Cambridge Assessment International Education

Interactive

Interactive Example Candidate Responses
Paper 2 (May/June 2016), Question 1
Cambridge International AS & A Level
Physics 9702

Version 1.0

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HIGH MIDDLE LOW

Answer **all** the questions in the spaces provided.

1 (a) Define *acceleration*.

rate of change of velocity

....[1]

(b) A man travels on a toboggan down a slope covered with snow from point A to point B and then to point C. The path is illustrated in Fig. 1.1.

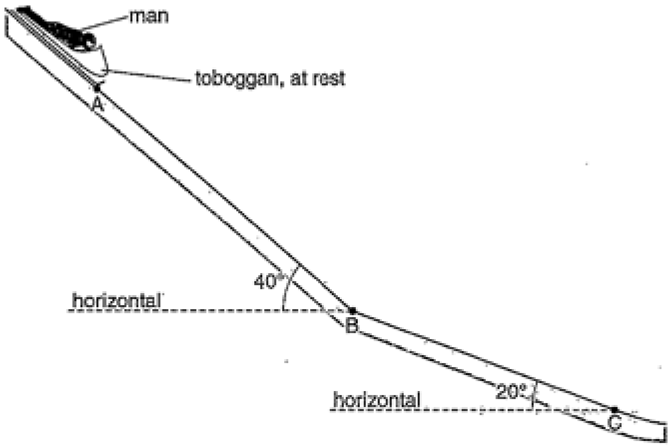

Fig. 1.1 (not to scale)

The slope AB makes an angle of 40° with the horizontal and the slope BC makes an angle of 20° with the horizontal. Friction is not negligible.

The man and toboggan have a combined mass of 95 kg.

The man starts from rest at A and has constant acceleration between A and B. The man takes 19 s to reach B. His speed is 36 m s^{-1} at B.

(i) Calculate the acceleration from A to B.

~~$v^2 = u^2 + 2as$~~
~~$36^2 = 0 + 2a(19)$~~
~~$a = 34$~~

$v = u + at$
$36 = a(19)$
$a = 1.9$

acceleration = ~~34~~ 1.9 m s^{-2} [2]

(ii) Show that the distance moved from A to B is 340 m.

$v^2 = u^2 + 2as$
$36^2 = 2(1.9)s$
$s = 342$
≈ 340 m

[1]

Your Mark

1(a)

1(b)(i)

1(b)(ii)

1(b)(iii)

1(b)(iv)

1(b)(v)

Q1	Mark scheme
(a)	acceleration = change in velocity / time (taken) or rate of change of velocity B1 **[1]**
(b)(i)	$v = 0 + at$ or $v = at$ C1 (a = 36 / 19 =) 1.9 (1.8947) m s^{-2} A1 **[2]**
(b)(ii)	s = ½(u + v)t **or** s = v^2/ 2a **or** s = ½at^2 = ½ x 36 x 19 = 36^2 / (2 x 1.89) = ½ x 1.89 x 19^2 = 340 m (342 m / 343 m / 341 m) M1 **[1]**
(b)(iii)	1. (ΔKE =) ½ x 95 x (36)^2 C1 = 62 000 (61 560) J A1 [2] 2. (ΔPE =) 95 x 9.81 x 340 sin 40° or 95 x 9.81 x 218.5 C1 = 200 000 J A1 [2] **[4]**
(b)(iv)	work done (by frictional force) = ΔPE – ΔKE **or** work done = 200 000 – 62 000 (values from **1b(iii) 1.** and ***2.***) C1 (frictional force = 138 000 / 340 =) 410 (406) N [420 N if full figures used] A1 **[2]**
(b)(v)	–ma = mg sin 20° – f or ma = –mg sin 20° + f C1 –95 x 3.0 = 95 x 3.36 – f f = 600 (604) N **[2]**

EXAMINER COMMENTS

MARK SCHEME

(iii) For the man and toboggan moving from A to B, calculate

1. the change in kinetic energy,

$\frac{1}{2}mv^2$

$= \frac{1}{2}(95)(36^2)$

$\approx 62\,000$

$= 61560$

change in kinetic energy = ...62 000........ J [2]

2. the change in potential energy.

~~change in KE~~ = change in PE

= mgh

= 95 × 9.81 × 342

= 318727

≈ 319 000

change in potential energy = ...319 000........ J [2]

(iv) Use your answers in (iii) to determine the average frictional force that acts on the toboggan between A and B.

318727 − 61560

$= 257 \times 10^3$ J

W = Fs

$F = \frac{257 \times 10^3}{342}$

= 752

frictional force = ...750........ N [2]

(v) A parachute opens on the toboggan as it passes point B. There is a constant deceleration of $3.0\,\text{m}\,\text{s}^{-2}$ from B to C.

Calculate the frictional force that produces this deceleration between B and C.

F = ma

= 95 × −3

= −285

$F_f - F = ma$

$F_f = -285 + F$

= −285 − 750

= −1035

frictional force = ...1035........ N [2]

[Total: 12]

Your Mark

1(a)

1(b)(i)

1(b)(ii)

1(b)(iii)

1(b)(iv)

1(b)(v)

Q1	Mark scheme	
(a)	acceleration = change in velocity / time (taken) or rate of change of velocity B1	**[1]**
(b)(i)	$v = 0 + at$ or $v = at$ C1 (a = 36 / 19 =) 1.9 (1.8947) m s^{-2} A1	**[2]**
(b)(ii)	$s = ½(u + v)t$ **or** $s = v^2/ 2a$ **or** $s = ½at^2$ = ½ x 36 x 19 = 36^2 / (2 x 1.89) = ½ x 1.89 x 19^2 = 340 m (342 m / 343 m / 341 m) M1	**[1]**
(b)(iii)	1. (ΔKE =) ½ x 95 x $(36)^2$ C1 = 62 000 (61 560) J A1 [2] 2. (ΔPE =) 95 x 9.81 x 340 sin 40° or 95 x 9.81 x 218.5 C1 = 200 000 J A1 [2]	**[4]**
(b)(iv)	work done (by frictional force) = ΔPE – ΔKE **or** work done = 200 000 – 62 000 (values from **1b(iii) 1.** and ***2.***) C1 (frictional force = 138 000 / 340 =) 410 (406) N [420 N if full figures used] A1	**[2]**
(b)(v)	$-ma = mg \sin 20° - f$ or $ma = -mg \sin 20° + f$ C1 –95 x 3.0 = 95 x 3.36 – f f = 600 (604) N	**[2]**

Select page

HIGH MIDDLE LOW

Answer **all** the questions in the spaces provided.

1 (a) Define *acceleration*.

final velocity − initial velocity / time. ....[1]

(b) A man travels on a toboggan down a slope covered with snow from point A to point B and then to point C. The path is illustrated in Fig. 1.1.

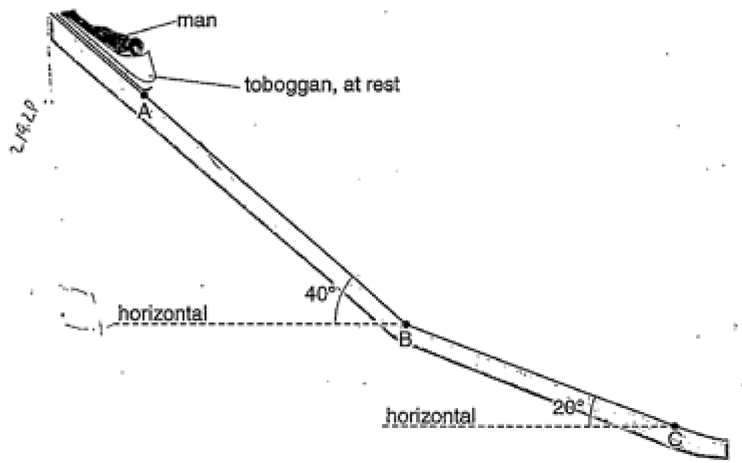

Fig. 1.1 (not to scale)

The slope AB makes an angle of 40° with the horizontal and the slope BC makes an angle of 20° with the horizontal. Friction is not negligible.

The man and toboggan have a combined mass of 95 kg.

The man starts from rest at A and has constant acceleration between A and B. The man takes 19 s to reach B. His speed is $36\,\mathrm{m\,s^{-1}}$ at B.

(i) Calculate the acceleration from A to B.

$a = \frac{36-0}{19}$

$a = \frac{36}{19}$

$a = 1.89$

acceleration = ...1.89.......... $\mathrm{m\,s^{-2}}$ [2]

(ii) Show that the distance moved from A to B is 340 m.

~~s×t = d~~ $s = ut + \frac{1}{2}at^2$

$s = \frac{1}{2}at^2$ $s = \frac{1}{2} \times 1.89 \times (19)^2$

$s = 341.145\ \mathrm{m}$

Your Mark

1(a)

1(b)(i)

1(b)(ii)

1(b)(iii)

1(b)(iv)

1(b)(v)

Q1	Mark scheme
(a)	acceleration = change in velocity / time (taken) or rate of change of velocity B1 **[1]**
(b)(i)	$v = 0 + at$ or $v = at$ C1 (a = 36 / 19 =) 1.9 (1.8947) m s^{-2} A1 **[2]**
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(b)(iii)	1. (ΔKE =) ½ x 95 x $(36)^2$ C1 = 62 000 (61 560) J A1 [2] 2. (ΔPE =) 95 x 9.81 x 340 sin 40° or 95 x 9.81 x 218.5 C1 = 200 000 J A1 [2] **[4]**
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(b)(v)	–ma = mg sin 20° – f or ma = –mg sin 20° + f C1 –95 x 3.0 = 95 x 3.36 – f f = 600 (604) N **[2]**

EXAMINER COMMENTS

MARK SCHEME

(iii) For the man and toboggan moving from A to B, calculate

1. the change in kinetic energy,

$E_K = \frac{1}{2} mv^2$ $v = \frac{d}{t}$ $v = \frac{341.145}{19}$

$E_K = \frac{1}{2} \times 95 \times 17.955$ $v = 17.955$

$E_K = 852.86$ J

change in kinetic energy = ... 852.86 .... J [2]

2. the change in potential energy.

$E_P = mgh$

$E_P = 95 \times 9.81 \times$ ... $341.45 \sin 40$

= 204274

95 × 9.81 × 340 sin 40

change in potential energy = ... 204274 .... J [2]

(iv) Use your answers in (iii) to determine the average frictional force that acts on the toboggan between A and B.

$E_P - E_K$ = friction force

204274 − 852.86

203421.79

2.03×10^5

frictional force = ... 2.03×10^5 .... N [2]

(v) A parachute opens on the toboggan as it passes point B. There is a constant deceleration of 3.0 m s^{-2} from B to C.

Calculate the frictional force that produces this deceleration between B and C.

$F = ma$ $F = 95 \times 3$

$F = 285$ N.

frictional force = ... 285 .... N [2]

[Total: 12]

Select page

HIGH | MIDDLE | LOW

Your Mark

1(a) ☐
1(b)(i) ☐
1(b)(ii) ☐
1(b)(iii) ☐
1(b)(iv) ☐
1(b)(v) ☐

Q1	Mark scheme
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(b)(v)	$-ma = mg \sin 20° - f$ or $ma = -mg \sin 20° + f$ C1 –95 x 3.0 = 95 x 3.36 – f f = 600 (604) N **[2]**

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH | MIDDLE | LOW

Answer **all** the questions in the spaces provided.

1 **(a)** Define *acceleration*.

acceleration = change in velocity (speed) / time taken

[1]

(b) A man travels on a toboggan down a slope covered with snow from point A to point B and then to point C. The path is illustrated in Fig. 1.1.

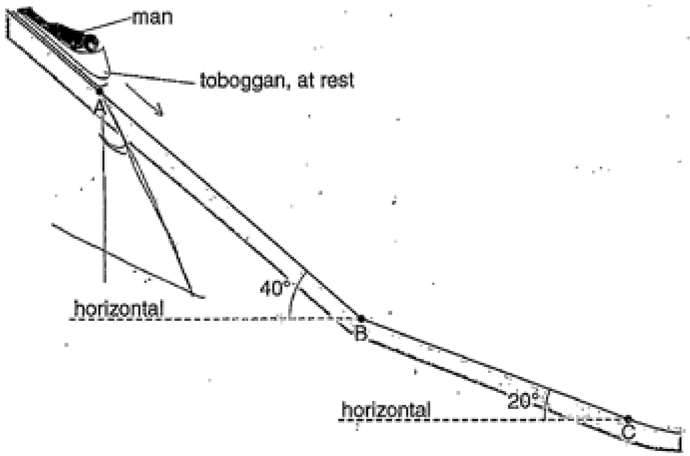

Fig. 1.1 (not to scale)

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The man and toboggan have a combined mass of 95 kg.

The man starts from rest at A and has constant acceleration between A and B. The man takes 19 s to reach B. His speed is 36 m s^{-1} at B.

(i) Calculate the acceleration from A to B.

$a = \frac{36}{19} \rightarrow 1.89$

acceleration = 1.89 m s^{-2} [2]

(ii) Show that the distance moved from A to B is 340 m.

$s = ut + \frac{1}{2}at^2$ $s = 0 + \frac{1}{2} \times 1.89 \times 19^2$

$= 341.145 \text{ m} \simeq 340 \text{ m}$

Your Mark

1(a)

1(b)(i)

1(b)(ii)

1(b)(iii)

1(b)(iv)

1(b)(v)

Q1	Mark scheme
(a)	acceleration = change in velocity / time (taken) or rate of change of velocity B1 **[1]**
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EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

(iii) For the man and toboggan moving from A to B, calculate

1. the change in kinetic energy,

$KE = \frac{1}{2}mv^2$

$= \frac{1}{2} \times 95 \times 30$

$= 1710$

change in kinetic energy = ...1710...... J [2]

2. the change in potential energy.

GPE = mgh

~~= 95 × 9.81 × h~~

~~= 95 × 9.81 × 219.8283~~

= 95 × 9.81 ×

~~sin 40° = 0 / 341.145 ∴ 0 = 341.145 sin 40° = 219.283~~

1710 = 95 × 9.81 × h

h = 1.83

GPE = 95 × 9.81 × 1.83 = 1705.47

change in potential energy = ...1705...... J [2]

(iv) Use your answers in **(iii)** to determine the average frictional force that acts on the toboggan between A and B.

~~F = ma~~ ~~WE~~ W = mg

= 95 × 9.81 → 931.95

frictional force = ... N [2]

(v) A parachute opens on the toboggan as it passes point B. There is a constant deceleration of 3.0 m s^{-2} from B to C.

Calculate the frictional force that produces this deceleration between B and C.

W − F = ma

W − F = 95 × 3.0

~~931.9~~

932 − F = 285

F = 1217

W = mg

= 95 × 9.81 → 931.95

frictional force = ...1217...... N [2]

[Total: 12]

Your Mark

1(a)

1(b)(i)

1(b)(ii)

1(b)(iii)

1(b)(iv)

1(b)(v)

Q1	Mark scheme		
(a)	acceleration = change in velocity / time (taken) or rate of change of velocity B1		[1]
(b)(i)	v = 0 + at or v = at (a = 36 / 19 =) 1.9 (1.8947) m s^{-2}	C1 A1	[2]
(b)(ii)	s = ½(u + v)t **or** s = v^2/ 2a **or** s = ½at^2 = ½ x 36 x 19 = 36^2 / (2 x 1.89) = ½ x 1.89 x 19^2 = 340 m (342 m / 343 m / 341 m)	M1	[1]
(b)(iii)	1. (ΔKE =) ½ x 95 x (36)^2 = 62 000 (61 560) J A1 2. (ΔPE =) 95 x 9.81 x 340 sin 40° or 95 x 9.81 x 218.5 = 200 000 J A1	C1 C1	 [2] [2] [4]
(b)(iv)	work done (by frictional force) = ΔPE – ΔKE **or** work done = 200 000 – 62 000 (values from **1b(iii) 1.** and ***2.***) C1 (frictional force = 138 000 / 340 =) 410 (406) N [420 N if full figures used]	 A1	[2]
(b)(v)	–ma = mg sin 20° – f or ma = –mg sin 20° + f –95 x 3.0 = 95 x 3.36 – f f = 600 (604) N	C1	[2]

EXAMINER COMMENTS

MARK SCHEME

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HIGH MIDDLE LOW

4 (a) By reference to the direction of the propagation of energy, state what is meant by a *longitudinal* wave and by a *transverse* wave.

longitudinal: Waves that travel parralel to direction of proporgation of energy.

transverse: Waves that travel at right angles to direction of proporgation of energy.

[2]

(b) The intensity of a sound wave passing through air is given by

$$I = Kv\rho f^2A^2$$

where I is the intensity (power per unit area),
K is a constant without units,
v is the speed of sound,
ρ is the density of air,
f is the frequency of the wave
and A is the amplitude of the wave.

Show that both sides of the equation have the same SI base units.

$I = \frac{P}{A}$ $P = \frac{F \times d}{t}$ → kg m s⁻² / kg m s⁻² ... kg m s⁻² × m s⁻¹, kg m² s⁻³ / m²

∴ I = kg s⁻³

$v\rho f^2 A^2$ → (m s⁻¹)(kg m⁻³) × (s⁻¹)² (m)²

→ kg m⁻² s⁻¹ × s⁻² × m²

→ kg s⁻³

∴ LHS = RHS

[3]

Your Mark

4(a)

4(b)

4(c)(i)

4(c)(ii)

4(d)

Q4	Mark scheme		
(a)	longitudinal: vibrations/oscillations (of the particles/wave) are parallel to the direction or in the same direction (of the propagation of energy)	B1	
	transverse: vibrations/oscillations (of the particles/wave) are perpendicular to the direction (of the propagation of energy)	B1	[2]
(b)	LHS: intensity = power / area units: kg m s^{-2} × m × s–1 × m^{-2} **or** kg m^2 s–3 × m–2	B1	
	RHS: units: m s^{-1} × kg m^{-3} × s^{-2} × m^2	M1	
	LHS and RHS both kg s^{-3}	A13	[3]
(c)(i)	change/difference in the observed/apparent frequency when the source is moving (relative to the observer)	B1	[1]
(c)(ii)	wavelength increases/frequency decreases/red shift	B1	[1]
(d)	observed frequency = $vf_S / (v - v_S)$	C1	
	550 = (340 × 510) / (340 – v_S)	C1	
	v_S = 25 (24.7) m s^{-1}	A1	[3]
			[Total: 10]

EXAMINER COMMENTS

MARK SCHEME

(c) (i) Describe the *Doppler effect.*

Where the observed frequency is different from the emitted frequency, when there is motion between the observer & source. [1]

(ii) A distant star is moving away from a stationary observer.

State the effect of the motion on the light observed from the star.

The light becomes less brighter since frequency decreases (observed). ~~and~~

[1]

(d) A car travels at a constant speed towards a stationary observer. The horn of the car sounds at a frequency of 510 Hz and the observer hears a frequency of 550 Hz. The speed of sound in air is 340 m s^{-1}.

Calculate the speed of the car.

$f_o = \frac{f_s \times v}{v - v_s}$

$550 = \frac{510 \times 330}{(330 - x)}$

$181{,}500 - 550x = 168{,}300$

$550x = 13{,}200$

$x = 24\ ms^{-1}$

speed = 24 ms^{-1} ms^{-1} [3]

[Total: 10]

Select page

HIGH | MIDDLE | LOW

Your Mark

4(a)

4(b)

4(c)(i)

4(c)(ii)

4(d)

Q4	Mark scheme		
(a)	longitudinal: vibrations/oscillations (of the particles/wave) are parallel to the direction or in the same direction (of the propagation of energy)	B1	
	transverse: vibrations/oscillations (of the particles/wave) are perpendicular to the direction (of the propagation of energy)	B1	**[2]**
(b)	LHS: intensity = power / area units: kg m s^{-2} × m × s–1 × m^{-2} **or** kg m^2 s–3 × m–2	B1	
	RHS: units: m s^{-1} × kg m^{-3} × s^{-2} × m^2	M1	
	LHS and RHS both kg s^{-3}	A13	**[3]**
(c)(i)	change/difference in the observed/apparent frequency when the source is moving (relative to the observer)	B1	**[1]**
(c)(ii)	wavelength increases/frequency decreases/red shift	B1	**[1]**
(d)	observed frequency = $vf_S / (v - v_S)$	C1	
	550 = (340 × 510) / (340 – v_S)	C1	
	v_S = 25 (24.7) m s^{-1}	A1	**[3]**
			[Total: 10]

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

4 (a) By reference to the direction of the propagation of energy, state what is meant by a *longitudinal* wave and by a *transverse* wave.

longitudinal: A wave in which the particle moves parallel to the propagation of energy is known as longitudinal wave.

transverse: A wave in which the particle of the motion moves perpendicular to the direction of motion is known as a transverse wave.

[2]

(b) The intensity of a sound wave passing through air is given by

$$I = Kv\rho f^2A^2$$

where I is the intensity (power per unit area),
K is a constant without units,
v is the speed of sound,
ρ is the density of air,
f is the frequency of the wave
and A is the amplitude of the wave.

mass/vol = kg m⁻³

Show that both sides of the equation have the same SI base units.

→ kg × ms⁻² × m / s = K × ms⁻¹ × kgm⁻³ × ...

kg × s⁻³ = K × ms⁻¹ × kgm⁻³ × s⁻² × m²

kg s⁻³ = K × m⁶ × kg × s⁻³

kg s⁻³ = K kg s⁻³

Hz = f = 1/T = s⁻¹

E = P × t

P = W/t

f × d ms⁻² = kg × a × m / s.

[3]

Your Mark	
4(a)	
4(b)	
4(c)(i)	
4(c)(ii)	
4(d)	

Q4	Mark scheme		
(a)	longitudinal: vibrations/oscillations (of the particles/wave) are parallel to the direction or in the same direction (of the propagation of energy)	B1	
	transverse: vibrations/oscillations (of the particles/wave) are perpendicular to the direction (of the propagation of energy)	B1	[2]
(b)	LHS: intensity = power / area units: kg m s^{-2} × m × s–1 × m^{-2} **or** kg m^2 s–3 × m–2	B1	
	RHS: units: m s^{-1} × kg m^{-3} × s^{-2} × m^2	M1	
	LHS and RHS both kg s^{-3}	A13	[3]
(c)(i)	change/difference in the observed/apparent frequency when the source is moving (relative to the observer)	B1	[1]
(c)(ii)	wavelength increases/frequency decreases/red shift	B1	[1]
(d)	observed frequency = $vf_S / (v - v_S)$	C1	
	550 = (340 × 510) / (340 – v_S)	C1	
	v_S = 25 (24.7) m s^{-1}	A1	[3]
			[Total: 10]

EXAMINER COMMENTS

MARK SCHEME

(c) (i) Describe the Doppler effect.

~~It~~ The observed frequency is always different to the frequency emmitted when source and sound are in a relative motion. [1]

(ii) A distant star is moving away from a stationary observer.

State the effect of the motion on the light observed from the star.

The wavelenght and the frequency has now been changed so the motion will also change. [1]

(d) A car travels at a constant speed towards a stationary observer. The horn of the car sounds at a frequency of 510 Hz and the observer hears a frequency of 550 Hz. The speed of sound in air is $340\,\text{m s}^{-1}$.

