of the output device. [2]

(b) Describe the function of

(i) the variable resistor R_V,

....

....[1]

(ii) the diode D.

....

....[1]

(c) State whether the lamp will switch on as the light level increases or as it decreases. Explain your answer.

....

....

....

....

....[3]

[Total: 9]

Question	Answer	Marks
3 (a) (i)	signal consists of (a series of) 1s and 0s **or** offs and ons **or** highs and lows	**1**
3 (a) (ii)	component X: parallel-to-serial converter	**1**
	component Y: DAC/digital-to-analogue converter	**1**
3 (a) (iii)	sample the (analogue) signal	**1**
	at regular intervals and converts the analogue number to a digital number	**1**
3 (b) (i)	attenuation in fibre = 84 × 0.19 (= 16 dB)	**1**
	ratio = 16 + 28 = 44 dB	**1**
3 (b) (ii)	ratio / dB = 10 lg (P_2 / P_1)	**1**
	44 = 10 lg ({9.7 × 10_{-3}} / *P*) **or** –44 = 10 lg (*P* / {9.7 × 10_{-3}})	**1**
	power = 3.9 × 10^{-7} W	**1**
		Total: 10
5 (a)	(loss in) kinetic energy of ⟨-particle = $Qq / 4\square\Sigma_0 r$ **or** 7.7 × 10^{-13} = $Qq / 4\pi\varepsilon_0 r$	**1**
	7.7 × 10^{-13} = 8.99 × 10^9 × 79 × 2 × (1.60 × $10^{-19})^2$ / *r*	**1**
	r = 4.7 × 10^{-14} m *r* is closest distance of approach so radius less than this	**1**
5 (b)	force = $Qq / 4\pi\varepsilon_0 r^2$ = 4u × *a*	**1**
	8.99 × 10^9 × 79 × 2 × (1.60 × $10^{-19})^2$ / (4.7 × $10^{-14})^2$ = 4 × 1.66 × 10^{-27} × *a*	**1**
	a = 2.5 × 10^{27} m s^{-2}	**1**
5 (c)	so that single interactions between nucleus and ⟨-particle can be studied **or** so that multiple deflections with nucleus do not occur	**1**
		Total: 7

Question	Answer	Marks
6 (a) (i)	lamp needs 'high' power/'large' current/'large' voltage	**1**
	op-amp can deliver only a small current/small voltage	**1**
6 (a) (ii)	correct symbol for relay coil connected between output and earth	**1**
	switch between mains supply and lamp	**1**
6 (b) (i)	vary light intensity at which lamp is switched on/off	**1**
6 (b) (ii)	so that relay operates for only one current/voltage direction **or** so that relay/lamp operates for either dark or light conditions	**1**
6 (c)	when light level increases, LDR resistance decreases	**1**
	(R_{LDR} low,) so $V^- > V^+$, so V_{OUT} negative/–5 V (must be consistent with previous mark)	**1**
	OR	
	when light level decreases, LDR resistance increases	**(1)**
	(R_{LDR} high,) so $V^- < V^+$, so V_{OUT} is positive/+5 V (must be consistent with previous mark)	**(1)**
	lamp comes on as light level decreases **or** lamp goes off as light level increases	**1**
		Total: 9

Notes about the mark scheme are available separately.

10: Electromagnetism – Topic questions

The questions in this document have been compiled from a number of past papers, as indicated in the table below.

Use these questions to formatively assess your learners' understanding of this topic.

Question	Year	Series	Paper number
7	2017	June	41
8	2017	June	41
9	2017	June	41

The mark scheme for each question is provided at the end of the document.

You can find the complete question papers and the complete mark schemes (with additional notes where available) on the School Support Hub at www.cambridgeinternational.org/support

7 An electron having charge $-q$ and mass m is accelerated from rest in a vacuum through a potential difference V.
The electron then enters a region of uniform magnetic field of magnetic flux density B, as shown in Fig. 7.1.