Calculate the speed of the car.

f = 510

$510 = 550 \times \left(\frac{340}{340 - V_{car}}\right)$

$0.927(340 - V_{car}) = 340$

$340 - V_{car} = 366.67$

$V_{car} = 26.67$

speed = ~~26~~ 26.67 m s^{-1} [3]

[Total: 10]

Select page

HIGH | MIDDLE | LOW

Your Mark

4(a)

4(b)

4(c)(i)

4(c)(ii)

4(d)

Q4	Mark scheme		
(a)	longitudinal: vibrations/oscillations (of the particles/wave) are parallel to the direction or in the same direction (of the propagation of energy)	B1	
	transverse: vibrations/oscillations (of the particles/wave) are perpendicular to the direction (of the propagation of energy)	B1	**[2]**
(b)	LHS: intensity = power / area units: kg m s^{-2} × m × s–1 × m^{-2} **or** kg m^2 s–3 × m–2	B1	
	RHS: units: m s^{-1} × kg m^{-3} × s^{-2} × m^2	M1	
	LHS and RHS both kg s^{-3}	A13	**[3]**
(c)(i)	change/difference in the <u>observed/apparent</u> frequency when the source is moving (relative to the observer)	B1	**[1]**
(c)(ii)	wavelength increases/frequency decreases/red shift	B1	**[1]**
(d)	observed frequency = $vf_S / (v - v_S)$	C1	
	$550 = (340 \times 510) / (340 - v_S)$	C1	
	$v_S = 25\ (24.7)\ \text{m s}^{-1}$	A1	**[3]**
			[Total: 10]

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH | MIDDLE | LOW

4 (a) By reference to the direction of the propagation of energy, state what is meant by a *longitudinal* wave and by a *transverse* wave.

longitudinal: The energy is ~~out~~ parallel to the direction of the propagation, such as a sound wave.

transverse: The energy is perpendicular to the direction of the propagation, such as in a guitar string.

[2]

(b) The intensity of a sound wave passing through air is given by

$$I = K v \rho f^2 A^2$$

where I is the intensity (power per unit area),
K is a constant without units,
v is the speed of sound,
ρ is the density of air,
f is the frequency of the wave
and A is the amplitude of the wave.

…w that both sides of the equation have the same SI base units.

power = f × d / t

– power = mad / t

= $kg\,ms^{-2}m / s$

= $kg\,m^2s^{-3} / t$

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

– v = ms^{-1}

– ρ = m/v = kg/m³ = $kg\,m^{-3}$

– f = s^{-3}

– A = m^2

I = ~~K~~ v ρ f² A²

$m^2s^{-4} = ms^{-1}\,kg\,m^{-3}\,s^{-3}\,m^2$

$kg\,s^{-4} = kg\,s^{-4}$

Thus proved

[3]

Your Mark

4(a)

4(b)

4(c)(i)

4(c)(ii)

4(d)

Examiner marks and comments

Mark	Comment
0/2	These definitions make no sense and do not describe the waves in the detail required.
0/3	Correct equation for power but mathematical error made in analysis. There is an apparent change in the frequency base units to make units on each side of the equation equal means that no credit can be awarded.
1/1	Clear description given.
1/1	Correct statement made.
2/3	Good presentation of equation and correct substitution of values. Mathematical error made in the third line hence incorrect final answer and loss of one mark.

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

(c) (i) Describe the *Doppler effect.*

The change in apparent frequency due to the ~~change in~~ movement of the source or observer [1]

(ii) A distant star is moving away from a stationary observer.

State the effect of the motion on the light observed from the star.

The apparent frequency would decrease [1]

(d) A car travels at a constant speed towards a stationary observer. The horn of the car sounds at a frequency of 510 Hz and the observer hears a frequency of 550 Hz. The speed of sound in air is 340 m s^{-1}.

Calculate the speed of the car.

$f_o = \left(\frac{V_w}{V_w - V_s}\right) f_s$

$550 = \left(\frac{340}{340 - V_s}\right) 510$

$40 = \frac{340}{340 - V_s}$

$340 = 13600 - 40V_s$

$-13260 = -40V_s$

$V_s = 331.5$

speed = 331.5 m s^{-1} [3]

[Total: 10]

Your Mark	
4(a)	
4(b)	
4(c)(i)	
4(c)(ii)	
4(d)	

Examiner marks and comments

Mark	Comment
0/2	These definitions make no sense and do not describe the waves in the detail required.
0/3	Correct equation for power but mathematical error made in analysis. There is an apparent change in the frequency base units to make units on each side of the equation equal means that no credit can be awarded.
1/1	Clear description given.
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2/3	Good presentation of equation and correct substitution of values. Mathematical error made in the third line hence incorrect final answer and loss of one mark.

EXAMINER COMMENTS

MARK SCHEME

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Cambridge Assessment International Education

Interactive

Interactive Example Candidate Responses
Paper 2 (May/June 2016), Question 5
Cambridge International AS & A Level
Physics 9702

Version 1.0

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Select page

HIGH MIDDLE LOW

5 (a) Light of a single wavelength is incident on a diffraction grating. Explain the part played by *diffraction* and *interference* in the production of the first order maximum by the diffraction grating.

diffraction: It is the spreading of waves through a narrow gap or opening.

interference: Interference is the overlapping of waves when they meet at a common point. These waves must be coherent, of the same type and polarised in the same plane.

[3]

(b) The diffraction grating illustrated in Fig. 5.1 is used with light of wavelength 486 nm.

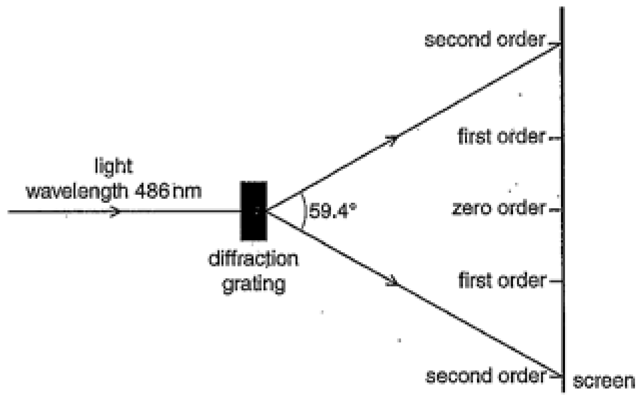

Fig. 5.1 (not to scale)

The orders of the maxima produced are shown on the screen in Fig. 5.1. The angle between the two second order maxima is 59.4°.

Calculate the number of lines per millimetre of the grating.

$\frac{59.4}{2} = 29.7°$

$d \sin\theta = n\lambda$

$d \sin 29.7° = 2(4.86 \times 10^{-7})$

$\therefore d = 1.96 \times 10^{-6}$ m

$d = \frac{1}{N}$

$1.96 \times 10^{-6} = \frac{1}{N}$

$\therefore N = 509731$ line (m)

$\therefore N = 509731140$ (mm)

number of lines per millimetre = 509731140 mm⁻¹ [3]

Your Mark

5(a)

5(b)

Q5	Mark scheme		
(a)	diffraction: spreading/diverging of waves/light (takes place) at (each) slit/element/gap/aperture	B1	
	interference: overlapping of waves (from coherent sources at each element)	B1	
	path difference λ/phase difference of 360(°)/2π (produces the first order)	B1	[3]
(b)	*d sinθ* = n*λ* **or** sinθ= Nnλ	C1	
	d = (2 × 486 × 10⁻⁹) / sin 29.7° (= 1.962 × 10⁻⁶)	C1	
	number of lines = 510 (509.7) mm⁻¹	A1	[3]
			[Total: 9]

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

5 **(a)** Light of a single wavelength is incident on a diffraction grating. Explain the part played by *diffraction* and *interference* in the production of the first order maximum by the diffraction grating.

diffraction: The wave experience a bending due to meeting an aperture or obstacle

interference: When two or more waves meet at a point, ~~the~~ the displacements add up, and there is a change in displacement.

[3]

(b) The diffraction grating illustrated in Fig. 5.1 is used with light of wavelength 486 nm.

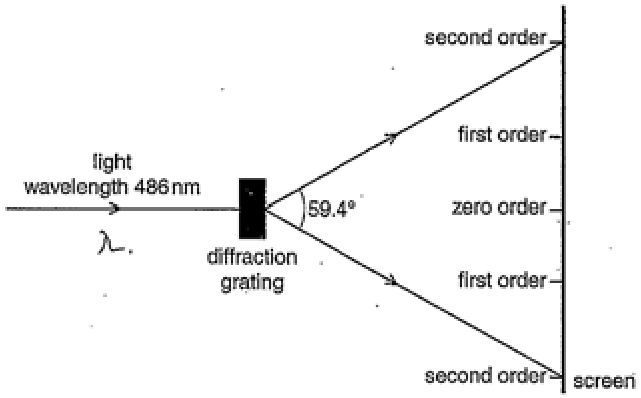

Fig. 5.1 (not to scale)

The orders of the maxima produced are shown on the screen in Fig. 5.1. The angle between the two second order maxima is 59.4°.

Calculate the number of lines per millimetre of the grating.

$D \sin\theta = n\lambda$

$D = \frac{2 \times 486 \times 10^{-9}}{\sin(\frac{59.4^\circ}{2})}$

$D =$ ~~1.13 × 10^-6~~ 1.96×10^{-6}

number of lines per millimetre = ... mm^{-1} [3]

Your Mark

5(a)

5(b)

Q5	Mark scheme		
(a)	diffraction: spreading/diverging of waves/light (takes place) at (each) slit/element/gap/aperture	B1	
	interference: overlapping of waves (from coherent sources at each element)	B1	
	path difference λ/phase difference of 360(°)/2π (produces the first order)	B1	[3]
(b)	$d \sin\theta = n\lambda$ **or** $\sin\theta = Nn\lambda$	C1	
	$d = (2 \times 486 \times 10^{-9}) / \sin 29.7^\circ$ (= 1.962×10^{-6})	C1	
	number of lines = 510 (509.7) mm^{-1}	A1	[3]
			[Total: 9]

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

5 (a) Light of a single wavelength is incident on a diffraction grating. Explain the part played by *diffraction* and *interference* in the production of the first order maximum by the diffraction grating.

diffraction: → This is when the light wave gets spreaded out or we can say when it bends on the edges.

interference: This is when the two waves meet at this point they may form a constructive interference or destructive interference.

[3]

(b) The diffraction grating illustrated in Fig. 5.1 is used with light of wavelength 486 nm.

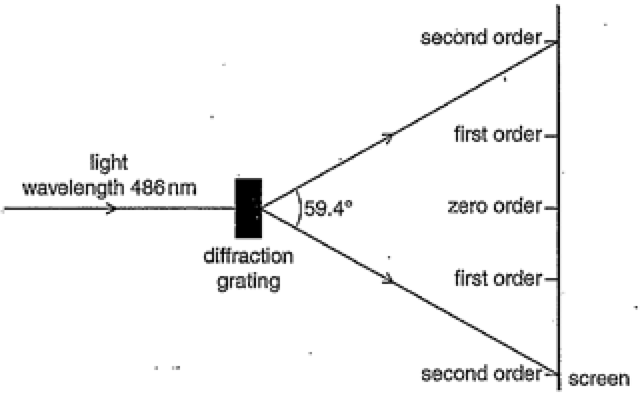

Fig. 5.1 (not to scale)

The orders of the maxima produced are shown on the screen in Fig. 5.1. The angle between the two second order maxima is 59.4°.

Calculate the number of lines per millimetre of the grating. $\lambda = 486$

$d \sin\theta = n\lambda$

$d \sin 59.4 = 2 \times 486$

$d = 1129.3$ $\qquad \frac{1}{1129.3} = 8.85 \times 10^{-4}$

number of lines per millimetre = 8.85×10^{-4} mm⁻¹ [3]

Your Mark

5(a)

5(b)

Q5	Mark scheme		
(a)	diffraction: spreading/diverging of waves/light (takes place) at (each) slit/element/gap/aperture	B1	
	interference: overlapping of waves (from coherent sources at each element)	B1	
	path difference λ/phase difference of 360(°)/2π (produces the first order)	B1	[3]
(b)	*d sinθ* = nλ **or** sinθ = Nnλ	C1	
	d = (2 × 486 × 10^{-9}) / sin 29.7° (= 1.962 × 10^{-6})	C1	
	number of lines = 510 (509.7) mm^{-1}	A1	[3]
			[Total: 9]

EXAMINER COMMENTS

MARK SCHEME

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Cambridge Assessment International Education

Interactive

Interactive Example Candidate Responses
Paper 3 (May/June 2016), Question 1
Cambridge International AS & A Level
Physics 9702

Version 1.0

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Select page

HIGH MIDDLE LOW

You may not need to use all of the materials provided.

1 In this experiment, you will investigate a wooden strip acted on by several forces.

(a) (i) Set up the apparatus as shown in Fig. 1.1.

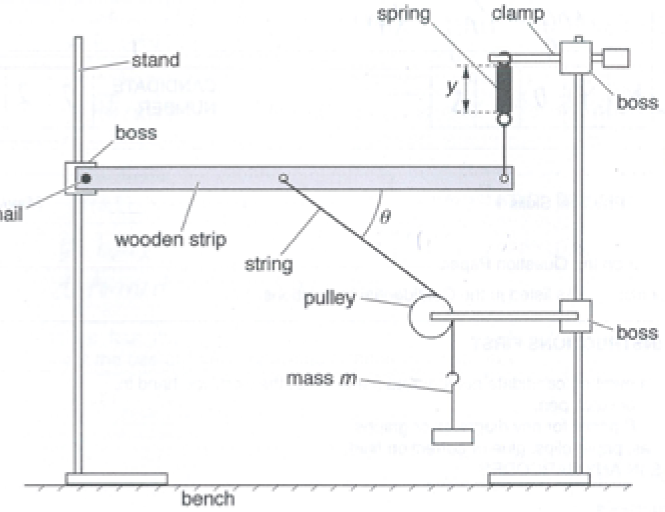


Fig. 1.1

The mass m should be 100 g.

The angle θ between the wooden strip and the string should be approximately 45°.

(ii) Adjust the apparatus so that the spring is vertical and the wooden strip is parallel to the bench.

(b) (i) Record the mass m.

m = 100 g

(ii) Measure and record the length y of the coiled part of the spring.

y_1	y_2	$\langle y \rangle$
4.50	4.50	4.50

y = 4.50 cm [1]

(iii) Measure and record θ.

θ_1	θ_2	$\langle\theta\rangle$
66.0°	68.0°	67.0°

θ = 67.0° [1]

Your Mark

1(b)(ii)

1(b)(iii)

1(d)

1(e)(i)

1(e)(ii)

1(e)(iii)

1(f)

Q1	Mark scheme
(b)(ii)	Value for y with unit in range 2.0 ≤ y ≤ 8.0 cm.
(b)(iii)	Raw values of θ to the nearest degree. Value of θ in the range 40° to 50°.

EXAMINER COMMENTS

MARK SCHEME

(c) (i) Add 100 g to the mass hanger.

(ii) Adjust the height of the boss holding the nail until the wooden strip is parallel to the bench.

(iii) Measure and record m, y and θ.

y_1	y_2	$<y>$
5.70	5.70	5.70

θ_1	θ_2	$<\theta>$
58.0°	59.0°	59.0°

m = 100 g

y = 5.70 cm

θ = 59.0°

Select page

HIGH MIDDLE LOW

Your Mark

1(b)(ii)

1(b)(iii)

1(d)

1(e)(i)

1(e)(ii)

1(e)(iii)

1(f)

Q1	Mark scheme
(b)(ii)	Value for y with unit in range 2.0 ≤ y ≤ 8.0 cm.
(b)(iii)	Raw values of θ to the nearest degree. Value of θ in the range 40° to 50°.

EXAMINER COMMENTS

MARK SCHEME

(d) Change m and repeat (c)(ii) and (c)(iii) until you have six sets of values of m, y and θ.

You may include your values from (b) and (c).

Include values of $m\sin\theta$ in your table.

m / g	y / cm			θ / °			m sin θ / g
	y_1	y_2	<y>	θ_1	θ_2	<θ>	
100	4.50	4.50	4.50	66.0	68.0	67.0	92.1
200	5.70	5.70	5.70	58.0	59.0	59.0	171.
250	6.50	6.50	6.50	60.0	62.0	61.0	219
300	7.20	7.20	7.20	57.0	59.0	58.0	254
350	7.90	8.00	8.00	56.0	56.0	56.0	290
450	9.30	9.40	9.40.	54.0	55.0	55.0	369

[10]

(e) (i) Plot a graph of y on the y-axis against $m\sin\theta$ 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 : $\frac{7.2-5.7}{369-171} = \frac{1}{132} = 7.58\times10^{-3}\ \text{cm g}^{-1}$

c, y-intercept : $y = mx + c$

$3.5 = 50(7.58\times10^{-3}) + c$

$C = 3.12$ cm

gradient = 7.58×10^{-3} cm g^{-1}

y-intercept = 3.12 cm

[2]

Select page

HIGH MIDDLE LOW

Your Mark

1(b)(ii)

1(b)(iii)

1(d)

1(e)(i)

1(e)(ii)

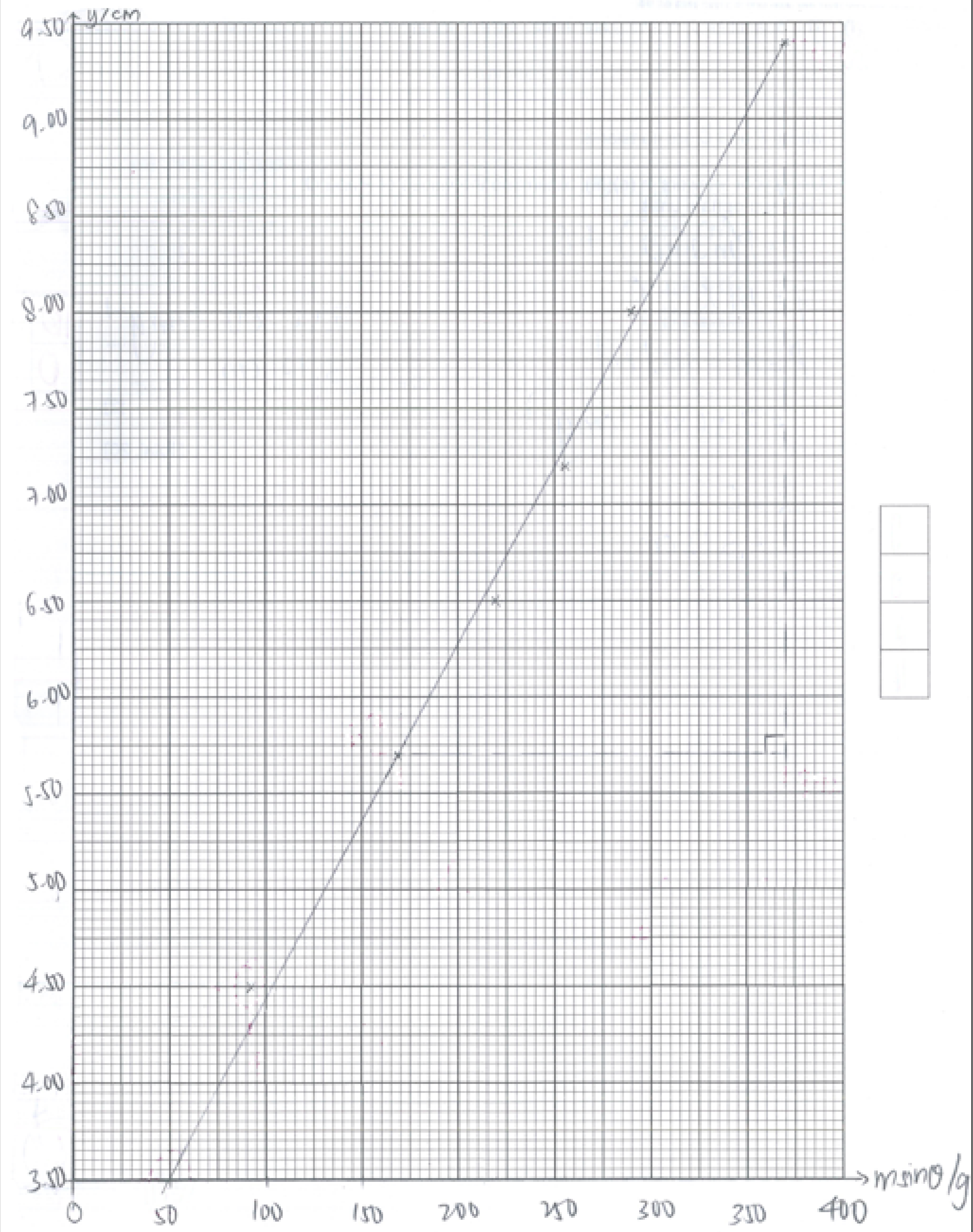
1(e)(iii)

1(f)

Q1	Mark scheme	
(d)	Six sets of readings of m, y and θ with correct trend scores 5 marks, five sets scores 4 marks etc. [5] Help from supervisor –1.	
	Range: Range of values to include m ≤ 150 g and m ≥ 400 g.	[1]
	Column headings: Each column heading must contain a quantity and a unit where appropriate. The unit must conform to accepted scientific convention, e.g. $m\sin\theta$ / g or θ (°).	[1]
	Consistency: All values of y must be given to the nearest mm only.	[1]
	Significant figures: Every value of $m\sin\theta$ must be given to 2 or 3 s.f.	[1]
	Calculation: Values of $m\sin\theta$ calculated correctly to the number of s.f. given by the candidate	[1] **[5]**
(e)(i)	**Axes:** Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed. 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. Diameter of plotted points must be ≤ half a small square (no "blobs"). Plotted points must be accurate to half a small square.	[1]
	Quality: All points in the table (at least 5) must be plotted on the grid for this mark to be awarded. All points must be within ±0.25 cm in the y direction of a straight line.	[1] **[3]**

EXAMINER COMMENTS

MARK SCHEME



Your Mark	
1(b)(ii)	
1(b)(iii)	
1(d)	
1(e)(i)	
1(e)(ii)	
1(e)(iii)	
1(f)	

Q1	Mark scheme
(e)(ii)	**Line of best fit:** **[1]** Judge by balance of all points on the grid about the candidate's line (at least 5 points). 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 by the candidate. Lines must not be kinked or thicker than half a square
(e)(iii)	**Gradient:** [1] The hypotenuse of the triangle must be greater than half of the length of the drawn line. The method of calculation must be correct. Both read-offs must be accurate to half a small square in both the x and y directions. **y-intercept:** [1] Either: Correct read-off from a point on the line and substituted into $y = mx + c$. Read-offs must be accurate to half a small square in both x and y directions. **Or:** Intercept read off directly from the graph (accurate to half a small square). **[2]**

Select page

HIGH MIDDLE LOW

(f) The quantities y, m and θ are related by the equation

$$y = Pm\sin\theta + Q$$

where P and Q are constants.

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

$y = P(m\sin\theta) + Q$
$y = mx + c$
$P = m = \text{gradient}$
$= 7.58 \times 10^{-3}\ \text{cm g}^{-1}$
$Q = c$
$= 3.12\ \text{cm}$

$P =$ $7.58 \times 10^{-3}\ \text{cm g}^{-1}$

$Q =$ 3.12 cm

[2]

[Total: 20]

Your Mark

1(b)(ii)

1(b)(iii)

1(d)

1(e)(i)

1(e)(ii)

1(e)(iii)

1(f)

Q1	Mark scheme
(f)	Value of P = candidate's gradient and value of Q = candidate's intercept. [1] Do not allow fractions. Unit for P correct (m kg^{-1} **or** cm kg^{-1} **or** mm kg^{-1} **or** m g^{-1} **or** cm g^{-1} **or** mm g^{-1}) and consistent with value. Unit for Q correct (m or cm or mm) and consistent with value. [1] **[2]** **[total: 20]**

EXAMINER COMMENTS

MARK SCHEME

You may not need to use all of the materials provided.

1 In this experiment, you will investigate a wooden strip acted on by several forces.

(a) (i) Set up the apparatus as shown in Fig. 1.1.

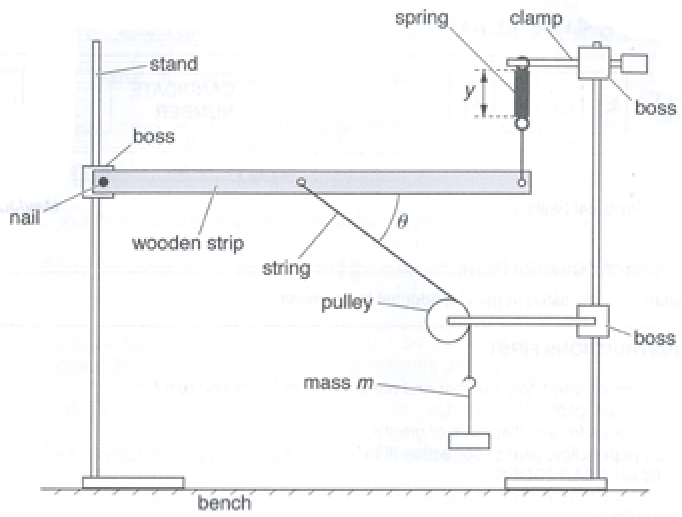


Fig. 1.1

The mass m should be 100 g.

The angle θ between the wooden strip and the string should be approximately 45°.

(ii) Adjust the apparatus so that the spring is vertical and the wooden strip is parallel to the bench.

(b) (i) Record the mass m.

m = 100 g

(ii) Measure and record the length y of the coiled part of the spring.

y = 0.035 m [1]

(iii) Measure and record θ.

θ = 45° [1]

Select page

HIGH | MIDDLE | LOW

Your Mark

1(b)(ii)

1(b)(iii)

1(d)

1(e)(i)

1(e)(ii)

1(e)(iii)

1(f)

Q1	Mark scheme
(b)(ii)	Value for y with unit in range 2.0 ≤ y ≤ 8.0 cm.
(b)(iii)	Raw values of θ to the nearest degree. Value of θ in the range 40° to 50°.

EXAMINER COMMENTS

MARK SCHEME

(c) (i) Add 100 g to the mass hanger.

(ii) Adjust the height of the boss holding the nail until the wooden strip is parallel to the bench.

(iii) Measure and record m, y and θ.

m = 200g

y = 0.045m

θ = 40.4°

Select page

HIGH MIDDLE LOW

Your Mark

1(b)(ii)

1(b)(iii)

1(d)

1(e)(i)

1(e)(ii)

1(e)(iii)

1(f)

Q1	Mark scheme
(b)(ii)	Value for y with unit in range 2.0 ≤ y ≤ 8.0 cm.
(b)(iii)	Raw values of θ to the nearest degree. Value of θ in the range 40° to 50°.

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

(d) Change *m* and repeat **(c)(ii)** and **(c)(iii)** until you have six sets of values of *m*, *y* and *θ*.

You may include your values from **(b)** and **(c)**.

Include values of *m* sin *θ* in your table.

m / g	y / cm	θ / °	m sin θ
100	3.5	45.0	70.70
150	3.8	44.0	104.2
200	4.5	40.4	129.6
250	4.8	38.0	153.9
300	5.4	41.0	196.8
350	6.0	39.0	220.3

[10]

(e) (i) Plot a graph of *y* on the *y*-axis against *m* sin *θ* on the *x*-axis. [3]

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

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

m = (6.0 − 3.5) / (220.3 − 70.7)

= 0.017

(220.3 − 70.7) / 8 = 18.7

(6 − 3.5) / 10 = 0.25

y = mx + c

6 = 0.017(220.3) + c

c = 2.3

gradient = 0.017

y-intercept = 2.3

[2]

Your Mark

1(b)(ii)

1(b)(iii)

1(d)

1(e)(i)

1(e)(ii)

1(e)(iii)

1(f)

Q1	Mark scheme	
(d)	Six sets of readings of m, y and *θ* with correct trend scores 5 marks, five sets scores 4 marks etc. [5] Help from supervisor –1.	
	Range: Range of values to include m ≤ 150 g and m ≥ 400 g.	[1]
	Column headings: Each column heading must contain a quantity and a unit where appropriate. The unit must conform to accepted scientific convention, e.g. *m* sin *θ* / g or *θ* (°).	[1]
	Consistency: All values of y must be given to the nearest mm only.	[1]
	Significant figures: Every value of *m* sin *θ* must be given to 2 or 3 s.f.	[1]
	Calculation: Values of *m* sin *θ* calculated correctly to the number of s.f. given by the candidate	[1] **[5]**
(e)(i)	**Axes:** Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed. 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]
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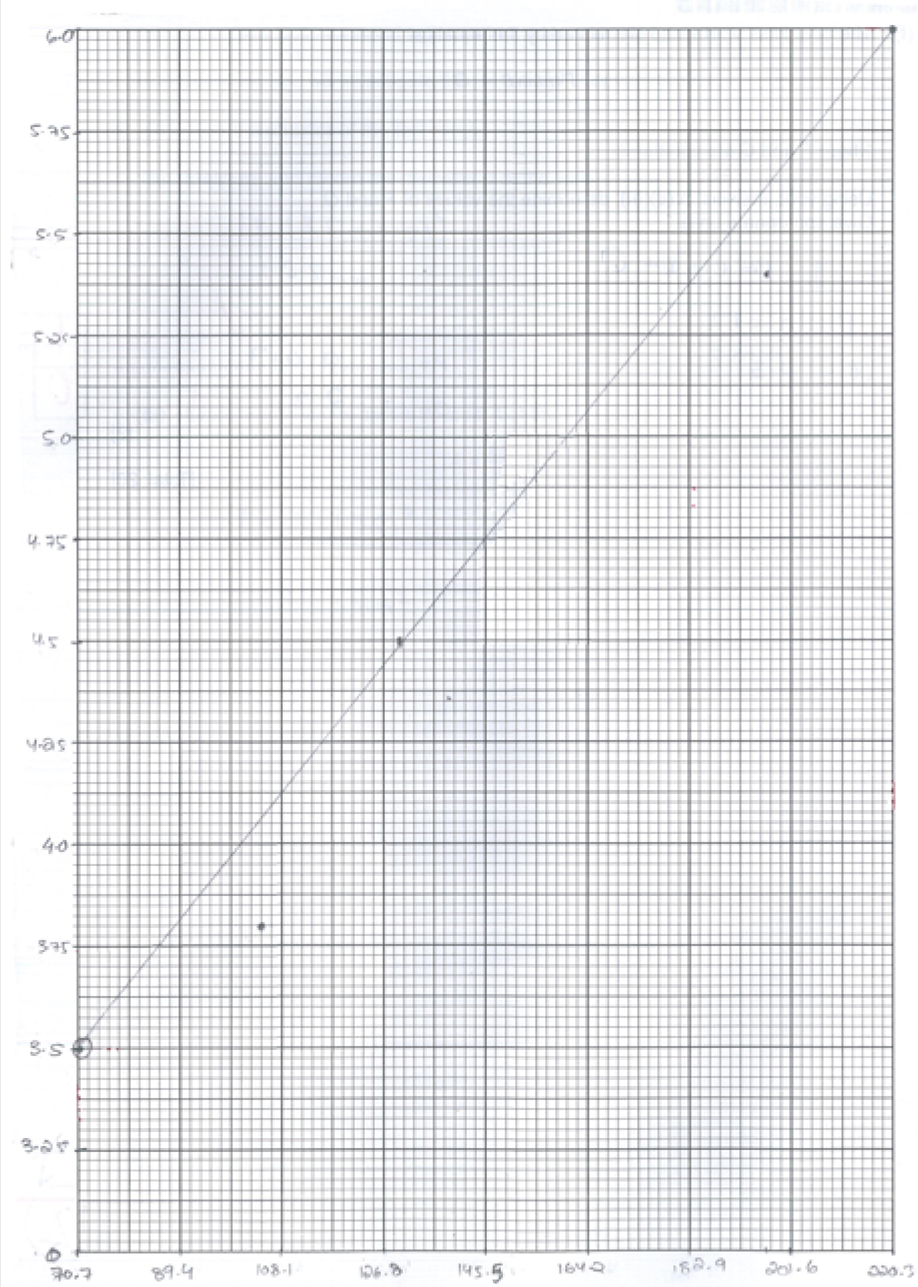
	Quality: All points in the table (at least 5) must be plotted on the grid for this mark to be awarded. All points must be within ±0.25 cm in the y direction of a straight line.	[1] **[3]**

EXAMINER COMMENTS

MARK SCHEME



Select page

HIGH | MIDDLE | LOW

Your Mark

1(b)(ii)

1(b)(iii)

1(d)

1(e)(i)

1(e)(ii)

1(e)(iii)

1(f)

Q1	Mark scheme
(e)(ii)	**Line of best fit:** **[1]** Judge by balance of all points on the grid about the candidate's line (at least 5 points). 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 by the candidate. Lines must not be kinked or thicker than half a square
(e)(iii)	**Gradient:** [1] The hypotenuse of the triangle must be greater than half of the length of the drawn line. The method of calculation must be correct. Both read-offs must be accurate to half a small square in both the x and y directions. **y-intercept:** [1] Either: Correct read-off from a point on the line and substituted into $y = mx + c$. Read-offs must be accurate to half a small square in both x and y directions. **Or:** Intercept read off directly from the graph (accurate to half a small square). **[2]**

EXAMINER COMMENTS

MARK SCHEME

(f) The quantities y, m and θ are related by the equation

$$y = Pm\sin\theta + Q$$

where P and Q are constants.

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

y = Pm sinθ + Q

P = 0.017

Q = 2.3

P = 0.017

Q = 2.3

[2]

[Total: 20]

Select page

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Your Mark

1(b)(ii)	
1(b)(iii)	
1(d)	
1(e)(i)	
1(e)(ii)	
1(e)(iii)	
1(f)	

Q1	Mark scheme
(f)	Value of P = candidate's gradient and value of Q = candidate's intercept. [1] Do not allow fractions. Unit for P correct (m kg^{-1} **or** cm kg^{-1} **or** mm kg^{-1} **or** m g^{-1} **or** cm g^{-1} **or** mm g^{-1}) and consistent with value. Unit for Q correct (m or cm or mm) and consistent with value. [1] **[2]** **[total: 20]**

EXAMINER COMMENTS

MARK SCHEME

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You may not need to use all of the materials provided.

1 In this experiment, you will investigate a wooden strip acted on by several forces.

(a) (i) Set up the apparatus as shown in Fig. 1.1.

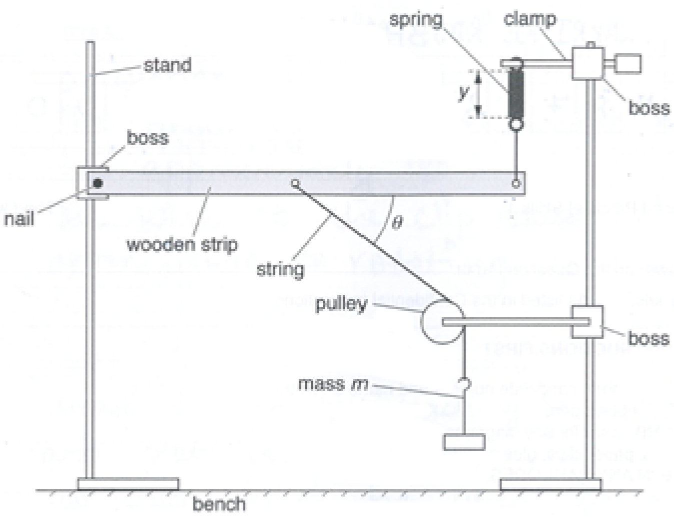


Fig. 1.1

The mass m should be 100 g.

The angle θ between the wooden strip and the string should be approximately 45°.

(ii) Adjust the apparatus so that the spring is vertical and the wooden strip is parallel to the bench.

(b) (i) Record the mass m.

m = ...100g......

(ii) Measure and record the length y of the coiled part of the spring.

$y = \frac{4.2 + 4.0 + 4.3}{3}$

y = ...4.17cm...... [1]

(iii) Measure and record θ.

θ = ...45°...... [1]

Your Mark

1(b)(ii)

1(b)(iii)

1(d)

1(e)(i)

1(e)(ii)

1(e)(iii)

1(f)

Q1	Mark scheme
(b)(ii)	Value for y with unit in range 2.0 ≤ y ≤ 8.0 cm.
(b)(iii)	Raw values of θ to the nearest degree. Value of θ in the range 40° to 50°.

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

(c) (i) Add 100 g to the mass hanger.

(ii) Adjust the height of the boss holding the nail until the wooden strip is parallel to the bench.

(iii) Measure and record m, y and θ.

$y = \frac{4.8 + 4.9 + 5.0}{3}$

m = 200 g

y = 4.9 cm

θ = 55°

Your Mark

1(b)(ii)

1(b)(iii)

1(d)

1(e)(i)

1(e)(ii)

1(e)(iii)

1(f)

Q1	Mark scheme
(b)(ii)	Value for y with unit in range 2.0 ≤ y ≤ 8.0 cm.
(b)(iii)	Raw values of θ to the nearest degree. Value of θ in the range 40° to 50°.

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

(d) Change m and repeat (c)(ii) and (c)(iii) until you have six sets of values of m, y and θ.

You may include your values from (b) and (c).

Include values of $m \sin\theta$ in your table.

S.No	m/g	y/cm	θ/°	m sinθ/g
1	100	4.28	45	70.7
2	150	4.6	50	114.9
3	200	4.9	55	163.8
4	250	6.0	60	216.5
5	300	7.0	65	271.9
6	350	7.8	70	328.9

[10]

(e) (i) Plot a graph of y on the y-axis against $m\sin\theta$ on the x-axis. [3]

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

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

Taking (80, 3.5) and (356, 8.2)

gradient $= \frac{\Delta y}{\Delta x} = \frac{8.2-3.5}{356-80} = 0.0170$

Taking (80, 3.5)

$y = mx + c$.

$3.5 = 0.0170 \times 80 + c$

$c = 2.14$

gradient = 0.0170

y-intercept = 2.14

[2]

Your Mark

1(b)(ii)

1(b)(iii)

1(d)

1(e)(i)

1(e)(ii)

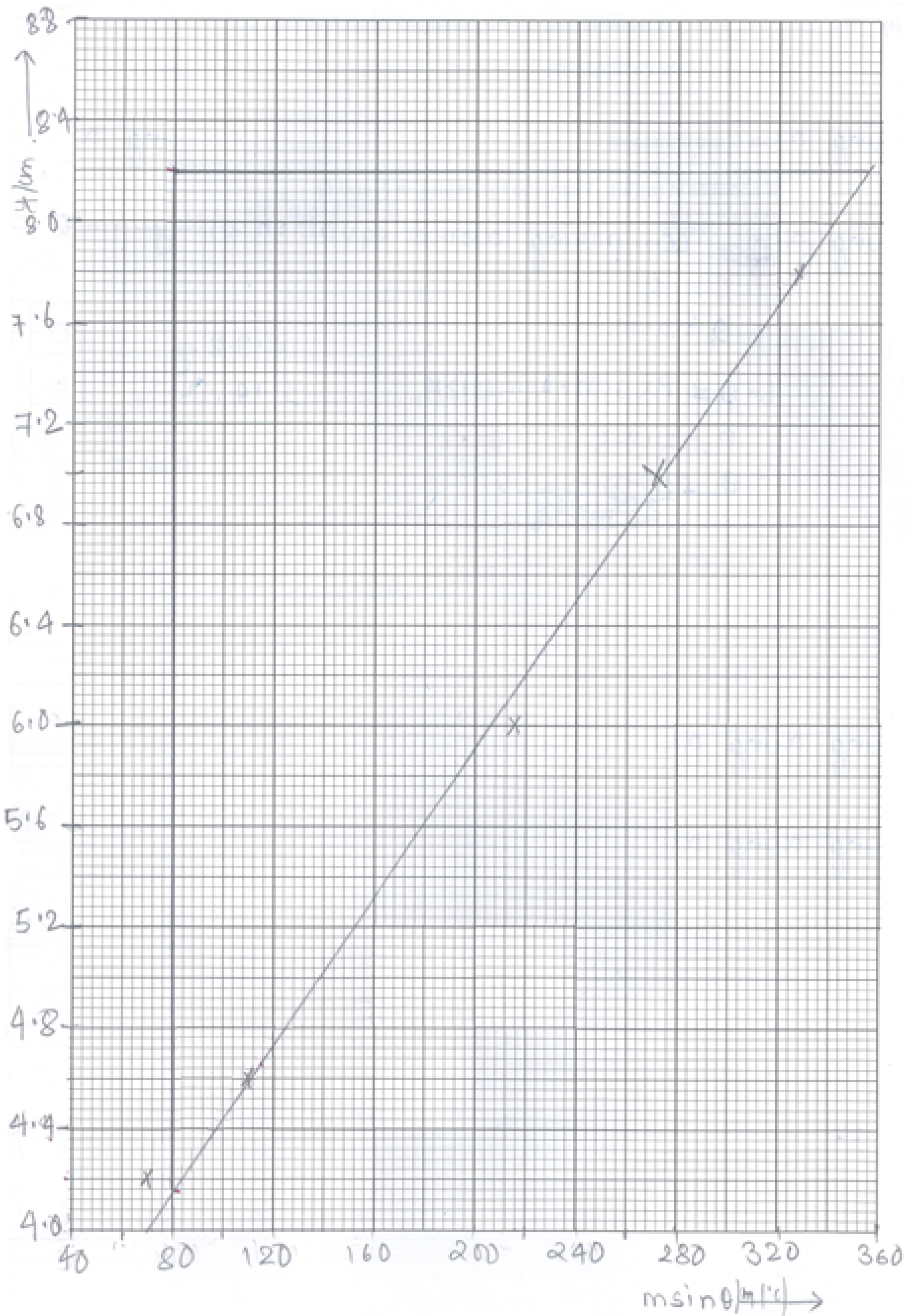
1(e)(iii)

1(f)

Q1	Mark scheme	
(d)	Six sets of readings of m, y and θ with correct trend scores 5 marks, five sets scores 4 marks etc. [5] Help from supervisor –1.	
	Range: Range of values to include m ≤ 150 g and m ≥ 400 g.	[1]
	Column headings: Each column heading must contain a quantity and a unit where appropriate. The unit must conform to accepted scientific convention, e.g. $m \sin \theta$ / g or θ (°).	[1]
	Consistency: All values of y must be given to the nearest mm only.	[1]
	Significant figures: Every value of $m \sin \theta$ must be given to 2 or 3 s.f.	[1]
	Calculation: Values of $m \sin \theta$ calculated correctly to the number of s.f. given by the candidate	[1] **[5]**
(e)(i)	**Axes:** Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed. 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. Diameter of plotted points must be ≤ half a small square (no "blobs"). Plotted points must be accurate to half a small square.	[1]
	Quality: All points in the table (at least 5) must be plotted on the grid for this mark to be awarded. All points must be within ±0.25 cm in the y direction of a straight line.	[1] **[3]**

EXAMINER COMMENTS

MARK SCHEME



Your Mark

1(b)(ii)

1(b)(iii)

1(d)

1(e)(i)

1(e)(ii)

1(e)(iii)

1(f)

Q1	Mark scheme
(e)(ii)	**Line of best fit:** **[1]** Judge by balance of all points on the grid about the candidate's line (at least 5 points). 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 by the candidate. Lines must not be kinked or thicker than half a square
(e)(iii)	**Gradient:** [1] The hypotenuse of the triangle must be greater than half of the length of the drawn line. The method of calculation must be correct. Both read-offs must be accurate to half a small square in both the x and y directions. **y-intercept:** [1] Either: Correct read-off from a point on the line and substituted into $y = mx + c$. Read-offs must be accurate to half a small square in both x and y directions. **Or:** Intercept read off directly from the graph (accurate to half a small square). **[2]**

(f) The quantities y, m and θ are related by the equation

$$y = Pm\sin\theta + Q$$

where P and Q are constants.

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

comparing above equation with y = mx+c
C = Q
Q = 2·14
6·0 = P × 0·0170 sin 60 + 2·14
P = 2·78

P = ...2·78 g..........

Q = ...2·14..........

[2]

[Total: 20]

Select page

HIGH MIDDLE LOW

Your Mark

1(b)(ii)

1(b)(iii)

1(d)

1(e)(i)

1(e)(ii)

1(e)(iii)

1(f)

Q1	Mark scheme
(f)	Value of P = candidate's gradient and value of Q = candidate's intercept. [1] Do not allow fractions. Unit for P correct (m kg^{-1} **or** cm kg^{-1} **or** mm kg^{-1} **or** m g^{-1} **or** cm g^{-1} **or** mm g^{-1}) and consistent with value. Unit for Q correct (m or cm or mm) and consistent with value. [1] **[2]** **[total: 20]**

EXAMINER COMMENTS

MARK SCHEME

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Cambridge Assessment International Education

Interactive

Interactive Example Candidate Responses
Paper 2 (May/June 2016), Question 7
Cambridge International AS & A Level
Physics 9702

Version 1.0

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7 (a) Electric current is a flow of charge carriers. The charge on the carriers is quantised. Explain what is meant by *quantised*.

It means that charge is divide among the elections [1]

(b) A battery of electromotive force (e.m.f.) 9.0V and internal resistance 0.25Ω is connected in series with two identical resistors X and a resistor Y, as shown in Fig. 7.1.

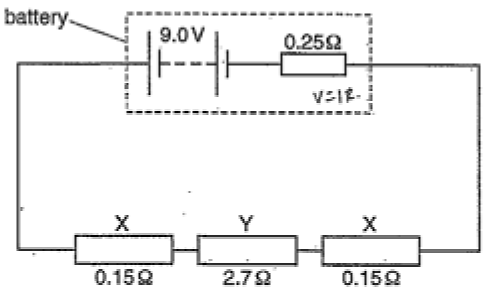

Fig. 7.1

The resistance of each resistor X is 0.15Ω and the resistance of resistor Y is 2.7Ω.

(i) Show that the current in the circuit is 2.8A.

V = IR
I = 9

$\frac{V_{battery}}{R_{total}} = I$

$I = \frac{9}{(0.25 + 0.15 + 0.15 + 2.7)}$

= 2.769 A

= 2.8 A

[3]

(ii) Calculate the potential difference across the battery.

V = IR

V = 2.8 × 0.25

= 0.69

9 − 0.69

= 8.307

= 8.31

potential difference = 8.31 V [2]

Select page

HIGH MIDDLE LOW

Your Mark

7(a)

7(b)(i)

7(b)(ii)

7(c)(i)

7(c)(ii)

Q7	Mark scheme		
(a)	charge exists only in discrete amounts	B1	[1]
(b)(i)	$E = I(R + r)$ or $V = IR$ (total resistance =) 2.7 + 0.30 + 0.25 (= 3.25 Ω) I = 9.0 / (2.7 + 0.30 + 0.25) **or** 9.0 / 3.25 = 2.8 A	C1 M1 A1	[3]
(b)(ii)	$V = IR_{ext}$ = 2.77 × 3.0 or 2.8 × 3.0 **or** $V = E - Ir$ = 9.0 – 2.77 × 0.25 or 9.0 – 2.8 × 0.25 V = 8.3 (8.31) V **or** 8.4 V A1	C1 (C1)	[2]
(c)(i)	$I = nevA$ v = 2.77 / (8.5 × 10^{29} × 1.6 × 10^{-19} × 2.5 × 10^{-6}) = 8.1 (8.147) × 10^{-6} ms^{-1} or 8.2 × 10–6 ms^{-1}	 M1 A1	[2]
(c)(ii)	A reduces by a factor 4 (1/4 less) **or** resistance of Z goes up by 4× current goes down but by less than a factor of 4 (as total resistance does not go up by a factor of 4) so drift speed goes up	M1 A1	[2] **[Total: 10]**

EXAMINER COMMENTS

MARK SCHEME

(c) Each resistor X connected in the circuit in (b) is made from a wire with a cross-sectional area of 2.5 mm^2. The number of free electrons per unit volume in the wire is $8.5 \times 10^{29} m^{-3}$.