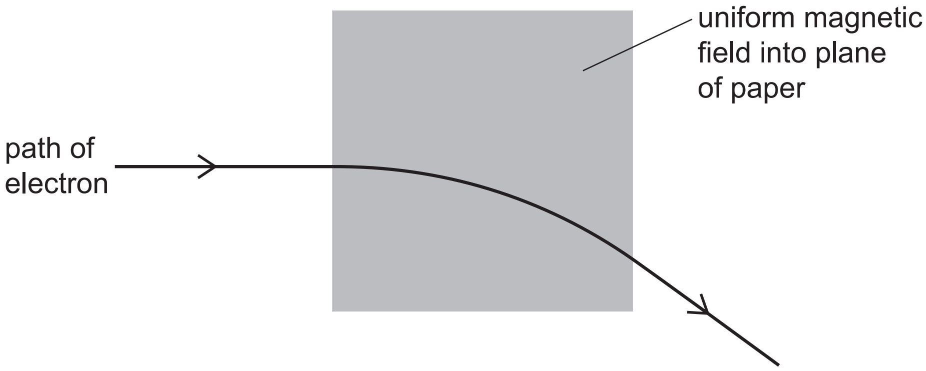

Fig. 7.1

The direction of the uniform magnetic field is into the plane of the paper.
The velocity of the electron as it enters the magnetic field is normal to the magnetic field.
The radius of the circular path of the electron in the magnetic field is r.

(a) Explain why the path of the electron in the magnetic field is the arc of a circle.

....

....

....

....[3]

(b) Show that the magnitude p of the momentum of the electron as it enters the magnetic field is given by

$$p = \sqrt{(2mqV)}.$$

[2]

(c) The potential difference V is 120 V. The radius r of the circular arc is 7.4 cm.

Determine the magnitude B of the magnetic flux density.

B = ... T [3]

(d) The potential difference V in **(c)** is increased. The magnetic flux density B remains unchanged.

By reference to the momentum of the electron, explain the effect of this increase on the radius r of the path of the electron in the magnetic field.

....

....

....[2]

[Total: 10]

8 Explain the main principles behind the use of nuclear magnetic resonance imaging (NMRI) to obtain information about internal body structures.

....

....

....

....

....

....

....

....

....

....

....

....

....

....[8]

[Total: 8]

9 A simple transformer is illustrated in Fig. 9.1.

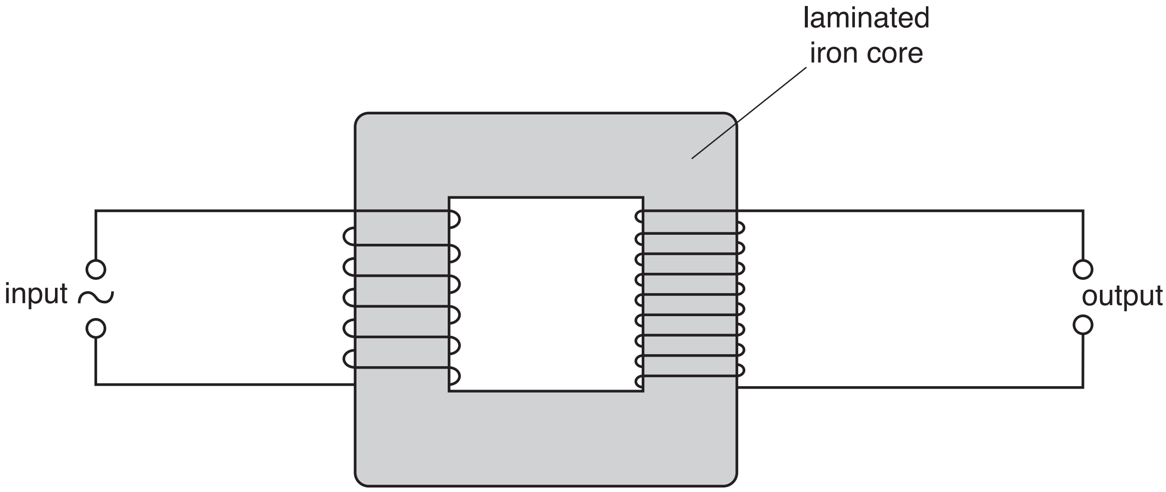

Fig. 9.1

(a) **(i)** State why the transformer has an iron core, rather than having no core.

....

....[1]

(ii) Explain why the core is laminated.

....

....

....[2]

(b) By reference to the action of a transformer, explain why the input to the transformer is an alternating voltage, rather than a constant voltage.

....

....

....

....