(i) Calculate the average drift speed of the electrons in X. I = nAve

I = nAve

$2.8 = 8.5 \times 10^{29} \times 2.5 \times 10^{6} \times v \times 1.6 \times 10^{-19}$

$\frac{2.8}{3.4 \times 10^{17}} = v$

$v = 8.14 \times 10^{-18}$

drift speed = 8.14×10^{-18} ms^{-1} [2]

(ii) The two resistors X are replaced by two resistors Z made of the same material and length but with half the diameter.

Describe and explain the difference between the average drift speed in Z and that in X.

Since the drift speed is inversely proportional to cross-sectional area, the drift speed in Z will be increased by 4 times. It will be four times more than X as the area is four times less than X [2]

[Total: 10]

Select page

HIGH MIDDLE LOW

Your Mark

7(a)

7(b)(i)

7(b)(ii)

7(c)(i)

7(c)(ii)

Q7	Mark scheme		
(a)	charge exists only in discrete amounts	B1	[1]
(b)(i)	$E = I(R + r)$ or $V = IR$ (total resistance =) 2.7 + 0.30 + 0.25 (= 3.25 Ω) I = 9.0 / (2.7 + 0.30 + 0.25) **or** 9.0 / 3.25 = 2.8 A	C1 M1 A1	[3]
(b)(ii)	$V = IR_{ext}$ = 2.77 × 3.0 or 2.8 × 3.0 **or** $V = E - Ir$ = 9.0 – 2.77 × 0.25 or 9.0 – 2.8 × 0.25 V = 8.3 (8.31) V **or** 8.4 V A1	C1 (C1)	[2]
(c)(i)	$I = nevA$ $v = 2.77 / (8.5 \times 10^{29} \times 1.6 \times 10^{-19} \times 2.5 \times 10^{-6})$ $= 8.1 (8.147) \times 10^{-6}$ ms^{-1} or $8.2 \times 10{-}6$ ms^{-1}	 M1 A1	[2]
(c)(ii)	A reduces by a factor 4 (1/4 less) **or** resistance of Z goes up by 4× current goes down but by less than a factor of 4 (as total resistance does not go up by a factor of 4) so drift speed goes up	M1 A1	[2]
			[Total: 10]

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

7 (a) Electric current is a flow of charge carriers. The charge on the carriers is quantised. Explain what is meant by *quantised*.

'quantised' means expressed as a numerical value. [1]

(b) A battery of electromotive force (e.m.f.) 9.0V and internal resistance 0.25Ω is connected in series with two identical resistors X and a resistor Y, as shown in Fig. 7.1.

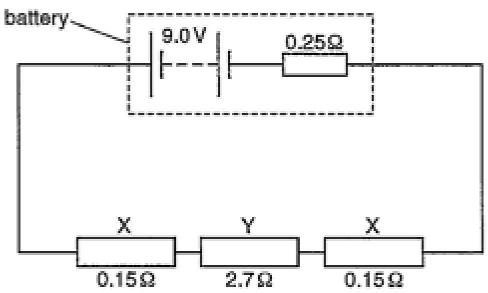

Fig. 7.1

The resistance of each resistor X is 0.15Ω and the resistance of resistor Y is 2.7Ω.

(i) Show that the current in the circuit is 2.8A.

V = IR
9 = I (0.25 + 0.15 + 0.15 + 2.7)
9 = I (3.25)
∴ I = 2.8 A shown.

[3]

(ii) Calculate the potential difference across the battery.

V = IR
= 2.8 x 0.25
= 0.7 V

potential difference = 0.7 V [2]

Your Mark

7(a)

7(b)(i)

7(b)(ii)

7(c)(i)

7(c)(ii)

Q7	Mark scheme		
(a)	charge exists only in discrete amounts	B1	[1]
(b)(i)	$E = I(R + r)$ or $V = IR$ (total resistance =) 2.7 + 0.30 + 0.25 (= 3.25 Ω) I = 9.0 / (2.7 + 0.30 + 0.25) **or** 9.0 / 3.25 = 2.8 A	C1 M1 A1	[3]
(b)(ii)	$V = IR_{ext}$ = 2.77 × 3.0 or 2.8 × 3.0 **or** $V = E – Ir$ = 9.0 – 2.77 × 0.25 or 9.0 – 2.8 × 0.25 V = 8.3 (8.31) V **or** 8.4 V A1	C1 (C1)	[2]
(c)(i)	$I = nevA$ v = 2.77 / (8.5 × 10^{29} × 1.6 × 10^{-19} × 2.5 × 10^{-6}) = 8.1 (8.147) × 10^{-6} ms^{-1} or 8.2 × 10–6 ms^{-1}	 M1 A1	[2]
(c)(ii)	A reduces by a factor 4 (1/4 less) **or** resistance of Z goes up by 4× current goes down but by less than a factor of 4 (as total resistance does not go up by a factor of 4) so drift speed goes up	M1 A1	[2] **[Total: 10]**

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

(c) Each resistor X connected in the circuit in **(b)** is made from a wire with a cross-sectional area of 2.5 mm^2. The number of free electrons per unit volume in the wire is 8.5 × 10^{29} m^{-3}.

(i) Calculate the average drift speed of the electrons in X.

$I = nAVq$

$2.8 = (8.5 \times 10^{29}) \cdot (2.5 \times 10^{-3})(V) \cdot (1.6 \times 10^{-19})$

$\therefore V = 8.2 \times 10^{-9}$ ms^{-1}

drift speed = 8.2×10^{-19} ms^{-1} [2]

(ii) The two resistors X are replaced by two resistors Z made of the same material and length but with half the diameter.

Describe and explain the difference between the average drift speed in Z and that in X.

If the diameter is halved, the area is decreased by four times. According to I = nAVq, if the area decreases by four times, the ~~veloci~~ average drift speed which increase by four times. [2]

[Total: 10]

$\frac{I}{nAq} = V$

Your Mark

7(a)

7(b)(i)

7(b)(ii)

7(c)(i)

7(c)(ii)

Q7	Mark scheme		
(a)	charge exists only in discrete amounts	B1	**[1]**
(b)(i)	$E = I(R + r)$ or $V = IR$ (total resistance =) 2.7 + 0.30 + 0.25 (= 3.25 Ω) I = 9.0 / (2.7 + 0.30 + 0.25) **or** 9.0 / 3.25 = 2.8 A	C1 M1 A1	 **[3]**
(b)(ii)	$V = IR_{ext}$ = 2.77 × 3.0 or 2.8 × 3.0 **or** $V = E - Ir$ = 9.0 – 2.77 × 0.25 or 9.0 – 2.8 × 0.25 V = 8.3 (8.31) V **or** 8.4 V A1	C1 (C1)	 **[2]**
(c)(i)	$I = nevA$ v = 2.77 / (8.5 × 10^{29} × 1.6 × 10^{-19} × 2.5 × 10^{-6}) = 8.1 (8.147) × 10^{-6} ms^{-1} or 8.2 × 10–6 ms^{-1}	 M1 A1	 **[2]**
(c)(ii)	A reduces by a factor 4 (1/4 less) **or** resistance of Z goes up by 4× current goes down but by less than a factor of 4 (as total resistance does not go up by a factor of 4) so drift speed goes up	M1 A1	 **[2]** **[Total: 10]**

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

7 (a) Electric current is a flow of charge carriers. The charge on the carriers is quantised. Explain what is meant by *quantised*.

measured how many charge flows per unit time ....[1]

(b) A battery of electromotive force (e.m.f.) 9.0V and internal resistance 0.25Ω is connected in series with two identical resistors X and a resistor Y, as shown in Fig. 7.1.

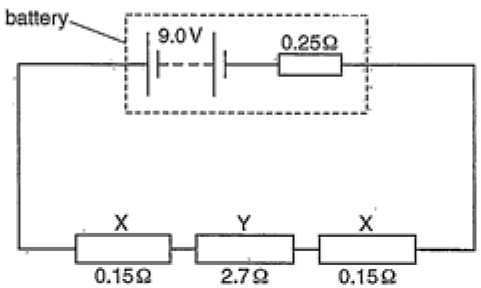

Fig. 7.1

The resistance of each resistor X is 0.15Ω and the resistance of resistor Y is 2.7Ω.

(i) Show that the current in the circuit is 2.8A.

E = I(R+r+r+r)
9.0V = I (0.25+0.15+2.7+0.15)
9.0 = I (3.25)
I = 9.0 / 3.25
= 2.769
≃ 2.8A
shown.

[3]

(ii) Calculate the potential difference across the battery.

V = IR
~~V=2.7×0.25~~ V = 2.769 × 0.25
~~V=0.69V~~ V = 0.69V

potential difference = 0.69.............................. V [2]

Your Mark

7(a)

7(b)(i)

7(b)(ii)

7(c)(i)

7(c)(ii)

Q7	Mark scheme		
(a)	charge exists only in discrete amounts	B1	[1]
(b)(i)	$E = I(R + r)$ or $V = IR$ (total resistance =) 2.7 + 0.30 + 0.25 (= 3.25 Ω) I = 9.0 / (2.7 + 0.30 + 0.25) **or** 9.0 / 3.25 = 2.8 A	C1 M1 A1	[3]
(b)(ii)	$V = IR_{ext}$ = 2.77 × 3.0 or 2.8 × 3.0 **or** $V = E – Ir$ = 9.0 – 2.77 × 0.25 or 9.0 – 2.8 × 0.25 V = 8.3 (8.31) V **or** 8.4 V A1	C1 (C1)	[2]
(c)(i)	$I = nevA$ v = 2.77 / (8.5 × 10^{29} × 1.6 × 10^{-19} × 2.5 × 10^{-6}) = 8.1 (8.147) × 10^{-6} ms^{-1} or 8.2 × 10–6 ms^{-1}	 M1 A1	[2]
(c)(ii)	A reduces by a factor 4 (1/4 less) **or** resistance of Z goes up by 4× current goes down but by less than a factor of 4 (as total resistance does not go up by a factor of 4) so drift speed goes up	M1 A1	[2]
			[Total: 10]

EXAMINER COMMENTS

MARK SCHEME

(c) Each resistor X connected in the circuit in (b) is made from a wire with a cross-sectic of 2.5 mm^2. The number of free electrons per unit volume in the wire is 8.5×10^{29} m^{-}

$2.5\times10^{-3}m^2$

(i) Calculate the average drift speed of the electrons in X.

$I = nAve$

$2.8 = 8.5\times10^{29} \times 2.5\times10^{-3} \times V \times 1.60\times10^{-19}$

$2.8 = 3.4\times10^{8}\ V$

$V = \frac{2.8}{3.4\times10^{8}}$

$V = 8.24\times10^{-9}$ drift speed = 8.24×10^{-9}

two resistors X are replaced by two resistors Z made of the same mat th but with half the diameter.

cribe and explain the difference between the average drift speed in Z and th

sistance is doubled therefore the current de

the average drift speed in Z is less than in

may be halved.

[

Select page

HIGH MIDDLE LOW

Your Mark

7(a)

7(b)(i)

7(b)(ii)

7(c)(i)

7(c)(ii)

Q7	Mark scheme		
(a)	charge exists only in discrete amounts	B1	**[1]**
(b)(i)	$E = I(R + r)$ or $V = IR$ (total resistance =) 2.7 + 0.30 + 0.25 (= 3.25 Ω) I = 9.0 / (2.7 + 0.30 + 0.25) **or** 9.0 / 3.25 = 2.8 A	C1 M1 A1	**[3]**
(b)(ii)	$V = IR_{ext}$ = 2.77 × 3.0 or 2.8 × 3.0 **or** $V = E - Ir$ = 9.0 – 2.77 × 0.25 or 9.0 – 2.8 × 0.25 V = 8.3 (8.31) V **or** 8.4 V A1	C1 (C1)	**[2]**
(c)(i)	$I = nevA$ v = 2.77 / (8.5 × 10^{29} × 1.6 × 10^{-19} × 2.5 × 10^{-6}) = 8.1 (8.147) × 10^{-6} ms^{-1} or 8.2 × 10–6 ms^{-1}	 M1 A1	**[2]**
(c)(ii)	A reduces by a factor 4 (1/4 less) **or** resistance of Z goes up by 4× current goes down but by less than a factor of 4 (as total resistance does not go up by a factor of 4) so drift speed goes up	M1 A1	**[2]**
			[Total: 10]

EXAMINER COMMENTS

MARK SCHEME

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Interactive

Interactive Example Candidate Responses Paper 3 (May/June 2016), Question 2

Cambridge International AS & A Level Physics 9702

Version 1.0

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You may not need to use all of the materials provided.

2 In this experiment, you will investigate the movement of a loaded wire.

(a) (i) Take the **shorter** of the two wires.

(ii) Measure and record the diameter d of the wire.

$\frac{0.31 + 0.29 + 0.29}{3}$
$= 0.297$
$= 0.30 mm$

$d =$ (0.30 ± 0.01) mm ~~(0.3 ± 1.0 mm)~~ [1]

(iii) Calculate the cross-sectional area A of the wire using

$$A = \frac{\pi d^2}{4}.$$

$A = \frac{\pi (0.30)^2}{4}$
$= 0.07067$
$= 0.071 mm^2$

$A =$ 0.071 mm² [1]

Select page

HIGH MIDDLE LOW

Your Mark

2(a)(ii)
2(a)(iii)
2(b)(iii)
2(b)(iv)
2(c)(i)
2(c)(ii)
2(d)(ii)
2(e)(ii)
2(f)(i)
2(f)(ii)
2(g)(i)
2(g)(ii)

Q2	Mark scheme
(a)(ii)	All raw values of d either to the nearest 0.01 or 0.001 mm with unit and in the range 0.250 mm to 0.450 mm **[1]**
(a)(iii)	Correct calculation of A with consistent unit and power of ten. **[1]**
(b)(iii)	Value of L with appropriate unit in range 10.0 cm ≤ L ≤ 20.0 cm. **[1]**
(b)(iv)	Percentage uncertainty in L based on absolute uncertainty of 2 mm to 8 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]**
(c)(i)	Correct calculation of C to the s.f. given by the candidate. **[1]**
(c)(ii)	Correct justification for s.f. in C linked to s.f. in d and L. **[1]**
(d)(ii)	Raw values for time to the nearest 0.1 s or better. T with unit and in range 0.5 s ≤ T ≤ 2.0 s. **[1]**
(e)(ii)	Second values of d and L. *Second value of T.* Quality: If $d_1 > d_2$ then second value of T > first value of T. **[1]**
(f)(i)	Two values of k calculated correctly. **[1]**
(f)(ii)	Sensible comment relating to the calculated values of k, testing against a criterion specified by the candidate. **[1]**

EXAMINER COMMENTS

MARK SCHEME

(b) (i) Secure the hook of the mass hanger to one end of the wire leaving at least 20 cm of excess wire.
The wire may be wrapped around the hook several times.

(ii) Set up the apparatus as shown in Fig. 2.1.

The length L of wire between the clip and the hook of the mass hanger should be approximately 15 cm.

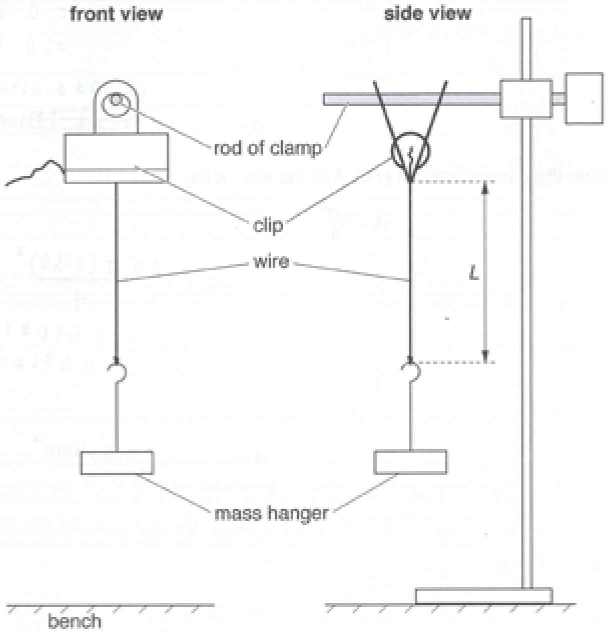

Fig. 2.1

(iii) Measure and record L.

$\frac{15.4 + 15.4}{2} = 15.4$ cm

L = (15.4 ± 0.1) cm [1]

(iv) Estimate the percentage uncertainty in your value of L.

$\frac{0.1}{15.4} \times 100 = 0.65\%$

percentage uncertainty = 0.65% [1]

Your Mark

2(a)(ii)
2(a)(iii)
2(b)(iii)
2(b)(iv)
2(c)(i)
2(c)(ii)
2(d)(ii)
2(e)(ii)
2(f)(i)
2(f)(ii)
2(g)(i)
2(g)(ii)

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(c) (i) Calculate C where

$$C = \frac{\sqrt{L}}{A}.$$

1cm = 10mm
1cm² = 100mm²
x = 0.071
x = 7.1 × 10⁻⁶ cm²

$C = \frac{\sqrt{L}}{A}$

$= \frac{\sqrt{15.4}}{7.1 \times 10^{-6}}$ = 553,000

= 552715.97

$C =$ 553,000 cm⁻¹·⁵ [1]

(ii) Justify the number of significant figures that you have given for your value of C.

A has two significant figures, so to increase the accuracy, 3 significant figures were used for C. [1]

(d) (i) Twist the mass hanger through approximately 180°.

Release the mass hanger. The mass hanger will oscillate as shown in Fig. 2.2.

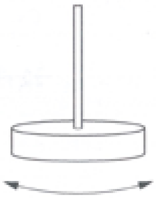

Fig. 2.2

(ii) Take measurements to determine the period T of the oscillations.

Record T.

$\frac{22.0 + 22.7}{42}$

= 1.1s.

$T =$ (1.18 ± 0.1)s [1]

(iii) Remove the wire from the mass hanger.

Your Mark

2(a)(ii)

2(a)(iii)

2(b)(iii)

2(b)(iv)

2(c)(i)

2(c)(ii)

2(d)(ii)

2(e)(ii)

2(f)(i)

2(f)(ii)

2(g)(i)

2(g)(ii)

Q2	Mark scheme
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EXAMINER COMMENTS | MARK SCHEME

(e) (i) Take the **longer** wire. Repeat (a)(ii) and (a)(iii).

0.11 + 0.10 + 0.10 / 3 = 0.103 = 0.10mm

d = (0.10 ± 0.01) mm

A = 0.0079 mm²

(ii) Secure the hook of the mass hanger to one end of the wire leaving 40 cm of excess wire.
Repeat (b)(ii), (b)(iii), (c)(i) and (d) for a value of *L* of approximately 30 cm.

(29.9 + 29.9) / 2 = 29.9

L = (29.9 ± 0.1) cm

6,920,000

C = ~~7,040,000~~ cm⁻¹

~~32.9~~ 26.2 + 26.2 / 16 ≈ 3.35

T = (3.3 ± 0.1) s

[3]

Select page

HIGH MIDDLE LOW

Your Mark

2(a)(ii)
2(a)(iii)
2(b)(iii)
2(b)(iv)
2(c)(i)
2(c)(ii)
2(d)(ii)
2(e)(ii)
2(f)(i)
2(f)(ii)
2(g)(i)
2(g)(ii)

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EXAMINER COMMENTS

MARK SCHEME

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(f) It is suggested that the relationship between T and C is

$$T = kC$$

where k is a constant.

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

$1.1 = k(553,000)$
$k = 1.99 \times 10^{-6}$

$3.3 = k(6,920,000)$
$k = 4.77 \times 10^{-7}$

first value of k = 1.99×10^{-6} cms

second value of k = 4.77×10^{-7} cms [1]

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

$\frac{|k_1 - k_2|}{k_1} \times 100\%$
$= 76.03\%$

No, as the percentage uncertainty 76.03% is more than 20%. [1]

Your Mark

2(a)(ii)

2(a)(iii)

2(b)(iii)

2(b)(iv)

2(c)(i)

2(c)(ii)

2(d)(ii)

2(e)(ii)

2(f)(i)

2(f)(ii)

2(g)(i)

2(g)(ii)

Q2	Mark scheme
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EXAMINER COMMENTS

MARK SCHEME

Select page

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

1. only two readings were taken to draw a conclusion which is insufficient.

2. The loop of wire around the mass hanger slips.

3. ~~Position error in~~ Hard to ~~measuring~~ measure length L as wire not straight.

4. Hard to ~~get exact~~ determine where is one oscillation of the mass hanger.

5. ~~Wire is not straight, hard to measure the length~~ Parallax error in measuring L. [4]

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

1. More readings should have been taken and a graph plotted to get a more accurate conclusion.

2. Use adhesive tape to stick the wire to the mass hanger.

3. ~~Mark length L on the wire used and measure before attaching wire to clip.~~ Straighten wires by using a motor and running the wire through the motor.

4. ~~Take a~~ Video camera with a timer should be used.

5. Mark length L on wire used and measure before attaching wire to clip. [4]

[Total: 20]

Your Mark

2(a)(ii)
2(a)(iii)
2(b)(iii)
2(b)(iv)
2(c)(i)
2(c)(ii)
2(d)(ii)
2(e)(ii)
2(f)(i)
2(f)(ii)
2(g)(i)
2(g)(ii)

Q2 Mark scheme

(g)	(i) Limitations [4]	(ii) Improvements [4]	Do not credit
A	Two readings not enough to draw a conclusion	Take many readings <u>and</u> plot a graph/ obtain more k values and <u>compare</u>	"Repeat readings" on its own/few readings/only one reading/not enough readings for accurate value
B	Difficult to judge beginning and/or end of a cycle/a complete cycle	Draw a line/mark on the mass/ (fiducial) marker at equilibrium position	
C	Wire not straight/ kinked	Method of straightening wire e.g. use larger mass	
D	Difficult to measure *L* with reason e.g. metre rule awkward to position/parallax error	Improved method of measuring *L* e.g. marking *L* before putting into clip/ detailed method using set squares or ruler/ use a length guide (e.g. 15 cm wood)/ use string with detail/ use tape measure	Vernier calipers on its own/ set square on its own/ 30 cm ruler on its own
E	Wire slips (in clip)	Better method of gripping wire e.g. wrap wire around clamp/use two wooden blocks and wire	Any reference to attaching the mass to the wire
F	Mass swings as well as rotates/ clip moves around rod/there is a force on release	Better method of attaching clip to rod e.g. glue	
G	Shorter/thicker wire has too few cycles/dampens quickly/ (percentage) uncertainty greater for shorter/thicker wire	Video and timer/replay frame by frame	Repeats Longer wire

[TOTAL: 18]

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH | MIDDLE | LOW

You may not need to use all of the materials provided.

2 In this experiment, you will investigate the movement of a loaded wire.

(a) (i) Take the **shorter** of the two wires.

(ii) Measure and record the diameter d of the wire.

0.01 × 38

d = 0.38 mm [1]

(iii) Calculate the cross-sectional area A of the wire using

$$A = \frac{\pi d^2}{4}.$$

~~A = π(0.38)² / 4 = 0.113~~ ~~1.13 × 10⁻⁷~~

1 m = 1000 mm
x = 0.38
0.00038 m.

A = π(0.038)² / 4

= ~~0.0298~~

= 1.13 × 10⁻³

A = ~~0.113 × 10⁻⁷ cm²~~ ~~0.0298 cm²~~ [1]

A = 1.13 × 10⁻³ cm²

Your Mark

2(a)(ii)
2(a)(iii)
2(b)(iii)
2(b)(iv)
2(c)(i)
2(c)(ii)
2(d)(ii)
2(e)(ii)
2(f)(i)
2(f)(ii)
2(g)(i)
2(g)(ii)

Q2	Mark scheme
(a)(ii)	All raw values of d either to the nearest 0.01 or 0.001 mm with unit and in the range 0.250 mm to 0.450 mm **[1]**
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Select page

HIGH MIDDLE LOW

(b) (i) Secure the hook of the mass hanger to one end of the wire leaving at least 20 cm of excess wire.
The wire may be wrapped around the hook several times.