....[3]

[Total: 6]

Question	Answer	Marks
7 (a)	(magnetic) force (always) normal to velocity/direction of motion	**1**
	(magnitude of magnetic) force constant **or** speed is constant/kinetic energy is constant	**1**
	so provides the centripetal force	**1**
7 (b)	increase in KE = loss in PE **or** $\frac{1}{2} mv^2 = qV$	**1**
	$p = mv$ with algebra leading to $p = \sqrt{(2mqV)}$	**1**
7 (c)	$Bqv = mv^2 / r$ $mv = Bqr$ **or** $p = Bqr$	**1**
	$(2 \times 9.11 \times 10^{-31} \times 1.60 \times 10^{-19} \times 120)^{1/2} = B \times 1.60 \times 10^{-19} \times 0.074$	**1**
	$B = 5.0 \times 10^{-4}$ T	**1**
7 (d)	greater momentum	**1**
	($p = Bqr$ and) so r increased	**1**
		Total: 10
8	strong (uniform) magnetic field	**1**
	* nuclei precess/rotate about field (direction)	
	radio frequency pulse/RF pulse (applied)	**1**
	* RF or pulse is at Larmor frequency / frequency of precession	
	causes resonance / excitation (of nuclei)/nuclei to absorb energy	**1**
	on relaxation/de-excitation, nuclei emit RF/pulse	**1**
	* (emitted) RF/pulse detected and processed	
	non-uniform field (superposed on uniform field)	**1**
	allows positions of (resonating) nuclei to be determined	**1**
	* allows for position of detection to be changed/different slices to be studied	
	*max. 2 of additional detail points marked **	**2**
		Total: 8

Question	Answer	Marks
9 (a) (i)	core reduces loss of (magnetic) flux linkage/improves flux linkage	**1**
9 (a) (ii)	reduces (size of eddy) currents in core	**1**
	(so that) heating of core is reduced	**1**
9 (b)	alternating voltage gives rise to changing magnetic flux in core	**1**
	(changing) flux links the secondary coil	**1**
	induced e.m.f. (in secondary) only when flux is changing/cut	**1**
		Total: 6

Notes about the mark scheme are available separately.

11: Quantum physics – Topic questions

The questions in this document have been compiled from a number of past papers, as indicated in the table below.

Use these questions to formatively assess your learners' understanding of this topic.

Question	Year	Series	Paper number
10	2017	June	41
11	2017	June	41
10	2017	March	42

The mark scheme for each question is provided at the end of the document.

You can find the complete question papers and the complete mark schemes (with additional notes where available) on the School Support Hub at www.cambridgeinternational.org/support

10 **(a)** State

(i) what is meant by the *hardness* of an X-ray beam,

....

....

....[2]

(ii) how the hardness of an X-ray beam from an X-ray tube is increased.

....

....[1]

(b) The same parallel beam of X-ray radiation is incident, separately, on samples of bone and of muscle.

Data for the thickness x of the samples of bone and of muscle, together with the linear attenuation (absorption) coefficients μ of the radiation in bone and in muscle, are given in Fig. 10.1.

	x / cm	μ / cm^{-1}
bone	1.5	2.9
muscle	4.0	0.95

Fig. 10.1

Determine the ratio

$$\frac{\text{intensity transmitted through bone}}{\text{intensity transmitted through muscle}}.$$

ratio = ... [2]

[Total: 5]

11 A beam of light consists of a continuous range of wavelengths from 420 nm to 740 nm.

The light passes through a cloud of cool gas, as shown in Fig. 11.1.

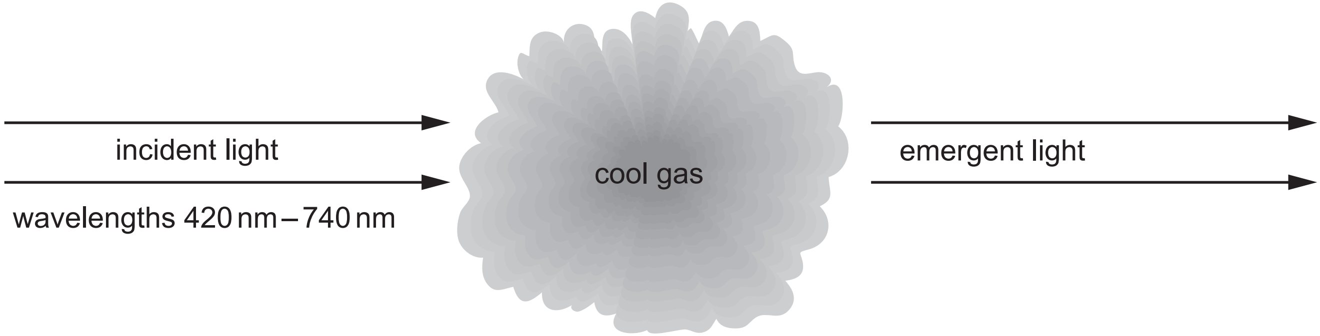

Fig. 11.1

(a) The spectrum of the light emerging from the cloud of cool gas is viewed using a diffraction grating.
Explain why this spectrum contains a number of dark lines.

....

....

....

....

....

....[4]

(b) Some of the electron energy levels of the atoms in the cloud of gas are represented in Fig. 11.2.

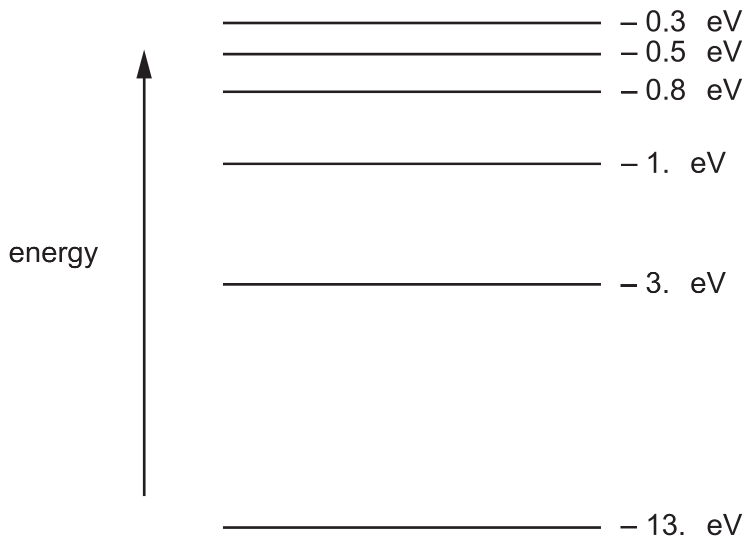

Fig. 11.2 (not to scale)

(i) Light of wavelength 420 nm has a photon energy of 2.96 eV.

Calculate the photon energy, in eV, of light of wavelength 740 nm.

photon energy = ... eV [2]

(ii) Use data from **(i)** and your answer in **(i)** to show, on Fig. 11.2, the changes in energy levels giving rise to the dark lines in **(a)**. [2]

[Total: 8]

10 **(a)** State what is meant by a *photon*.

....

....[2]

(b) Light in a beam has a continuous spectrum that lies within the visible region. The photons of light have energies ranging from 1.60 eV to 2.60 eV.

The beam passes through some hydrogen gas. It then passes through a diffraction grating and an absorption spectrum is observed.

(i) All of the light absorbed by the hydrogen is re-emitted. Explain why dark lines are still observed in the absorption spectrum.

....

....[1]

(ii) Some of the energy levels of an electron in a hydrogen atom are illustrated in Fig. 10.1.

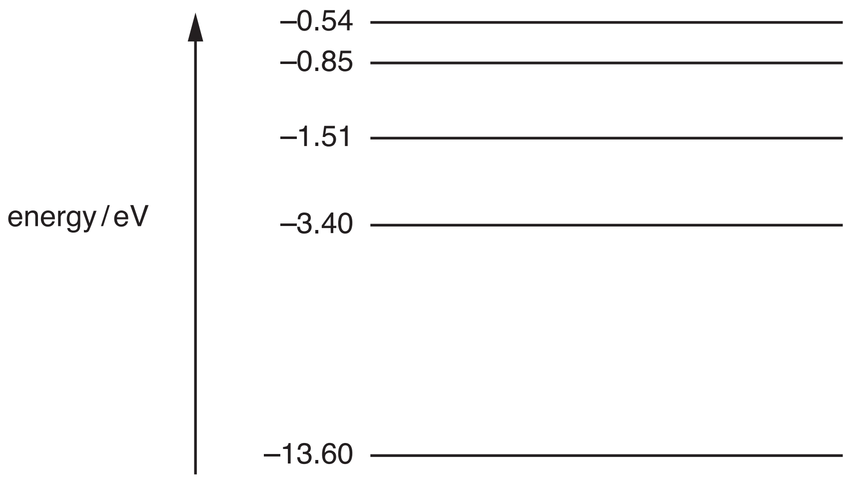

Fig. 10.1 (not to scale)

The dark lines in the absorption spectrum are the result of electron transitions between energy levels.