(ii) Set up the apparatus as shown in Fig. 2.1.

The length L of wire between the clip and the hook of the mass hanger should be approximately 15 cm.

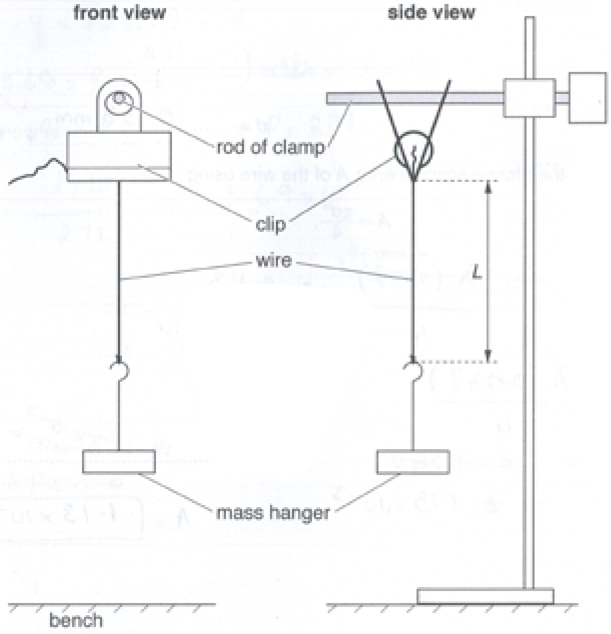

Fig. 2.1

(iii) Measure and record L.

15.40 cm.

L = ~~0.152 m~~ ~~24.2 cm~~ ~~15.20 cm~~ 15.40 cm [1]

(iv) Estimate the percentage uncertainty in your value of L.

0.2 / ~~24.2~~ ~~15.2~~ 15.40 × 100 = 1.3

= 1 %

percentage uncertainty = 1 % [1]

	Your Mark
2(a)(ii)	
2(a)(iii)	
2(b)(iii)	
2(b)(iv)	
2(c)(i)	
2(c)(ii)	
2(d)(ii)	
2(e)(ii)	
2(f)(i)	
2(f)(ii)	
2(g)(i)	
2(g)(ii)	

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EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH | MIDDLE | LOW

(c) (i) Calculate C where

$$C = \frac{\sqrt{L}}{A}.$$

0·113 – mm²
0·00113 – cm²

$C = \frac{\sqrt{15 \cdot 24}}{~~0 \cdot 00113~~ \; ~~0 \cdot 113~~ \; 0 \cdot 0298}$

$C = \frac{\sqrt{15 \cdot 240}}{1 \cdot 13 \times 10^{-3}}$

$= 3472 \cdot 8$

$C =$ ~~3452~~ 3470 [1]

(ii) Justify the number of significant figures that you have given for your value of C.

The raw value of L and A are given to 3 significant figures so

[1]

(d) (i) Twist the mass hanger through approximately 180°.

Release the mass hanger. The mass hanger will oscillate as shown in Fig. 2.2.

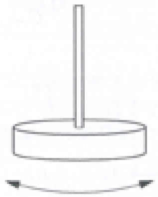

Fig. 2.2

(ii) Take measurements to determine the period T of the oscillations.

Record T.

T_1/s	T_2/s	T_3/s	T_{avg}/s
0·97	1·0	0·96	0·98

$T =$ ~~3·665~~ 0·985 [1]

(iii) Remove the wire from the mass hanger.

Your Mark
2(a)(ii)
2(a)(iii)
2(b)(iii)
2(b)(iv)
2(c)(i)
2(c)(ii)
2(d)(ii)
2(e)(ii)
2(f)(i)
2(f)(ii)
2(g)(i)
2(g)(ii)

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EXAMINER COMMENTS | MARK SCHEME

Select page

HIGH MIDDLE LOW

(e) (i) Take the **longer** wire. Repeat **(a)(ii)** and **(a)(iii)**.

15 × 0.01 = 0.15

d = ~~0.38mm~~ to 0.15 mm

= π(1.5 × 10⁻³)² / 4 = 1.77 × 10⁻⁶

A = 1.77 × 10⁻⁶ cm²

(ii) Secure the hook of the mass hanger to one end of the wire leaving 40 cm of excess wire.
Repeat **(b)(ii)**, **(b)(iii)**, **(c)(i)** and **(d)** for a value of *L* of approximately 30 cm.

L = 15.90 cm
15.20

C = √15.20 / 1.13 × 10⁻³

C = 3450

T/s	T_2/s	T_3/s	T_{avg}/s
3.67	3.65	3.66	3.66

T = 3.66 s. [3]

Your Mark	
2(a)(ii)	
2(a)(iii)	
2(b)(iii)	
2(b)(iv)	
2(c)(i)	
2(c)(ii)	
2(d)(ii)	
2(e)(ii)	
2(f)(i)	
2(f)(ii)	
2(g)(i)	
2(g)(ii)	

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(f) It is suggested that the relationship between T and C is

$$T = kC$$

where k is a constant.

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

$k_1 = \frac{C}{T}$

$k_1 = \frac{3470}{0.98}$

$= 3540$

$k_2 = \frac{C}{T}$

$= \frac{3450}{3.66}$

$= 943$

first value of k = 3540

second value of k = 943 [1]

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

$\frac{3540 - 943}{3540} \times 100 = 73\%$

73% results of my investigation shows that it does not support the suggested relationship as it is greater than 30%. [1]

Your Mark	
2(a)(ii)	
2(a)(iii)	
2(b)(iii)	
2(b)(iv)	
2(c)(i)	
2(c)(ii)	
2(d)(ii)	
2(e)(ii)	
2(f)(i)	
2(f)(ii)	
2(g)(i)	
2(g)(ii)	

Q2	Mark scheme
(a)(ii)	All raw values of d either to the nearest 0.01 or 0.001 mm with unit and in the range 0.250 mm to 0.450 mm **[1]**
(a)(iii)	Correct calculation of A with consistent unit and power of ten. **[1]**
(b)(iii)	Value of *L* with appropriate unit in range 10.0 cm ≤ *L* ≤ 20.0 cm. **[1]**
(b)(iv)	Percentage uncertainty in L based on absolute uncertainty of 2 mm to 8 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]**
(c)(i)	Correct calculation of *C* to the s.f. given by the candidate. **[1]**
(c)(ii)	Correct justification for s.f. in *C* linked to s.f. in d and *L*. **[1]**
(d)(ii)	Raw values for time to the nearest 0.1 s or better. *T* with unit and in range 0.5 s ≤ *T* ≤ 2.0 s. **[1]**
(e)(ii)	Second values of *d* and *L*. *Second value of T.* Quality: If $d_1 > d_2$ then second value of *T* > first value of *T*. **[1]**
(f)(i)	Two values of k calculated correctly. **[1]**
(f)(ii)	Sensible comment relating to the calculated values of k, testing against a criterion specified by the candidate. **[1]**

EXAMINER COMMENTS

MARK SCHEME

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

1. Two sets of readings are not enough to arrive at a valid conclusion.

2. Difficult to measure ~~the~~ T ~~because~~ for shorter wire because it stops rotation very quickly and speed of rotation was high

3. The fans in the room affected rotation because wire is thin and light weight so it moved by wind as well.

4. The longer wire was very thin. It breaks when the clip ~~was~~ is tight or if it is clipped several times. [4]

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

1. Take more readings and ~~plot~~ plot a graph or compare k values with more readings.

2. use a ~~video~~ play back camera or a slow motion camera to find T.

3. Turn off the fans while doing the experiment.

4. ~~use a small ball of clay~~ use a cork and a small ball of clay to hang the wire instead of the clip. [4]

[Total: 20]

Select page

HIGH MIDDLE LOW

Your Mark

2(a)(ii)
2(a)(iii)
2(b)(iii)
2(b)(iv)
2(c)(i)
2(c)(ii)
2(d)(ii)
2(e)(ii)
2(f)(i)
2(f)(ii)
2(g)(i)
2(g)(ii)

Q2 Mark scheme

(g)	(i) Limitations [4]	(ii) Improvements [4]	Do not credit
A	Two readings not enough to draw a conclusion	Take many readings and plot a graph/ obtain more k values and compare	"Repeat readings" on its own/few readings/only one reading/not enough readings for accurate value
B	Difficult to judge beginning and/or end of a cycle/a complete cycle	Draw a line/mark on the mass/ (fiducial) marker at equilibrium position	
C	Wire not straight/ kinked	Method of straightening wire e.g. use larger mass	
D	Difficult to measure L with reason e.g. metre rule awkward to position/parallax error	Improved method of measuring L e.g. marking L before putting into clip/ detailed method using set squares or ruler/ use a length guide (e.g. 15 cm wood)/ use string with detail/ use tape measure	Vernier calipers on its own/ set square on its own/ 30 cm ruler on its own
E	Wire slips (in clip)	Better method of gripping wire e.g. wrap wire around clamp/use two wooden blocks and wire	Any reference to attaching the mass to the wire
F	Mass swings as well as rotates/ clip moves around rod/there is a force on release	Better method of attaching clip to rod e.g. glue	
G	Shorter/thicker wire has too few cycles/dampens quickly/ (percentage) uncertainty greater for shorter/thicker wire	Video and timer/replay frame by frame	Repeats Longer wire

EXAMINER COMMENTS

MARK SCHEME

You may not need to use all of the materials provided.

2 In this experiment, you will investigate the movement of a loaded wire.

(a) (i) Take the **shorter** of the two wires.

(ii) Measure and record the diameter d of the wire.

diameter = $\frac{0.2+0.3+0.4}{3}$

= 0.3

d = 0.03 mm [1]

(iii) Calculate the cross-sectional area A of the wire using

$$A = \frac{\pi d^2}{4}.$$

$A = \frac{\pi (0.03)^2}{4}$

$= 7.07 \times 10^{-4}$

A = 7.07×10^{-4} mm² [1]

Select page

HIGH MIDDLE LOW

Your Mark

2(a)(ii)	
2(a)(iii)	
2(b)(iii)	
2(b)(iv)	
2(c)(i)	
2(c)(ii)	
2(d)(ii)	
2(e)(ii)	
2(f)(i)	
2(f)(ii)	
2(g)(i)	
2(g)(ii)	

Q2	Mark scheme
(a)(ii)	All raw values of d either to the nearest 0.01 or 0.001 mm with unit and in the range 0.250 mm to 0.450 mm **[1]**
(a)(iii)	Correct calculation of A with consistent unit and power of ten. **[1]**
(b)(iii)	Value of L with appropriate unit in range 10.0 cm ≤ L ≤ 20.0 cm. **[1]**
(b)(iv)	Percentage uncertainty in L based on absolute uncertainty of 2 mm to 8 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]**
(c)(i)	Correct calculation of C to the s.f. given by the candidate. **[1]**
(c)(ii)	Correct justification for s.f. in C linked to s.f. in d and L. **[1]**
(d)(ii)	Raw values for time to the nearest 0.1 s or better. T with unit and in range 0.5 s ≤ T ≤ 2.0 s. **[1]**
(e)(ii)	Second values of d and L. *Second value of T.* Quality: If $d_1 > d_2$ then second value of T > first value of T. **[1]**
(f)(i)	Two values of k calculated correctly. **[1]**
(f)(ii)	Sensible comment relating to the calculated values of k, testing against a criterion specified by the candidate. **[1]**

EXAMINER COMMENTS

MARK SCHEME

(b) (i) Secure the hook of the mass hanger to one end of the wire leaving at least 20 cm of excess wire.
The wire may be wrapped around the hook several times.

(ii) Set up the apparatus as shown in Fig. 2.1.

The length L of wire between the clip and the hook of the mass hanger should be approximately 15 cm.

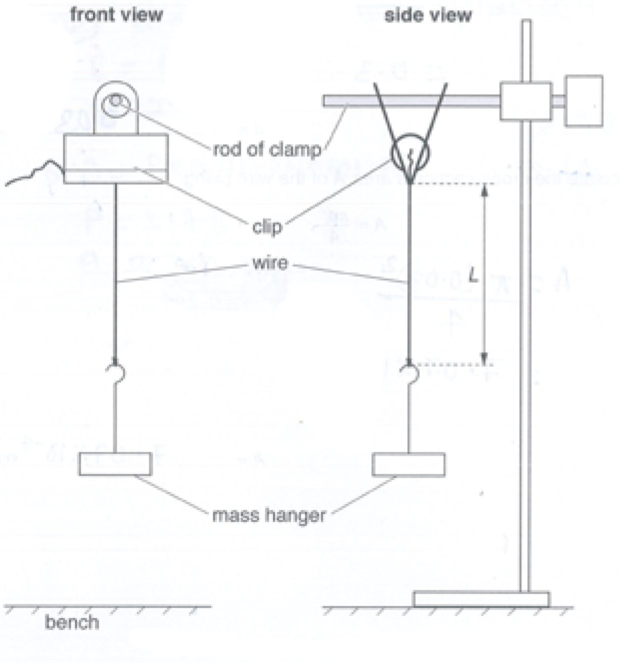

Fig. 2.1

(iii) Measure and record L.

$L = \frac{14+15+14.5}{3}$

L = 14.5cm. [1]

(iv) Estimate the percentage uncertainty in your value of L.

Percentage Uncertainty $= \frac{\Delta L}{L} \times 100\%$

$= \frac{0.1}{14.5} \times 100\%$

percentage uncertainty = 0.69% [1]

Your Mark

2(a)(ii)
2(a)(iii)
2(b)(iii)
2(b)(iv)
2(c)(i)
2(c)(ii)
2(d)(ii)
2(e)(ii)
2(f)(i)
2(f)(ii)
2(g)(i)
2(g)(ii)

Q2	Mark scheme
(a)(ii)	All raw values of d either to the nearest 0.01 or 0.001 mm with unit and in the range 0.250 mm to 0.450 mm **[1]**
(a)(iii)	Correct calculation of A with consistent unit and power of ten. **[1]**
(b)(iii)	Value of L with appropriate unit in range 10.0 cm ≤ L ≤ 20.0 cm. **[1]**
(b)(iv)	Percentage uncertainty in L based on absolute uncertainty of 2 mm to 8 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]**
(c)(i)	Correct calculation of C to the s.f. given by the candidate. **[1]**
(c)(ii)	Correct justification for s.f. in C linked to s.f. in d and L. **[1]**
(d)(ii)	Raw values for time to the nearest 0.1 s or better. T with unit and in range 0.5 s ≤ T ≤ 2.0 s. **[1]**
(e)(ii)	Second values of d and L. *Second value of T.* Quality: If $d_1 > d_2$ then second value of T > first value of T. **[1]**
(f)(i)	Two values of k calculated correctly. **[1]**
(f)(ii)	Sensible comment relating to the calculated values of k, testing against a criterion specified by the candidate. **[1]**

Select page

HIGH MIDDLE LOW

(c) (i) Calculate C where

$$C = \frac{\sqrt{L}}{A}.$$

$C = \frac{\sqrt{14.5 \times 10^{-1}}}{7.07 \times 10^{-4}}$
$= 1.70 \times 10^3$

$C =$ ......1.70×10^3...... [1]

(ii) Justify the number of significant figures that you have given for your value of C.

I've used three significant figure. As all my value of L and A are in three significant figure. [1]

(d) (i) Twist the mass hanger through approximately 180°

Release the mass hanger. The mass hanger will oscillate as shown in Fig. 2.2.

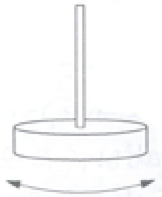

Fig. 2.2

(ii) Take measurements to determine the period T of the oscillations.

Record T.

Time taken for 10 oscillation (t_1) = 10.63.
Time taken for 1 oscillation(t_1) = 1.063.
Time taken for 10 oscillation = 12.78
Time taken for 1 oscillation (t_2) = 1.278

$T = \frac{t_1 + t_2}{2}$
$= 1.171$

$T =$ ......1.171 s...... [1]

(iii) Remove the wire from the mass hanger.

	Your Mark
2(a)(ii)	
2(a)(iii)	
2(b)(iii)	
2(b)(iv)	
2(c)(i)	
2(c)(ii)	
2(d)(ii)	
2(e)(ii)	
2(f)(i)	
2(f)(ii)	
2(g)(i)	
2(g)(ii)	

Q2	Mark scheme
(a)(ii)	All raw values of d either to the nearest 0.01 or 0.001 mm with unit and in the range 0.250 mm to 0.450 mm **[1]**
(a)(iii)	Correct calculation of A with consistent unit and power of ten. **[1]**
(b)(iii)	Value of L with appropriate unit in range 10.0 cm ≤ L ≤ 20.0 cm. **[1]**
(b)(iv)	Percentage uncertainty in L based on absolute uncertainty of 2 mm to 8 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]**
(c)(i)	Correct calculation of C to the s.f. given by the candidate. **[1]**
(c)(ii)	Correct justification for s.f. in C linked to s.f. in d and L. **[1]**
(d)(ii)	Raw values for time to the nearest 0.1 s or better. T with unit and in range 0.5 s ≤ T ≤ 2.0 s. **[1]**
(e)(ii)	Second values of d and L. *Second value of T.* Quality: If $d_1 > d_2$ then second value of $T >$ first value of T. **[1]**
(f)(i)	Two values of k calculated correctly. **[1]**
(f)(ii)	Sensible comment relating to the calculated values of k, testing against a criterion specified by the candidate. **[1]**

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

(e) (i) Take the **longer** wire. Repeat (a)(ii) and (a)(iii).

d = 0.1+0.2 / 2

d = 0.15 mm

A = π(0.015)² / 4

A = 1.76 × 10⁻⁴ mm²

(ii) Secure the hook of the mass hanger to one end of the wire leaving 40 cm of excess wire.
Repeat (b)(ii), (b)(iii), (c)(i) and (d) for a value of *L* of approximately 30 cm.

L = 29.5+30+29 / 3

L = 29.5 cm

C = √(29.5 × 10⁻¹ / 1.76 × 10⁻⁴)

= 9.76 × 10³

C = 9.76 × 10³.

Time taken for 10 oscillation = 13.78
Time taken for 1 oscillation (t₁) = 1.378
Time taken for 10 oscillation = 13.22
Time taken for 1 oscillation (t₂) = 1.322

T = t₁+t₂ / 2

T = 1.35 s

[3]

Your Mark	
2(a)(ii)	
2(a)(iii)	
2(b)(iii)	
2(b)(iv)	
2(c)(i)	
2(c)(ii)	
2(d)(ii)	
2(e)(ii)	
2(f)(i)	
2(f)(ii)	
2(g)(i)	
2(g)(ii)	

Q2	Mark scheme
(a)(ii)	All raw values of d either to the nearest 0.01 or 0.001 mm with unit and in the range 0.250 mm to 0.450 mm **[1]**
(a)(iii)	Correct calculation of A with consistent unit and power of ten. **[1]**
(b)(iii)	Value of *L* with appropriate unit in range 10.0 cm ≤ *L* ≤ 20.0 cm. **[1]**
(b)(iv)	Percentage uncertainty in L based on absolute uncertainty of 2 mm to 8 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]**
(c)(i)	Correct calculation of *C* to the s.f. given by the candidate. **[1]**
(c)(ii)	Correct justification for s.f. in *C* linked to s.f. in d and *L*. **[1]**
(d)(ii)	Raw values for time to the nearest 0.1 s or better. *T* with unit and in range 0.5 s ≤ *T* ≤ 2.0 s. **[1]**
(e)(ii)	Second values of *d* and *L*. *Second value of T.* Quality: If $d_1 > d_2$ then second value of *T* > first value of *T*. **[1]**
(f)(i)	Two values of k calculated correctly. **[1]**
(f)(ii)	Sensible comment relating to the calculated values of k, testing against a criterion specified by the candidate. **[1]**

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

(f) It is suggested that the relationship between T and C is

$$T = kC$$

where k is a constant.

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

For first value .
T = KC
1·17 = K × 1·70 × 10³
K = 6·88 × 10⁻⁴

For second value .
T = KC .
1·35 = K × 9·76 × 10³
K = 1·38 × 10⁻⁴

first value of k = 6·88 × 10⁻⁴

second value of k = 1·38 × 10⁻⁴ [1]

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

The result does not supports the relationship because as the value of K increases the value of T also increases with it. [1]

Your Mark: 2(a)(ii), 2(a)(iii), 2(b)(iii), 2(b)(iv), 2(c)(i), 2(c)(ii), 2(d)(ii), 2(e)(ii), 2(f)(i), 2(f)(ii), 2(g)(i), 2(g)(ii)

Q2	Mark scheme
(a)(ii)	All raw values of d either to the nearest 0.01 or 0.001 mm with unit and in the range 0.250 mm to 0.450 mm **[1]**
(a)(iii)	Correct calculation of A with consistent unit and power of ten. **[1]**
(b)(iii)	Value of L with appropriate unit in range 10.0 cm ≤ L ≤ 20.0 cm. **[1]**
(b)(iv)	Percentage uncertainty in L based on absolute uncertainty of 2 mm to 8 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]**
(c)(i)	Correct calculation of C to the s.f. given by the candidate. **[1]**
(c)(ii)	Correct justification for s.f. in C linked to s.f. in d and L. **[1]**
(d)(ii)	Raw values for time to the nearest 0.1 s or better. T with unit and in range 0.5 s ≤ T ≤ 2.0 s. **[1]**
(e)(ii)	Second values of d and L. *Second value of T.* Quality: If $d_1 > d_2$ then second value of T > first value of T. **[1]**
(f)(i)	Two values of k calculated correctly. **[1]**
(f)(ii)	Sensible comment relating to the calculated values of k, testing against a criterion specified by the candidate. **[1]**

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

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

1. Two sets of of data are not enough to draw conclusion.
2. Parall. Error while seeing the oscillation.
3. The angle of rotation might not be approximately 180°.
4. The wire at the clip brings error while rotating.

[4]

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

1. Atleast six sets of reading is required and plot its graph.
2. Sensor must be used for viewing the wire while it goes back and forth.
3. Protractor must be used to while rotating.
4. The wire must be glued at the top so that it doesn't move while rotating.

[4]

[Total: 20]

Your Mark

2(a)(ii)
2(a)(iii)
2(b)(iii)
2(b)(iv)
2(c)(i)
2(c)(ii)
2(d)(ii)
2(e)(ii)
2(f)(i)
2(f)(ii)
2(g)(i)
2(g)(ii)

Q2 Mark scheme

(g)	(i) Limitations [4]	(ii) Improvements [4]	Do not credit
A	Two readings not enough to draw a conclusion	Take many readings and plot a graph/ obtain more k values and compare	"Repeat readings" on its own/few readings/only one reading/not enough readings for accurate value
B	Difficult to judge beginning and/or end of a cycle/a complete cycle	Draw a line/mark on the mass/ (fiducial) marker at equilibrium position	
C	Wire not straight/ kinked	Method of straightening wire e.g. use larger mass	
D	Difficult to measure *L* with reason e.g. metre rule awkward to position/parallax error	Improved method of measuring *L* e.g. marking *L* before putting into clip/ detailed method using set squares or ruler/ use a length guide (e.g. 15 cm wood)/ use string with detail/ use tape measure	Vernier calipers on its own/ set square on its own/ 30 cm ruler on its own
E	Wire slips (in clip)	Better method of gripping wire e.g. wrap wire around clamp/use two wooden blocks and wire	Any reference to attaching the mass to the wire
F	Mass swings as well as rotates/ clip moves around rod/there is a force on release	Better method of attaching clip to rod e.g. glue	
G	Shorter/thicker wire has too few cycles/dampens quickly/ (percentage) uncertainty greater for shorter/thicker wire	Video and timer/replay frame by frame	Repeats Longer wire

EXAMINER COMMENTS

MARK SCHEME

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Cambridge Assessment International Education

Interactive

Interactive Example Candidate Responses
Paper 4 (May/June 2016), Question 1

Cambridge International AS & A Level
Physics 9702

Version 1.0

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Select page

HIGH MIDDLE LOW

1 A binary star consists of two stars A and B that orbit one another, as illustrated in Fig. 1.1.

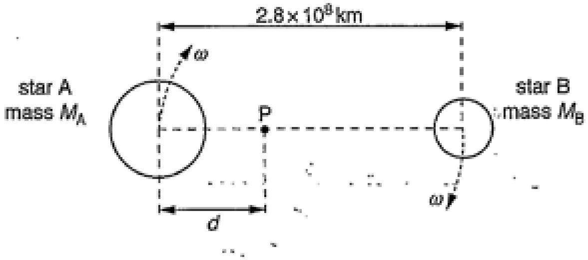

Fig. 1.1

The stars are in circular orbits with the centres of both orbits at point P, a distance *d* from the centre of star A.

(a) (i) Explain why the centripetal force acting on both stars has the same magnitude.

Because the centripetal force acting on both stars are provided by the gravitational force. $F_G = \frac{G M_A M_B}{r^2} = m\omega^2 r = m\left(\frac{2\pi}{T}\right)^2 r$. The angular velocity ω and period T of both stars are the same. So the centripetal force (and gravitational forces) for both stars are the same. [2]

(ii) The period of the orbit of the stars about point P is 4.0 years.

Calculate the angular speed ω of the stars.

$$\omega = \frac{2\pi}{T} = \frac{2\pi}{4 \times 365 \times 24 \times 3600}$$

$$= 4.98 \times 10^{-8} \text{ rad s}^{-1}$$

ω = 4.98 × 10⁻⁸ rad s⁻¹ [2]

Your Mark

1(a)(i)

1(a)(ii)

1(b)(i)

1(b)(ii)

Q1	Mark scheme		
(a)(i)	gravitational force provides/is the centripetal force	B1	
	same gravitational force (by Newton III)	B1	[2]
(a)(ii)	$\omega = 2\pi / T$		
	$= 2\pi / (4.0 \times 365 \times 24 \times 3600)$	C1	
	$= 5.0\ (4.98) \times 10^{-8}$ rad s^{-1}	A1	[2]
(b)(i)	(centripetal force =) $M_A d\omega^2 = M_B(2.8 \times 10^8 - d)\omega^2$ **or**		
	$M_A d_A = M_B dB$	C1	
	$M_A / M_B = 3.0 = (2.8 \times 10^8 - d) / d$	C1	
	$d = 7.0 \times 10^7$ km	A1	[3]
(b)(ii)	$GM_A M_B / (2.8 \times 10^{11})2 = M_A d\omega^2$	B1	
	$M_B = (2.8 \times 10^{11})^2 \times d\omega^2 / G$		
	$= (2.8 \times 10^{11})^2 \times (7.0 \times 10^{10}) \times (4.98 \times 10^{-8})^2 / (6.67 \times 10^{-11})$	C1	
	$= 2.0 \times 10^{29}$ kg	A1	[3]
			[Total: 10]

EXAMINER COMMENTS

MARK SCHEME

(b) The separation of the centres of the stars is 2.8×10^8 km.
The mass of star A is M_A. The mass of star B is M_B.

The ratio $\frac{M_A}{M_B}$ is 3.0.

(i) Determine the distance d.

∵ ω, T, Fc are the same for A and B
∴ $M_A \omega^2 d = M_B \omega^2 (2.8 \times 10^8 - d)$
∴ $\frac{M_A}{M_B} = \frac{2.8 \times 10^8 - d}{d} = 3$
∴ $d = 7.0 \times 10^7$ km

d = 7.0 x10⁷ km [3]

(ii) Use your answers in (a)(ii) and (b)(i) to determine the mass M_B of star B.
Explain your working.

∵ $\frac{M_A}{M_B} = 3$ ∴ $M_A = 3M_B$
∴ $G\frac{3M_B \cdot M_B}{\ell^2} = M_B \omega^2 \ell$
$6.67 \times 10^{-11} \times \frac{3M_B}{(2.8 \times 10^8 \times 10^3)^2} = (4.98 \times 10^{-8})^2 \times (2.8 \times 10^8 \times 10^3 - 7 \times 10^7)$
$M_B = 2.72 \times 10^{29}$ kg

M_B = 2.72 x10²⁹ kg [3]

[Total: 10]

Select page

HIGH | MIDDLE | LOW

Your Mark

1(a)(i)

1(a)(ii)

1(b)(i)

1(b)(ii)

Q1	Mark scheme		
(a)(i)	gravitational force provides/is the centripetal force	B1	
	same gravitational force (by Newton III)	B1	[2]
(a)(ii)	$\omega = 2\pi / T$		
	$= 2\pi / (4.0 \times 365 \times 24 \times 3600)$	C1	
	$= 5.0\ (4.98) \times 10^{-8}$ rad s^{-1}	A1	[2]
(b)(i)	(centripetal force =) $M_A d\omega^2 = M_B(2.8 \times 10^8 - d)\omega^2$ **or** $M_A d_A = M_B d_B$	C1	
	$M_A / M_B = 3.0 = (2.8 \times 10^8 - d) / d$	C1	
	$d = 7.0 \times 10^7$ km	A1	[3]
(b)(ii)	$GM_AM_B / (2.8 \times 10^{11})2 = M_A d\omega^2$	B1	
	$M_B = (2.8 \times 10^{11})^2 \times d\omega^2 / G$ $= (2.8 \times 10^{11})^2 \times (7.0 \times 10^{10}) \times (4.98 \times 10^{-8})^2 / (6.67 \times 10^{-11})$	C1	
	$= 2.0 \times 10^{29}$ kg	A1	[3]
			[Total: 10]

EXAMINER COMMENTS | MARK SCHEME

Select page

HIGH MIDDLE LOW

1 A binary star consists of two stars A and B that orbit one another, as illustrated in Fig. 1.1.

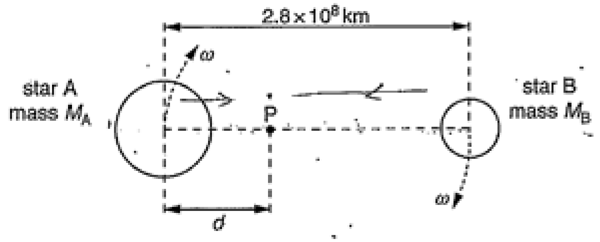

Fig. 1.1

mxω²
mv²/r   mvω
Fc = ma

The stars are in circular orbits with the centres of both orbits at point P, a distance *d* from the centre of star A.

(a) (i) Explain why the centripetal force acting on both stars has the same magnitude.

Both stars have same angular speed. ~~and acceleration~~. They act as point masses so mass has negligible effect on force. [2]

(ii) The period of the orbit of the stars about point P is 4.0 years.

Calculate the angular speed ω of the stars.

$\omega = \theta / T = 2\pi / T = 2\pi / T = 2\pi f = 2\pi / (4 \times 365 \times 24 \times 3600)$

$= 4.98 \times 10^{-8}$.

ω = 4.98 × 10⁻⁸ rad s⁻¹ [2]

Your Mark

1(a)(i)

1(a)(ii)

1(b)(i)

1(b)(ii)

Q1	Mark scheme		
(a)(i)	gravitational force provides/is the centripetal force	B1	
	same gravitational force (by Newton III)	B1	[2]
(a)(ii)	$\omega = 2\pi / T$		
	$= 2\pi / (4.0 \times 365 \times 24 \times 3600)$	C1	
	$= 5.0\ (4.98) \times 10^{-8}$ rad s^{-1}	A1	[2]
(b)(i)	(centripetal force =) $M_A d\omega^2 = M_B(2.8 \times 10^8 - d)\omega^2$ **or**		
	$M_A d_A = M_B dB$	C1	
	$M_A / M_B = 3.0 = (2.8 \times 10^8 - d) / d$	C1	
	$d = 7.0 \times 10^7$ km	A1	[3]
(b)(ii)	$GM_AM_B / (2.8 \times 10^{11})2 = M_A d\omega^2$	B1	
	$M_B = (2.8 \times 10^{11})^2 \times d\omega^2 / G$		
	$= (2.8 \times 10^{11})^2 \times (7.0 \times 10^{10}) \times (4.98 \times 10^{-8})^2 / (6.67 \times 10^{-11})$	C1	
	$= 2.0 \times 10^{29}$ kg	A1	[3]
			[Total: 10]

EXAMINER COMMENTS

MARK SCHEME

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HIGH MIDDLE LOW

(b) The separation of the centres of the stars is 2.8×10^8 km.
The mass of star A is M_A. The mass of star B is M_B.
The ratio $\frac{M_A}{M_B}$ is 3.0.

Fc force.

(i) Determine the distance *d*.

$M_A \times d \times \omega^2 = M_B \times (2.8 \times 10^8 - d)\,\omega^2$

$\frac{M_A}{M_B} \times d = (2.8 \times 10^8 - d)$

$3 \times d = 2.8 \times 10^8 - d$

$3d + d = 2.8 \times 10^8$

7.0×10^7 km

d = 7.0×10^7 km [3]

(ii) Use your answers in **(a)(ii)** and **(b)(i)** to determine the mass M_B of star B.
Explain your working.

$F_c = mr\omega^2$. $r = 2.1 \times 10^8$ km.

$mr\omega^2 = \frac{GMm}{r^2}$

$(7.0 \times 10^7) \times (4.98 \times 10^{-8})^2 = \frac{(6.67 \times 10^{-11})(M_A)}{(7.0 \times 10^7)^2}$

2602.7
2600 2.6×10^3 kg.

$\frac{M_A}{M_B} = 3$

M_B = 8.7×10^2 kg [3]

$\frac{(2.6 \times 10^3)}{3} = M_B$. 870

[Total: 10]

Your Mark

1(a)(i)

1(a)(ii)

1(b)(i)

1(b)(ii)

Q1	Mark scheme		
(a)(i)	gravitational force provides/is the centripetal force	B1	
	same gravitational force (by Newton III)	B1	[2]
(a)(ii)	$\omega = 2\pi / T$		
	$= 2\pi / (4.0 \times 365 \times 24 \times 3600)$	C1	
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(b)(i)	(centripetal force =) $M_A d\omega^2 = M_B(2.8 \times 10^8 - d)\omega^2$ **or**		
	$M_A d_A = M_B dB$	C1	
	$M_A / M_B = 3.0 = (2.8 \times 10^8 - d) / d$	C1	
	$d = 7.0 \times 10^7$ km	A1	[3]
(b)(ii)	$GM_AM_B / (2.8 \times 10^{11})2 = M_A d\omega^2$	B1	
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	$= (2.8 \times 10^{11})^2 \times (7.0 \times 10^{10}) \times (4.98 \times 10^{-8})^2 / (6.67 \times 10^{-11})$	C1	
	$= 2.0 \times 10^{29}$ kg	A1	[3]
			[Total: 10]

EXAMINER COMMENTS

MARK SCHEME

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HIGH MIDDLE LOW

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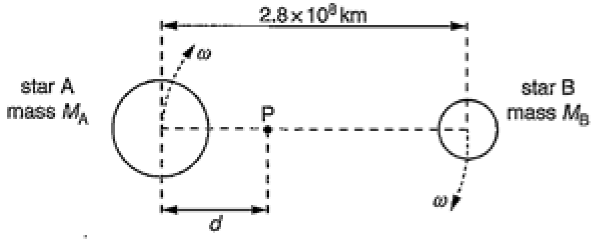

Fig. 1.1

The stars are in circular orbits with the centres of both orbits at point P, a distance d from the centre of star A.

(a) (i) Explain why the centripetal force acting on both stars has the same magnitude.

The Torque forces of on both stars are a couple. The (Torque) force of torque is equal to the centripetal force which is. The torque forces = force on each one × the distance between them, which are same. [2]

(ii) The period of the orbit of the stars about point P is 4.0 years.

Calculate the angular speed ω of the stars.

$\omega = \frac{2\pi}{T}$ $\qquad T = 4 \times 365 \times 24 \times 60 \times 60$

$= \frac{2\pi}{126144000}$ $\qquad = 126144000$ s

$= 4.98 \times 10^{-8}$

$= 5.0 \times 10^{-8}$

ω = ...5.0 × 10⁻⁸...... rad s⁻¹ [2]

Your Mark

1(a)(i)

1(a)(ii)

1(b)(i)

1(b)(ii)

Q1	Mark scheme		
(a)(i)	gravitational force provides/is the centripetal force	B1	
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			[Total: 10]

EXAMINER COMMENTS

MARK SCHEME

(b) The separation of the centres of the stars is 2.8×10^8 km.
The mass of star A is M_A. The mass of star B is M_B.

The ratio $\frac{M_A}{M_B}$ is 3.0.

(i) Determine the distance d.

$F_{(A)} = F_{(B)}$ $\frac{GMm}{r} = F \times d$

$(F_{cp} = F'_{cp})$ → $F_A = F_G$

$\frac{GM_A}{r^2} = \frac{GMm}{r^2}$ $3 = (2.8 \times 10^8)^2$

$\frac{M_A}{r^2} = \frac{M_B}{r^2}$

$\frac{M_A}{M_B} = \frac{r^2}{r^2}$

d = ...1.6 × 10⁸...... km [3]

(ii) Use your answers in (a)(ii) and (b)(i) to determine the mass M_B of star B.
Explain your working.

$\frac{GMm}{r} = \frac{GMm}{r}$ $\frac{F}{m\omega^2 r} = \frac{F}{m_A \omega^2 r}$

$F = m\omega^2 r$ $F = m\omega^2 r$

$m = \frac{F}{\omega^2 r} = \frac{F}{(5.0 \times 10^{-8})^2 \times 1.6 \times 10^8}$ $m = \frac{F}{(5.0 \times 10^{-8})^2 \times 1.6 \times 10^8}$

$= \frac{F}{4 \times 10^{-7}}$

M_B = ... $\frac{F}{4 \times 10^{-7}}$ ...... kg [3]

[Total: 10]

Your Mark

1(a)(i)

1(a)(ii)

1(b)(i)

1(b)(ii)

Q1	Mark scheme		
(a)(i)	gravitational force provides/is the centripetal force	B1	
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	or		
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	$M_A / M_B = 3.0 = (2.8 \times 10^8 - d) / d$	C1	
	$d = 7.0 \times 10^7$ km	A1	[3]
(b)(ii)	$GM_A M_B / (2.8 \times 10^{11})2 = M_A d\omega^2$	B1	
	$M_B = (2.8 \times 10^{11})^2 \times d\omega^2 / G$		
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			[Total: 10]

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Interactive

Interactive Example Candidate Responses Paper 4 (May/June 2016), Question 4

Cambridge International AS & A Level Physics 9702

Version 1.0

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HIGH MIDDLE LOW

4 A metal block hangs vertically from one end of a spring. The other end of the spring is tied to a thread that passes over a pulley and is attached to a vibrator, as shown in Fig. 4.1.

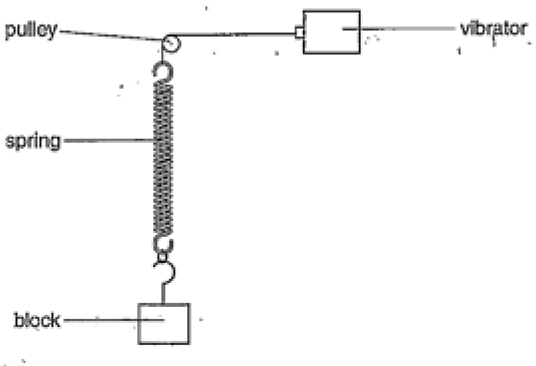

Fig. 4.1

(a) The vibrator is switched off.
The metal block of mass 120 g is displaced vertically and then released. The variation with time t of the displacement y of the block from its equilibrium position is shown in Fig. 4.2.

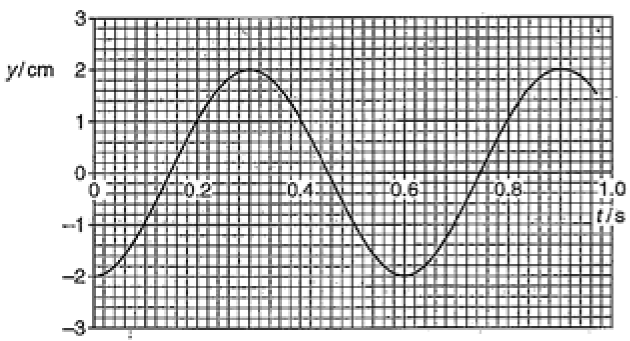

Fig. 4.2

For the vibrations of the block, calculate

(i) the angular frequency ω,

$\omega = \frac{2\pi}{T} = \frac{2\pi}{0.6}$

$\omega = 10.47$

ω = ...10.5.......... rad s^{-1} [2]

Your Mark

4(a)(i)

4(a)(ii)

4(b)

4(c)

Q4	Mark scheme		
(a)(i)	T = 0.60 s and $\omega = 2\pi / T$	C1	
	ω = 10 (10.47) rad s^{-1}	A1	[2]
(a)(ii)	energy $= \frac{1}{2}m\omega^2 x_0^2$ or $\frac{1}{2}mv^2$ and $v = \omega x_0$	C1	
	$= \frac{1}{2} \times 120 \times 10^{-3} \times (10.5)^2 \times (2.0 \times 10^{-2})^2$		
	$= 2.6 \times 10^{-3}$ J	A1	[2]
(b)	sketch: smooth curve in correct directions	B1	
	peak at f	M1	
	amplitude never zero and line extends from $0.7f$ to $1.3f$	A1	[3]
(c)	sketch: peaked line always below a peaked line A	M1	
	peak not as sharp and at (or slightly less than) frequency of peak in line A	A1	[2]
			[Total: 9]

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

(ii) the energy of the vibrations.

$E = \frac{1}{2} m (\omega \sqrt{x_0^2 - x^2})^2$

$= \frac{1}{2} m \omega^2 x_0^2$

$= \frac{1}{2} \times 120 \times 10^{-3} \times (10.47)^2 \times (2 \times 10^{-2})^2$

$= 2.631 \times 10^{-3}$

energy = 2.6×10^{-3} J [2]

(b) The vibrator is now switched on.

The frequency of vibration is varied from 0.7*f* to 1.3*f* where *f* is the frequency of vibration of the block in **(a)**.

For the block, complete Fig. 4.3 to show the variation with frequency of the amplitude of vibration. Label this line A. [3]

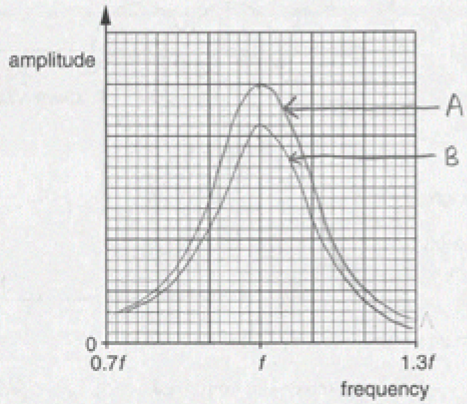

Fig. 4.3

(c) Some light feathers are now attached to the block in **(b)** to increase air resistance.

The frequency of vibration is once again varied from 0.7*f* to 1.3*f*. The new amplitude of vibration is measured for each frequency.

On Fig. 4.3, draw a line to show the variation with frequency of the amplitude of vibration. Label this line B. [2]

[Total: 9]

Your Mark

4(a)(i)

4(a)(ii)

4(b)

4(c)

Q4	Mark scheme		
(a)(i)	$T = 0.60$ s and $\omega = 2\pi / T$	C1	
	$\omega = 10$ (10.47) rad s^{-1}	A1	**[2]**
(a)(ii)	energy $= \frac{1}{2} m\omega^2 x_0^2$ or $\frac{1}{2} mv^2$ and $v = \omega x_0$	C1	
	$= \frac{1}{2} \times 120 \times 10^{-3} \times (10.5)^2 \times (2.0 \times 10^{-2})^2$		
	$= 2.6 \times 10^{-3}$ J	A1	**[2]**
(b)	sketch: smooth curve in correct directions	B1	
	peak at *f*	M1	
	amplitude never zero and line extends from 0.7*f* to 1.3*f*	A1	**[3]**
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EXAMINER COMMENTS

MARK SCHEME

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HIGH MIDDLE LOW

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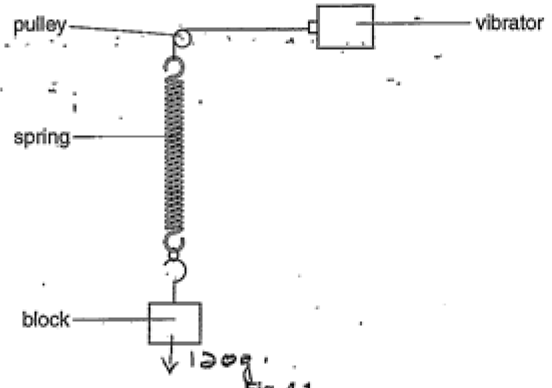

Fig. 4.1

(a) The vibrator is switched off.
The metal block of mass 120 g is displaced vertically and then released. The variation with time t of the displacement y of the block from its equilibrium position is shown in Fig. 4.2.

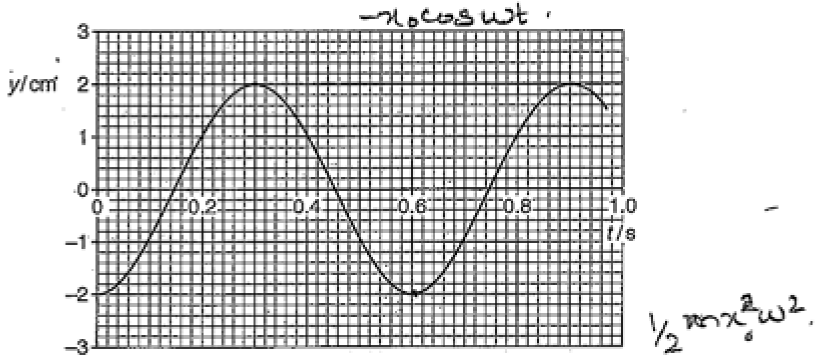

Fig. 4.2

For the vibrations of the block, calculate

(i) the angular frequency ω,

$\omega = 2\pi f$ $= 1/0.6 = f = 1.67$ Hz. $= 10.5$

ω = ...10.5......

Your Mark

4(a)(i)

4(a)(ii)

4(b)

4(c)

Q4	Mark scheme		
(a)(i)	T = 0.60 s and $\omega = 2\pi / T$	C1	
	ω = 10 (10.47) rad s^{-1}	A1	[2]
(a)(ii)	energy $= \frac{1}{2} m\omega^2 x_0^2$ or $\frac{1}{2} mv^2$ and $v = \omega x_0$	C1	
	$= \frac{1}{2} \times 120 \times 10^{-3} \times (10.5)^2 \times (2.0 \times 10^{-2})^2$		
	$= 2.6 \times 10^{-3}$ J	A1	[2]
(b)	sketch: smooth curve in correct directions	B1	
	peak at f	M1	
	amplitude never zero and line extends from 0.7f to 1.3f	A1	[3]
(c)	sketch: peaked line always below a peaked line A	M1	
	peak not as sharp and at (or slightly less than) frequency of peak in line A	A1	[2]
			[Total: 9]

EXAMINER COMMENTS

MARK SCHEME

(ii) the energy of the vibrations.

$T.E = \frac{1}{2} m x_0^2 \omega^2$

$= \frac{1}{2}(0.12)(2\times10^{-2})^2(10.5)^2$

$= 2.646\times10^{-3}$

energy = 2.65×10^{-3} J [2]

(b) The vibrator is now switched on.

The frequency of vibration is varied from 0.7*f* to 1.3*f* where *f* is the frequency of vibration of the block in **(a)**.