On Fig. 10.1, draw arrows to show the initial electron transitions between energy levels that could give rise to dark lines in the absorption spectrum. [2]

(iii) Calculate the shortest wavelength of the light in the beam.

wavelength = ... m [3]

[Total: 8]

Question	Answer	Marks
10 (a) (i)	penetration of beam	**1**
	greater hardness means greater penetration/shorter wavelength/higher frequency/higher photon energy	**1**
	so provides the centripetal force	**1**
10 (a) (ii)	greater accelerating potential difference **or** greater p.d. between anode and cathode	**1**
10 (b)	$I = I_0 \exp(-\mu x)$ ratio = (exp {–1.5 × 2.9}) / (exp {–4.0 × 0.95}) (= exp {–0.55})	**1**
	= 0.58	**1**
		Total: 6
11 (a)	electrons (in gas atoms/molecules) interact with photons	**1**
	photon energy causes electron to move to higher energy level/to be excited	**1**
	photon energy = difference in energy of (electron) energy levels	**1**
	when electrons de-excite, photons emitted in all directions (so dark line)	**1**
11 (b) (i)	photon energy ∝ 1 / λ	**1**
	energy = 1.68 eV	**1**
	or	
	$E = hc / \lambda$ $E = 6.63 \times 10^{-34} \times 3.0 \times 10^{8} / (740 \times 10^{-9})$ = 2.688 × 10–19 J	**(1)**
	energy = 1.68 eV	**(1)**
11 (b) (ii)	3.4 eV → 1.5 eV 3.4 eV → 0.85 eV 3.4 eV → 0.54 eV *all correct and none incorrect 2/2* *2 correct and 1 incorrect or only 2 correctly drawn 1/2*	**2**
		Total: 8

Question	Answer	Marks
10 (a)	packet / quantum of energy	**1**
	of electromagnetic radiation	**1**
10 (b) (i)	light is re-emitted in all directions / only part of the re-emitted light is in the direction of the beam	**1**
10 (b) (ii)	an arrow between –3.40 eV and –1.51 eV and an arrow between –3.40 eV and –0.85 eV	**1**
	all arrows shown point 'upwards'	**1**
10 (b) (iii)	$E = hc / \lambda$ *or* $E = hf$ and $c = f\lambda$	**1**
	$2.60 \times 1.60 \times 10^{-19} = (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / \lambda$	**1**
	$\lambda = 4.8 \times 10^{-7}$ m	**1**
		Total: 8

Notes about the mark scheme are available separately.

12: Nuclear physics – Topic questions

The questions in this document have been compiled from a number of past papers, as indicated in the table below.

Use these questions to formatively assess your learners' understanding of this topic.

Question	Year	Series	Paper number
12	2017	June	41
12	2017	March	42
13	2016	March	42

The mark scheme for each question is provided at the end of the document.

You can find the complete question papers and the complete mark schemes (with additional notes where available) on the School Support Hub at www.cambridgeinternational.org/support

12 One possible nuclear reaction that takes place in a nuclear reactor is given by the equation

$$^{235}_{92}\text{U} + ^{1}_{0}\text{n} \rightarrow ^{95}_{42}\text{Mo} + ^{139}_{57}\text{La} + 2^{1}_{0}\text{n} + x\,^{0}_{-1}\text{e}$$

Data for the nuclei and particles are given in Fig. 12.1.

nucleus or particle	mass / u
$^{235}_{92}\text{U}$	235.123
$^{95}_{42}\text{Mo}$	94.945
$^{139}_{57}\text{La}$	138.955
$^{1}_{0}\text{n}$	1.00863
$^{0}_{-1}\text{e}$	5.49×10^{-4}

Fig. 12.1

(a) Determine, for this nuclear reaction, the value of *x*.

x = ...[1]

(b) **(i)** Show that the energy equivalent to 1.00 u is 934 MeV.

[3]

(ii) Calculate the energy, in MeV, released in this reaction. Give your answer to three significant figures.

energy = ... MeV [3]

(c) Suggest the forms of energy into which the energy calculated in **(b)(ii)** is transformed.

....

....

....

....[2]

[Total: 9]

12 **(a)** Define the *binding energy* of a nucleus.

....

....