For the block, complete Fig. 4.3 to show the variation with frequency of the amplitude of vibration. Label this line A. [3]

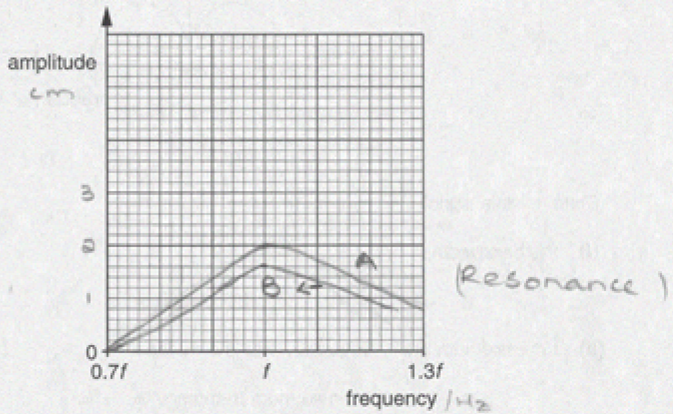

Fig. 4.3

(c) Some light feathers are now attached to the block in **(b)** to increase air resistance.

The frequency of vibration is once again varied from 0.7*f* to 1.3*f*. The new amplitude of vibration is measured for each frequency.

On Fig. 4.3, draw a line to show the variation with frequency of the amplitude of vibration. Label this line B. [2]

[Total: 9]

Your Mark

4(a)(i)

4(a)(ii)

4(b)

4(c)

Q4	Mark scheme		
(a)(i)	T = 0.60 s and $\omega = 2\pi / T$	C1	
	ω = 10 (10.47) rad s^{-1}	A1	**[2]**
(a)(ii)	energy $= \frac{1}{2}m\omega^2 x_0^2$ or $\frac{1}{2}mv^2$ and $v = \omega x_0$	C1	
	$= \frac{1}{2} \times 120 \times 10^{-3} \times (10.5)^2 \times (2.0 \times 10^{-2})^2$		
	$= 2.6 \times 10^{-3}$ J	A1	**[2]**
(b)	sketch: smooth curve in correct directions	B1	
	peak at *f*	M1	
	amplitude never zero and line extends from 0.7*f* to 1.3*f*	A1	**[3]**
(c)	sketch: peaked line always below a peaked line A	M1	
	peak not as sharp and at (or slightly less than) frequency of peak in line A	A1	**[2]**
			[Total: 9]

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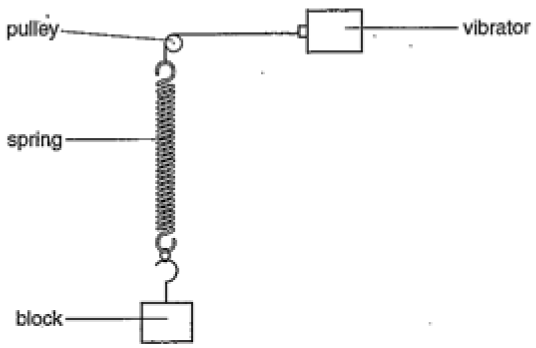

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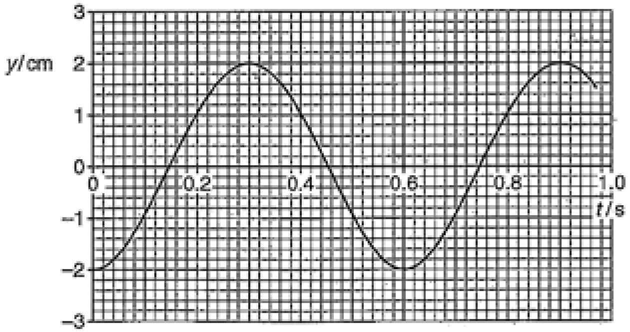

Fig. 4.2

For the vibrations of the block, calculate

(i) the angular frequency ω,

~~$f = \frac{1}{T}$~~ ~~$= \frac{1}{0.6} = 1.67$~~

$\omega = \frac{2\pi}{T}$

$= \frac{2\pi}{0.6}$

$=$

ω = ~~1.67~~ 10.47 rad s^{-1} [2]

Your Mark

4(a)(i)

4(a)(ii)

4(b)

4(c)

Q4	Mark scheme		
(a)(i)	T = 0.60 s and $\omega = 2\pi / T$	C1	
	ω = 10 (10.47) rad s^{-1}	A1	**[2]**
(a)(ii)	energy $= \frac{1}{2}m\omega^2 x_0^2$ or $\frac{1}{2}mv^2$ and $v = \omega x_0$	C1	
	$= \frac{1}{2} \times 120 \times 10^{-3} \times (10.5)^2 \times (2.0 \times 10^{-2})^2$		
	$= 2.6 \times 10^{-3}$ J	A1	**[2]**
(b)	sketch: smooth curve in correct directions	B1	
	peak at f	M1	
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	peak not as sharp and at (or slightly less than) frequency of peak in line A	A1	**[2]**
			[Total: 9]

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

(ii) the energy of the vibrations.

$\frac{1}{2} \times m \times \omega^2$

$= \frac{1}{2} \times 0.12 \times (10.47)^2$

$= 0.06 \times 109.6 = 6.58$

energy = ...6.58...... J [2]

(b) The vibrator is now switched on.

The frequency of vibration is varied from 0.7*f* to 1.3*f* where *f* is the frequency of vibration of the block in **(a)**.

For the block, complete Fig. 4.3 to show the variation with frequency of the amplitude of vibration. Label this line A. [3]

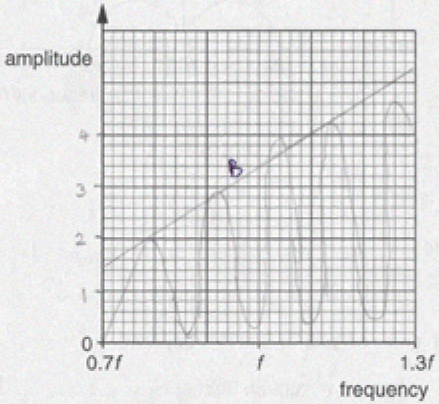

Fig. 4.3

(c) Some light feathers are now attached to the block in **(b)** to increase air resistance.

The frequency of vibration is once again varied from 0.7*f* to 1.3*f*. The new amplitude of vibration is measured for each frequency.

On Fig. 4.3, draw a line to show the variation with frequency of the amplitude of vibration. Label this line B. [2]

[Total: 9]

Your Mark

4(a)(i)

4(a)(ii)

4(b)

4(c)

Q4	Mark scheme		
(a)(i)	T = 0.60 s and ω = 2π / T	C1	
	ω = 10 (10.47) rad s^{-1}	A1	[2]
(a)(ii)	energy = ½$m\omega^2 x_0^2$ or ½mv^2 and v = ωx_0	C1	
	= ½ × 120 × 10^{-3} × $(10.5)^2$ × $(2.0 \times 10^{-2})^2$		
	= 2.6 × 10^{-3} J	A1	[2]
(b)	sketch: smooth curve in correct directions	B1	
	peak at *f*	M1	
	amplitude never zero and line extends from 0.7*f* to 1.3*f*	A1	[3]
(c)	sketch: peaked line always below a peaked line A	M1	
	peak not as sharp and at (or slightly less than) frequency of peak in line A	A1	[2]
			[Total: 9]

EXAMINER COMMENTS

MARK SCHEME

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Interactive

Interactive Example Candidate Responses
Paper 4 (May/June 2016), Question 6
Cambridge International AS & A Level
Physics 9702

Version 1.0

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6 (a) By reference to electric field lines, explain why, for points outside an isolated spherical conductor, the charge on the sphere may be considered to act as a point charge at its centre.

The electric field lines spread outwards radially and would meet at a point in the centre of the sphere. The electric field lines show the strength of the electric field, which is concentrated in the centre. Thus all the charge is considered to act at its centre. [2]

(b) Two isolated protons are separated in a vacuum by a distance x.

(i) Calculate the ratio

$$\frac{\text{electric force between the two protons}}{\text{gravitational force between the two protons}}.$$

$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2} = \frac{(1.60\times10^{-19})^2}{4\pi\varepsilon_0 x^2}$

$F = \frac{GMm}{r^2} = \frac{6.67\times10^{-11}\times(1.67\times10^{-27})^2}{x^2}$

$\frac{(1.60\times10^{-19})^2}{4\pi\varepsilon_0 x^2} \div \frac{6.67\times10^{-11}\times(1.67\times10^{-27})^2}{x^2}$

$\frac{2.56\times10^{-38}}{1.11\times10^{-11}} \times \frac{1}{1.86\times10^{-64}}$

$\frac{2.56\times10^{-38}}{2.07\times10^{-74}} = \frac{1.24\times10^{36}}{1}$ ratio = 1.24×10^{36} [3]

(ii) By reference to your answer in (i), suggest why gravitational forces are not considered when calculating the force between charged particles.

The gravitational forces are negligible compared to the force between charges. (1.24×10^{36} : 1, F_E : F_G) [1]

[Total: 6]

Select page

HIGH MIDDLE LOW

Your Mark

6(a)

6(b)(i)

6(b)(ii)

Q6	Mark scheme		
(a)	lines perpendicular to surface **or** lines are radial	M1	
	lines appear to come from centre	A1	[2]
(b)(i)	$F_E = (1.6\times10^{-19})^2 / 4\pi\varepsilon_0 x^2$	C1	
	$F_G = G\times(1.67\times10^{-27})^2 / x^2$	C1	
	$F_E / F_G = (1.6\times10^{-19})^2 \times (8.99\times10^9) / [(1.67\times10^{-27})^2 \times (6.67\times10^{-11})]$ $= 1.2\ (1.24)\times 1036$	A1	[3]
(b) (ii)	$F_E >> F_G$	B1	[1]
			[Total: 6]

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

6 (a) By reference to electric field lines, explain why, for points outside an isolated spherical conductor, the charge on the sphere may be considered to act as a point charge at its centre.

Outside spherical conductor, charges can move and hence there is a resultant force on charge. With resultant force, there is field acting on the charge.

.... [2]

(b) Two isolated protons are separated in a vacuum by a distance x.

(i) Calculate the ratio

$$\frac{\text{electric force between the two protons}}{\text{gravitational force between the two protons}} = \frac{Q_1Q_2}{4\pi\varepsilon_0 x^2} \div \frac{GM_1M_2}{x^2}$$

$$= \frac{(1.6\times10^{-19})^2}{4\pi(8.85\times10^{-12})x^2} \div \frac{6.67\times10^{-11}(1.67\times10^{-27})^2}{x^2}$$

$$= \frac{(1.6\times10^{-19})^2}{4\pi(8.85\times10^{-12})} \times \frac{1}{6.67\times10^{-11}(1.67\times10^{-27})^2}$$

$$= 1.24\times10^{36} \text{ (3sf)}$$

ratio = 1.24×10^{36} [3]

(ii) By reference to your answer in (i), suggest why gravitational forces are not considered when calculating the force between charged particles.

It is too small compared to electric force and ratio is big.

.... [1]

[Total: 6]

Your Mark

6(a)

6(b)(i)

6(b)(ii)

Q6	Mark scheme		
(a)	lines perpendicular to surface **or** lines are radial	M1	
	lines appear to come from centre	A1	[2]
(b)(i)	$F_E = (1.6\times10^{-19})^2/4\pi\varepsilon_0 x^2$	C1	
	$F_G = G\times(1.67\times10^{-27})^2/x^2$	C1	
	$F_E/F_G = (1.6\times10^{-19})^2\times(8.99\times10^9)/[(1.67\times10^{-27})^2\times(6.67\times10^{-11})]$ $= 1.2\ (1.24)\times1036$	A1	[3]
(b) (ii)	$F_E >> F_G$	B1	[1]
			[Total: 6]

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

6 (a) By reference to electric field lines, explain why, for points outside an isolated spherical conductor, the charge on the sphere may be considered to act as a point charge at its centre.

Electric field lines show the path and direction of an isolated positive charge. Since the isolated spherical conductor has a charge and is in the electric field it can be considered as a point charge. [2]

(b) Two isolated protons are separated in a vacuum by a distance x.

(i) Calculate the ratio

$$\frac{\text{electric force between the two protons}}{\text{gravitational force between the two protons}}.$$

$$= \frac{kQQ_2}{x^2} \div \frac{GM_1M_2}{x^2}$$

$$= \frac{kQQ_2}{x^2} \times \frac{x^2}{GM_1M_2}$$

$$= \frac{\frac{1}{4\pi\varepsilon_0} \times (1.6\times10^{-19})^2}{6.67\times10^{-11} \times 2(1.67\times10^{-27})} = \frac{2.3\times10^{-48}}{2.2\times10^{-37}}$$

ratio = 1.03 [3]

(ii) By reference to your answer in (i), suggest why gravitational forces are not considered when calculating the force between charged particles.

It's almost the same, since the ratio between the two forces is one. [1]

[Total: 6]

Your Mark

6(a)

6(b)(i)

6(b)(ii)

Q6	Mark scheme		
(a)	lines perpendicular to surface **or** lines are radial	M1	
	lines appear to come from centre	A1	**[2]**
(b)(i)	$F_E = (1.6 \times 10^{-19})^2 / 4\pi\varepsilon_0 x^2$	C1	
	$F_G = G \times (1.67 \times 10^{-27})^2 / x^2$	C1	
	$F_E / F_G = (1.6 \times 10^{-19})^2 \times (8.99 \times 10^9) / [(1.67\times10^{-27})^2 \times (6.67\times10^{-11})]$		
	$= 1.2\ (1.24) \times 1036$	A1	**[3]**
(b) (ii)	$F_E >> F_G$	B1	**[1]**
			[Total: 6]

EXAMINER COMMENTS

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Interactive Example Candidate Responses Paper 4 (May/June 2016), Question 12

Cambridge International AS & A Level Physics 9702

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12 High-energy electrons collide with a metal target, producing X-ray photons.

The variation with wavelength of the intensity of the X-ray beam is illustrated in Fig. 12.1.

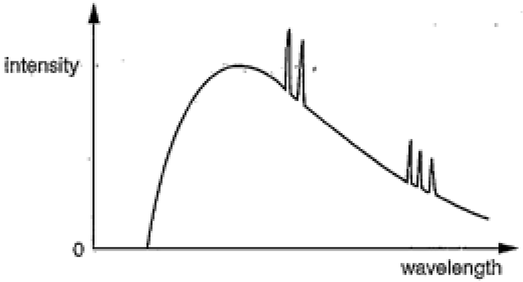

Fig. 12.1

(a) Explain why there is

(i) a continuous distribution of wavelengths,

Electromagnetic radiation is ~~released~~ emitted as electrons accelerate. Electrons has a wide range of acceleration so there is a range of wavelengths. Electrons are accelerating continuously so continuous distribution of wavelengths. [3]

(ii) a sharp cut-off at short wavelength,

For shortest wavelength, acceleration is greatest. [2]

(iii) a series of peaks superimposed on the continuous distribution of wavelengths.

De-excitation of some electrons in target atom gives line spectra forming some peaks on distribution graph. [1]

(b) In the X-ray imaging of body structures, longer wavelength photons are frequently filtered out of the X-ray beam.

(i) State how this filtering is achieved.

Place a aluminium filter in x-ray beam. [1]

Your Mark

12(a)(i)

12(a)(ii)

12(a)(iii)

12(b)(i)

12(b)(iii)

Q12	Mark scheme		
(a)(i)	(X–ray) photon produced when electron/charged particle is stopped/accelerated (suddenly) range of accelerations (in target) hence distribution of wavelengths	B1 M1 A1	 [3]
(a)(ii)	electron gives all its energy to one photon electron stopped in single collision	B1 B1	 [2]
(a)(iii)	de-excitation of (orbital) electrons in target/anode/metal	B1	[1]
(b)(i)	aluminium sheet/filter/foil (placed in beam from tube)	B1	[1]
(b)(ii)	(long wavelength X-rays) do not pass through the body	B1	[1] [Total: 8]

(ii) Suggest the reason for this filtering.

It is that long wavelengths x-rays are absorbed by aluminium rather than body. [1]

[Total: 8]

Select page

HIGH MIDDLE LOW

Your Mark

12(a)(i)

12(a)(ii)

12(a)(iii)

12(b)(i)

12(b)(iii)

Q12	Mark scheme	
(a)(i)	(X–ray) photon produced when electron/charged particle is stopped/accelerated (suddenly) range of accelerations (in target) hence distribution of wavelengths	B1 M1 A1 **[3]**
(a)(ii)	electron gives all its energy to one photon electron stopped in single collision	B1 B1 **[2]**
(a)(iii)	de-excitation of (orbital) electrons in target/anode/metal	B1 **[1]**
(b)(i)	aluminium sheet/filter/foil (placed in beam from tube)	B1 **[1]**
(b)(ii)	(long wavelength X-rays) do not pass through the body	B1 **[1]** **[Total: 8]**

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

12 High-energy electrons collide with a metal target, producing X-ray photons.

The variation with wavelength of the intensity of the X-ray beam is illustrated in Fig. 12.1.

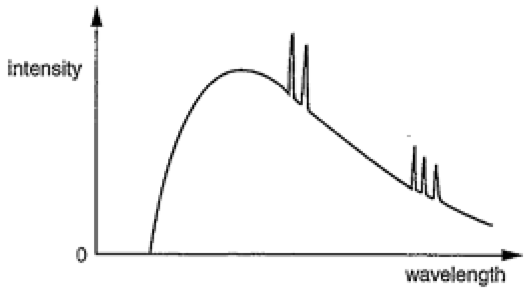

Fig. 12.1

(a) Explain why there is

(i) a continuous distribution of wavelengths,

Because there was of continuous range of deaccelaration of electrons when they hit metal plate so the X-rays emitted also had continuous distribution of wavelength. For each acceleration there is particular wavelength. [3]

(ii) a sharp cut-off at short wavelength,

It is because of the maximum energy/frequency electron ~~which was due to single photon~~ hitting the metal & emitting single photon [2]

(iii) a series of peaks superimposed on the continuous distribution of wavelengths.

It is Because of slow impact time of between metal & the electron collision & also because of transition in metal when electron hit the metal. [1]

(b) In the X-ray imaging of body structures, longer wavelength photons are frequently filtered out of the X-ray beam.

(i) State how this filtering is achieved.

An Aluminium Filter is placed in the way of X-ray beam. [1]

Your Mark

12(a)(i)

12(a)(ii)

12(a)(iii)

12(b)(i)

12(b)(iii)

Q12	Mark scheme		
(a)(i)	(X–ray) photon produced when electron/charged particle is stopped/accelerated (suddenly) range of accelerations (in target) hence distribution of wavelengths	B1 M1 A1	[3]
(a)(ii)	electron gives all its energy to one photon electron stopped in single collision	B1 B1	[2]
(a)(iii)	de-excitation of (orbital) electrons in target/anode/metal	B1	[1]
(b)(i)	aluminium sheet/filter/foil (placed in beam from tube)	B1	[1]
(b)(ii)	(long wavelength X-rays) do not pass through the body	B1	[1] [Total: 8]

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

(ii) Suggest the reason for this filtering.

They ~~take~~ lack energy to penetrate through body skin they only increase the dose they donot ~~part~~ take in image. [1]

[Total: 8]

Your Mark

12(a)(i)

12(a)(ii)

12(a)(iii)

12(b)(i)

12(b)(iii)

Q12	Mark scheme		
(a)(i)	(X–ray) photon produced when electron/charged particle is stopped/accelerated (suddenly) range of accelerations (in target) hence distribution of wavelengths	B1 M1 A1	[3]
(a)(ii)	electron gives all its energy to one photon electron stopped in single collision	B1 B1	[2]
(a)(iii)	de-excitation of (orbital) electrons in target/anode/metal	B1	[1]
(b)(i)	aluminium sheet/filter/foil (placed in beam from tube)	B1	[1]
(b)(ii)	(long wavelength X-rays) do not pass through the body	B1	[1] [Total: 8]

EXAMINER COMMENTS

MARK SCHEME

Select page | HIGH | MIDDLE | LOW

12 High-energy electrons collide with a metal target, producing X-ray photons.

The variation with wavelength of the intensity of the X-ray beam is illustrated in Fig. 12.1.

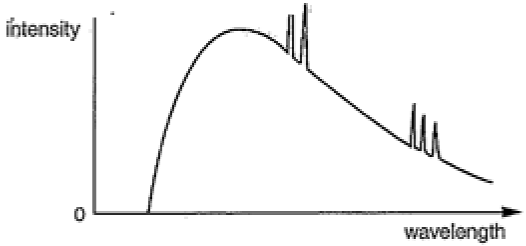

Fig. 12.1

(a) Explain why there is

(i) a continuous distribution of wavelengths,

Electrons have various velocities. High wavelength X ray beams are due to low energy electrons.
.... [3]

(ii) a sharp cut-off at short wavelength,

Electrons would have an energy value more than one specific value. (threshold frequency) [2]

(iii) a series of peaks superimposed on the continuous distribution of wavelengths.

When a series of electrons hit the metal target and more than one photon is emitted from the similar wavelength electrons. [1]

(b) In the X-ray imaging of body structures, longer wavelength photons are frequently filtered out of the X-ray beam.

(i) State how this filtering is achieved.

By keeping a thin Aluminium sheet between the body and beam. [1]

Your Mark

12(a)(i) | 12(a)(ii) | 12(a)(iii) | 12(b)(i) | 12(b)(iii)

Q12	Mark scheme		
(a)(i)	(X–ray) photon produced when electron/charged particle is stopped/accelerated (suddenly) range of accelerations (in target) hence distribution of wavelengths	B1 M1 A1	[3]
(a)(ii)	electron gives all its energy to one photon electron stopped in single collision	B1 B1	[2]
(a)(iii)	de-excitation of (orbital) electrons in target/anode/metal	B1	[1]
(b)(i)	aluminium sheet/filter/foil (placed in beam from tube)	B1	[1]
(b)(ii)	(long wavelength X-rays) do not pass through the body	B1	[1] [Total: 8]

EXAMINER COMMENTS | MARK SCHEME

(ii) Suggest the reason for this filtering.

It absorbs high wavelength X ray beams which would be absorbed by the body and not contribute to the image. [1]

[Total: 8]

Select page

HIGH MIDDLE LOW

Your Mark

12(a)(i)

12(a)(ii)

12(a)(iii)

12(b)(i)

12(b)(iii)

Q12	Mark scheme		
(a)(i)	(X–ray) photon produced when electron/charged particle is stopped/accelerated (suddenly) range of accelerations (in target) hence distribution of wavelengths	B1 M1 A1	 **[3]**
(a)(ii)	electron gives all its energy to one photon electron stopped in single collision	B1 B1	 **[2]**
(a)(iii)	de-excitation of (orbital) electrons in target/anode/metal	B1	**[1]**
(b)(i)	aluminium sheet/filter/foil (placed in beam from tube)	B1	**[1]**
(b)(ii)	(long wavelength X-rays) do not pass through the body	B1	**[1]** **[Total: 8]**

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Select page

HIGH MIDDLE LOW

13 (a) Explain what is meant by *gamma radiation* (*γ-radiation*).

The emission of gamma particles from a radioactive sample due to spontaneous and random nature. [2]

(b) A source of gamma radiation is placed a fixed distance away from a detector and counter, as illustrated in Fig. 13.1.