....[2]

(b) A stationary nucleus of uranium-238 ($^{238}_{92}U$) decays to form a nucleus of thorium-234 ($^{234}_{90}Th$). An α-particle and a gamma-ray photon are emitted. The equation representing the decay is

$$^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He + {}^{0}_{0}\gamma$$

The masses of the nuclei are given in Fig. 12.1.

nucleus	mass / u
uranium-238	238.05076
thorium-234	234.04357
helium-4	4.00260

Fig. 12.1

(i) State the relationship between the binding energies of the nuclei that is consistent with this reaction being energetically possible.

....

....[1]

(ii) Calculate, for this reaction,

1. the change, in u, of the mass,

change of mass = ...u [1]

2. the total energy, in J, released.

energy = ...J [2]

(iii) State and explain whether the energy of the gamma-ray photon is equal to the energy released in the reaction.

....

....

....[2]

[Total: 8]

13 Beryllium-7 ($^{7}_{4}Be$) is produced in the upper atmosphere and then sinks down onto the Earth's surface. Nuclei of beryllium-7 decay with a half-life of 53.3 days to form stable nuclei.

The activity of a sample of beryllium-7 on a tree leaf is 39 mBq.

(a) Show that the decay constant of beryllium-7 is $1.5 \times 10^{-7}\,s^{-1}$.

[1]

(b) Determine the mass of the beryllium-7 on the leaf.

mass = ... kg [3]

(c) The leaf is covered so that no further beryllium-7 is added to the existing sample from the atmosphere.

Calculate the time that must elapse before the activity of the sample is reduced to 2.0 mBq.

time = ... s [2]

[Total: 6]

Question	Answer	Marks
12 (a)	$x = 7$	**1**
12 (b) (i)	$E = mc^2$	**1**
	$= 1.66 \times 10^{-27} \times (3.0 \times 10^8)^2$ $= 1.494 \times 10^{-10}$ J	**1**
	division by 1.6×10^{-13} clear to give 934 MeV	**1**
12 (b) (ii)	$\Delta m = (235.123 + 1.00863) - (94.945 + 138.955 + 2 \times 1.00863 + 7 \times 5.49 \times 10^{-4})$ **or** $\Delta m = 235.123 - (94.945 + 138.955 + 1 \times 1.00863 + 7 \times 5.49 \times 10^{-4})$	**1**
	= 0.21053 u	**1**
	energy = 0.21053 × 934 = 197 MeV	**1**
12 (c)	kinetic energy of nuclei/particles/products/fragments	**1**
	γ–ray photon energy	**1**
		Total: 9
12 (a)	*either*	
	(minimum) energy required / work done to separate the nucleons (in a nucleus)	**1**
	to infinity	**1**
	or	
	energy released when nucleons come together (to form a nucleus)	**(1)**
	from infinity	**(1)**
12 (b) (i)	(total) binding energy of thorium and helium (nuclei) greater than binding energy of uranium (nucleus)	**1**
12 (b) (ii)1	change in mass = 238.05076 – (234.04357 + 4.00260) = 4.59×10^{-3} u	**1**
12 (b) (ii)2	*either*	
	$E = mc^2$ $= 4.59 \times 10^{-3} \times 1.66 \times 10^{-27} \times (3.00 \times 10^8)^2$	**1**
	$= 6.9 \times 10^{-13}$J	**1**
	or	
	1u = 931 MeV $E = 4.59 \times 10^{-3} \times 931 \times 10^6 \times 1.6 \times 10^{-19}$	**(1)**
	$= 6.8 \times 10^{-13}$J	**(1)**
12 (b) (iii)	Th nucleus / He nucleus / product nucleus has kinetic energy	**1**
	energy of gamma photon must be less than energy released	**1**
		Total: 8

Question	Answer	Marks
13 (a)	λ = ln2 / $T_{½}$ = ln2 / (53.3 × 24 × 60 × 60) =1.5 × 10^{-7} s^{-1}	**1**
13 (b)	A = λN	**1**
	N = 39 × 10^{-3} / 1.5 × 10^{-7} = 2.6 ×10^{5} m = (2.6 × 10^{5} / 6.0 × 10^{23}) × 7 × 10^{-3} or 2.6 × 10^{5} × 1.66 × 10^{-27} × 7	**1**
	= 3.0 × 10^{-21}kg	**1**
13 (c)	2 / 39 = exp (–1.5 × 10^{-7} × t) or 2 / 39 = (1 / 2)$^{[t / (53.3 \times 24 \times 3600)]}$	**1**
	t = 2.0 × 10^{7} s	**1**
		Total: 6

Notes about the mark scheme are available separately.