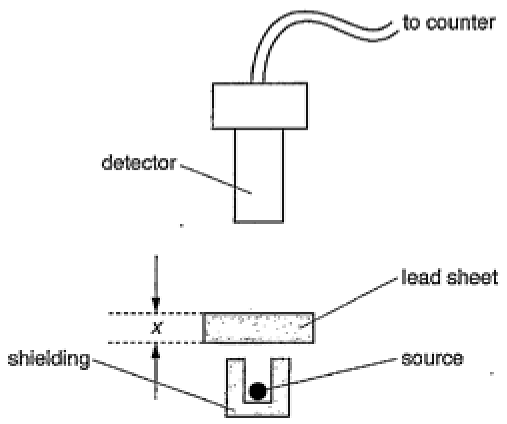

Fig. 13.1

A sheet of lead of thickness x is placed between the source and the detector.
The average count rate C, corrected for background, is recorded. This is repeated for different values of x.
The variation with thickness x of ln C is shown in Fig. 13.2.

$$C = C_0 e^{-\mu x}$$

$$\ln C = \ln C_0 e^{-\mu x}$$

$$\ln C = -\mu x + \ln C_0$$

Your Mark

13(a)

13(b)

13(c)

Q13	Mark scheme		
(a)	(photons of) electromagnetic radiation	M1	
	emitted from nuclei	A1	[2]
(b)	line of best fit drawn	B1	
	recognises μ as given by the gradient of best-fit line **or** ln C = ln $C_0 - \mu x$	B1	
	μ = 0.061 mm^{-1} (within ±0.004 mm^{-1}, 1 mark; within ±0.002 mm^{-1}, 2 marks)	A2	[4]
(c)	aluminium is less absorbing (than lead) **or** gradient of graph would be less M1		
	so μ is smaller A1		[2]
			[Total: 8]

EXAMINER COMMENTS

MARK SCHEME

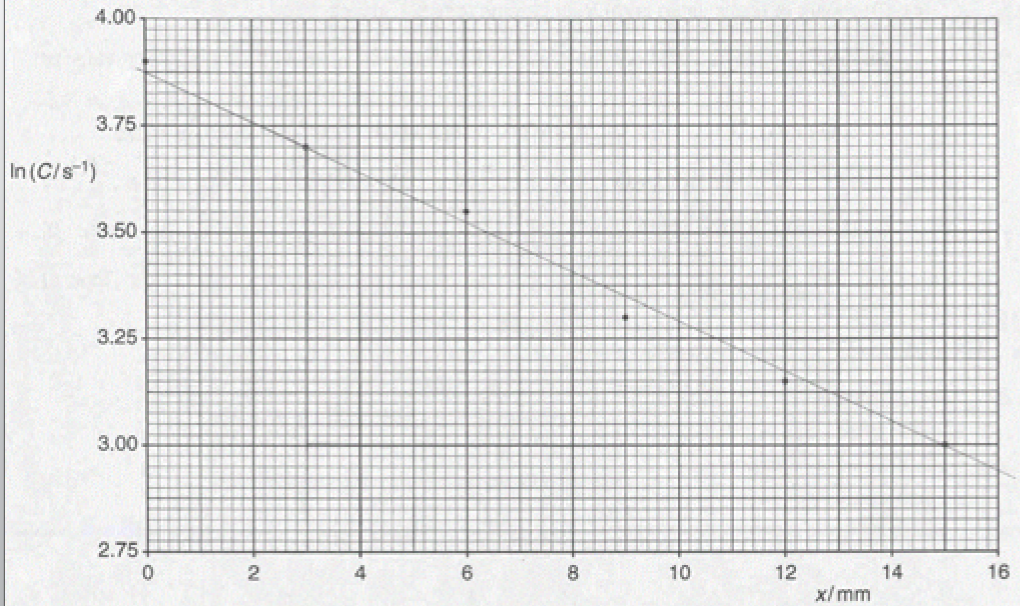

Fig. 13.2

(15, 3)

(3, 3.7)

The absorption of gamma radiation in lead may be represented by the equation

$$C = C_0 e^{-\mu x}$$

where C_0 is the count rate for $x = 0$ and μ is the linear attenuation (absorption) coefficient.

Use Fig. 13.2 to determine the linear attenuation coefficient μ for this gamma radiation in lead.

$C = C_0 e^{-\mu x}$

$\ln C = \ln (C_0 e^{-\mu x})$

$\ln C = \ln C_0 + (-\mu x)$

$\ln C = -\mu x + \ln C_0$

$y = m x + c$

$-\mu =$ gradient.

$m = \dfrac{3.7 - 3}{3 - 15}$ mm

$-\mu = -0.05833$

$\mu =$ ~~0.06~~ 0.058 mm⁻¹ [4]

Question 13 continues on the next page.

Select page

HIGH MIDDLE LOW

Your Mark

13(a)

13(b)

13(c)

Q13	Mark scheme		
(a)	(photons of) electromagnetic radiation	M1	
	emitted from nuclei	A1	**[2]**
(b)	line of best fit drawn	B1	
	recognises μ as given by the gradient of best-fit line **or** ln C = ln $C_0 - \mu x$	B1	
	μ = 0.061 mm⁻¹ (within ±0.004 mm⁻¹, 1 mark; within ±0.002 mm⁻¹, 2 marks)	A2	**[4]**
(c)	aluminium is less absorbing (than lead) **or** gradient of graph would be less M1		
	so μ is smaller A1		**[2]**
			[Total: 8]

EXAMINER COMMENTS

MARK SCHEME

(c) The value of μ calculated in **(b)** is for gamma radiation in lead.

Suggest and explain whether the value of μ for aluminium would be the same, greater or smaller.

Attenuation coefficient would be smaller for Aluminium as the absorption of by Al is lesser than of lead. [2]

[Total: 8]

Your Mark

13(a)

13(b)

13(c)

Q13	Mark scheme		
(a)	(photons of) electromagnetic radiation	M1	
	emitted from nuclei	A1	**[2]**
(b)	line of best fit drawn	B1	
	recognises μ as given by the gradient of best-fit line **or** $\ln C = \ln C_0 - \mu x$	B1	
	$\mu = 0.061\ mm^{-1}$ (within $\pm 0.004\ mm^{-1}$, 1 mark; within $\pm 0.002\ mm^{-1}$, 2 marks)	A2	**[4]**
(c)	aluminium is less absorbing (than lead) **or** gradient of graph would be less M1		
	so μ is smaller A1		**[2]**
			[Total: 8]

Select page

HIGH MIDDLE LOW

13 (a) Explain what is meant by *gamma radiation* (*γ-radiation*).

It is the electromagnetic wave of the very high frequency range and are released during the decay of a radioactive nucleus. [2]

(b) A source of gamma radiation is placed a fixed distance away from a detector and counter, as illustrated in Fig. 13.1.

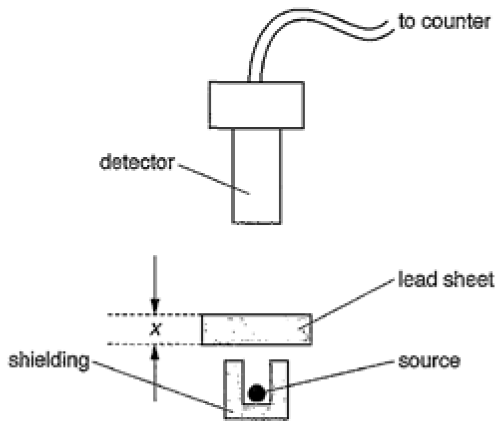

Fig. 13.1

A sheet of lead of thickness *x* is placed between the source and the detector.
The average count rate *C*, corrected for background, is recorded. This is repeated for different values of *x*.
The variation with thickness *x* of ln *C* is shown in Fig. 13.2.

Your Mark

13(a)

13(b)

13(c)

Q13	Mark scheme		
(a)	(photons of) electromagnetic radiation	M1	
	emitted from nuclei	A1	[2]
(b)	line of best fit drawn	B1	
	recognises μ as given by the gradient of best-fit line **or** ln C = ln $C_0 - \mu x$	B1	
	μ = 0.061 mm^{-1} (within ±0.004 mm^{-1}, 1 mark; within ±0.002 mm^{-1}, 2 marks)	A2	[4]
(c)	aluminium is less absorbing (than lead) **or** gradient of graph would be less M1		
	so μ is smaller A1		[2]
			[Total: 8]

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Select page

HIGH | MIDDLE | LOW

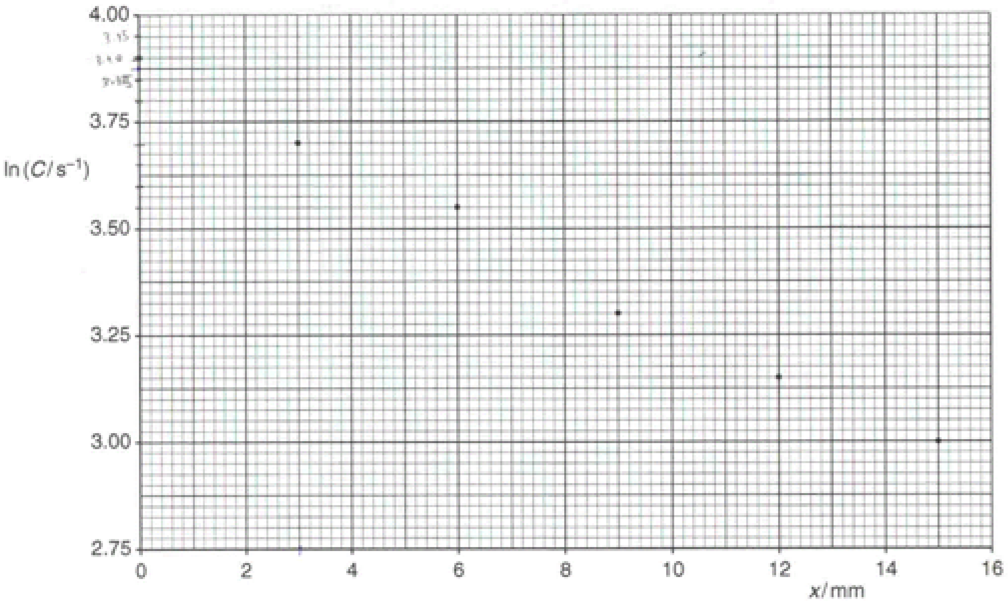

Fig. 13.2

The absorption of gamma radiation in lead may be represented by the equation

$$C = C_0 e^{-\mu x}$$

where C_0 is the count rate for $x = 0$ and μ is the linear attenuation (absorption) coefficient.

Use Fig. 13.2 to determine the linear attenuation coefficient μ for this gamma radiation in lead.

$C_0 = 3.855$, $x = 0$

$C = 3.70$, $x = 3$mm.

$3.70 = 3.855 \times e^{-\mu(3)}$

$0.9598 = e^{-\mu(3)}$

$-0.041 = -\mu(3)$

$\mu = \frac{0.041}{3} =$ ~~0.0136~~ $0.0137 = 1.37 \times 10^{-2}$

μ = ...~~0.0137~~ 1.37×10^{-2} mm^{-1} [4]

Question 13 continues on the next page.

Your Mark

13(a)

13(b)

13(c)

Q13	Mark scheme		
(a)	(photons of) electromagnetic radiation	M1	
	emitted from nuclei	A1	[2]
(b)	line of best fit drawn	B1	
	recognises μ as given by the gradient of best-fit line **or** ln C = ln $C_0 - \mu x$	B1	
	$\mu = 0.061$ mm^{-1} (within ±0.004 mm^{-1}, 1 mark; within ±0.002 mm^{-1}, 2 marks)	A2	[4]
(c)	aluminium is less absorbing (than lead) **or** gradient of graph would be less M1		
	so μ is smaller A1		[2]
			[Total: 8]

EXAMINER COMMENTS

MARK SCHEME

(c) The value of μ calculated in (b) is for gamma radiation in lead.

Suggest and explain whether the value of μ for aluminium would be the same, greater or smaller.

It would be lower as aluminium ~~is a~~ absorbs less gamma radiations than lead [2]

[Total: 8]

Select page

HIGH MIDDLE LOW

Your Mark

13(a)

13(b)

13(c)

Q13	Mark scheme		
(a)	(photons of) electromagnetic radiation	M1	
	emitted from nuclei	A1	[2]
(b)	line of best fit drawn	B1	
	recognises μ as given by the gradient of best-fit line **or** $\ln C = \ln C_0 - \mu x$	B1	
	$\mu = 0.061\ mm^{-1}$ (within $\pm 0.004\ mm^{-1}$, 1 mark; within $\pm 0.002\ mm^{-1}$, 2 marks)	A2	[4]
(c)	aluminium is less absorbing (than lead) **or** gradient of graph would be less M1		
	so μ is smaller A1		[2]
			[Total: 8]

EXAMINER COMMENTS

MARK SCHEME

13 (a) Explain what is meant by *gamma radiation* (γ-radiation).

radiations of high frequency electromagnetic ~~and~~ waves from nucleus of an unstable atom to attain stability ..... [2]

(b) A source of gamma radiation is placed a fixed distance away from a detector and counter, as illustrated in Fig. 13.1.

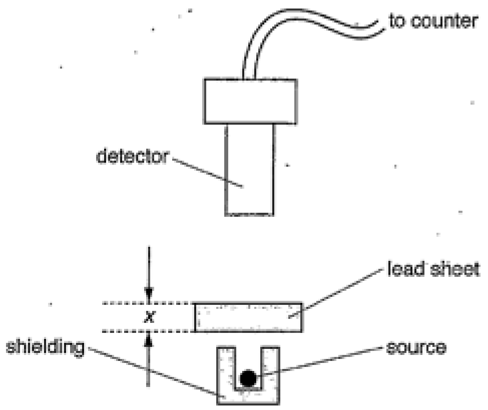

Fig. 13.1

A sheet of lead of thickness *x* is placed between the source and the detector.
The average count rate *C*, corrected for background, is recorded. This is repeated for different values of *x*. adjusted count rate
The variation with thickness *x* of ln *C* is shown in Fig. 13.2.

Select page

HIGH MIDDLE LOW

Your Mark

13(a)

13(b)

13(c)

Q13	Mark scheme	
(a)	(photons of) electromagnetic radiation	M1
	emitted from nuclei	A1 [2]
(b)	line of best fit drawn	B1
	recognises μ as given by the gradient of best-fit line **or** ln C = ln $C_0 - \mu x$	B1
	μ = 0.061 mm^{-1} (within ±0.004 mm^{-1}, 1 mark; within ±0.002 mm^{-1}, 2 marks)	A2 [4]
(c)	aluminium is less absorbing (than lead) **or** gradient of graph would be less M1	
	so μ is smaller A1	[2]
		[Total: 8]

EXAMINER COMMENTS

MARK SCHEME

Select page

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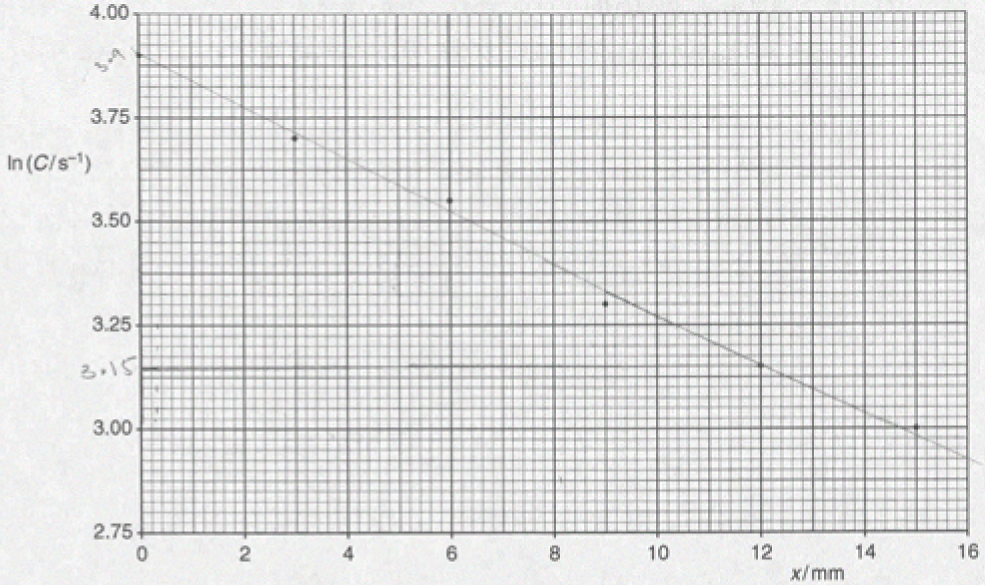

Fig. 13.2

The absorption of gamma radiation in lead may be represented by the equation

$$C = C_0 e^{-\mu x}$$

where C_0 is the count rate for $x = 0$ and μ is the linear attenuation (absorption) coefficient.

Use Fig. 13.2 to determine the linear attenuation coefficient μ for this gamma radiation in lead.

ln C = Co x lne^-ux

ln(C) = -ux x lnCo
= -lnCo x u

3.9 − 3.15
0 − 12

μ = −0.063 mm^{-1} [4]

Question 13 continues on the next page.

Your Mark

13(a)

13(b)

13(c)

Q13	Mark scheme
(a)	(photons of) electromagnetic radiation M1 emitted from nuclei A1 **[2]**
(b)	line of best fit drawn B1 recognises μ as given by the gradient of best-fit line **or** $\ln C = \ln C_0 - \mu x$ B1 $\mu = 0.061\ mm^{-1}$ (within $\pm 0.004\ mm^{-1}$, 1 mark; within $\pm 0.002\ mm^{-1}$, 2 marks) A2 **[4]**
(c)	aluminium is less absorbing (than lead) **or** gradient of graph would be less M1 so μ is smaller A1 **[2]** **[Total: 8]**

EXAMINER COMMENTS

MARK SCHEME

(c) The value of μ calculated in **(b)** is for gamma radiation in lead.

Suggest and explain whether the value of μ for aluminium would be the same, greater or smaller.

In aluminium the value will be small as aluminium sheet does not absorb gamma radiation so intensity will not be changed significantly. [2]

[Total: 8]

Select page

HIGH MIDDLE LOW

Your Mark

13(a)

13(b)

13(c)

Q13	Mark scheme		
(a)	(photons of) electromagnetic radiation	M1	
	emitted from nuclei	A1	**[2]**
(b)	line of best fit drawn	B1	
	recognises μ as given by the gradient of best-fit line **or** In C = In $C_0 - \mu x$	B1	
	μ = 0.061 mm^{-1} (within ±0.004 mm^{-1}, 1 mark; within ±0.002 mm^{-1}, 2 marks)	A2	**[4]**
(c)	aluminium is less absorbing (than lead) **or** gradient of graph would be less M1		
	so μ is smaller A1		**[2]**
			[Total: 8]

EXAMINER COMMENTS

MARK SCHEME

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Cambridge Assessment International Education

Interactive

Interactive Example Candidate Responses
Paper 5 (May/June 2016), Question 1
Cambridge International AS & A Level
Physics 9702

Version 1.0

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1 A student is investigating the acceleration of a trolley moving up an inclined plane as shown in Fig. 1.1.

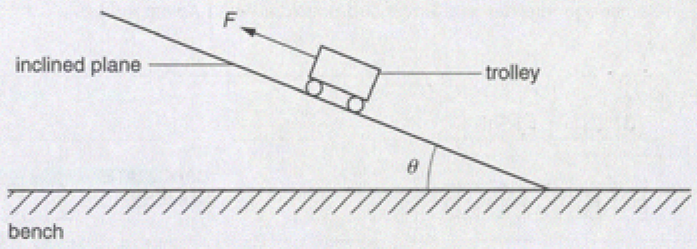


Fig. 1.1

The student is investigating the relationship between the acceleration a of the trolley and the angle θ of the inclined plane when a force F is applied to the trolley.

It is suggested that the relationship is

$$ma = F - (mg\sin\theta + k)$$

where g is the acceleration of free fall, m is the mass of the trolley and k is a constant.

Design a laboratory experiment to test the relationship between a and θ. Explain how your results could be used to determine a value for k. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

- the procedure to be followed,
- the measurements to be taken,
- the control of variables,
- the analysis of the data,
- any safety precautions to be taken.

[15]

$F = BIL\sin\theta$

$F =$

$ma = F - mg\sin\theta + k$

$ma = \frac{F}{m} - g\sin\theta + \frac{k}{m}$

$a = -g\sin\theta + \left(\frac{k}{m} - g\right)$

$\frac{k}{m} - g$

$\frac{k}{m}$

$ma = F - mg\sin\theta - k$

$a = \frac{F}{m} - g\sin\theta - \frac{k}{m}$

$a = -g\sin\theta + \left(\frac{F-k}{m}\right)$

$\frac{F-k}{m} = c$

$mc = F - k$

$F - c = k$

Select page

HIGH MIDDLE LOW

Your Mark

1

Q1 Mark scheme

Planning (15 marks)

Defining the problem (2 marks)

P θ is the independent variable and a is the dependent variable, or vary θ and measure a. [1]

P Keep F constant. [1]

Methods of data collection (4 marks)

M Diagram showing inclined plane with labelled support (not if a ruler used as the inclined plane or as vertical support). [1]

M Method to measure angle e.g. use a protractor to measure θ or use a ruler to measure marked distances from which sin θ or θ may be determined. (Allow a labelled protractor in the correct position.) [1]

M Method to measure a time or velocity to determine a, e.g. measure the time using a stopwatch, light gate(s) connected to a timer, motion sensor connected to a time display. [1]

M Use a balance to measure the mass of the trolley. [1]

Method of analysis (3 marks)

A Plot a graph of a against sin θ. **or** Plot a graph of ma against sin θ. **or** Plot a graph of ma against mg sin θ [1]

A Relationship is valid if the graph is a straight line and does **not** pass through the origin [1]

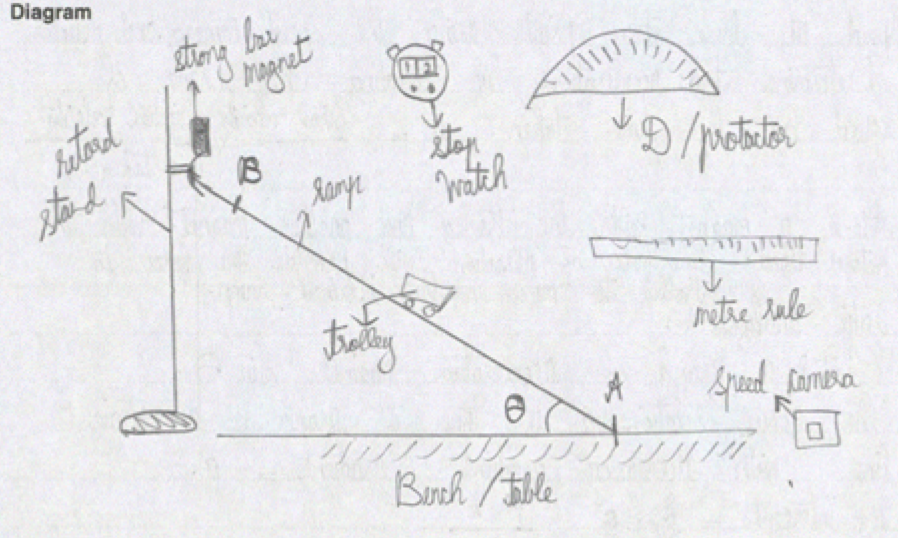
A k = F – m × (y-intercept) **or** k = F – (y-intercept) **or** k = F – (y-intercept) [1]

Do not allow lg-lg graphs.

EXAMINER COMMENTS

MARK SCHEME

Diagram



Defining problem :-

- θ is the independent variable
- a is the dependent variable
- m should be kept constant by using the same trolley.

Method of data collection :-

- Set up the apparatus as shown in diagram by clamping one end of the ramp with retord stand.
- Measure the angle between the bench and ramp by using a protractor.
- Measure the length of the ramp through which the trolley moves.
- Between 2 fixed points on ramp, ~~measure~~ ~~determine~~ record the time taken by the trolley and note the change in

Your Mark

1

Q1 Mark scheme

Planning (15 marks)

Defining the problem (2 marks)

P θ is the independent variable and a is the dependent variable, or vary θ and measure *a*. [1]

P Keep F constant. [1]

Methods of data collection (4 marks)

M Diagram showing inclined plane with labelled support (not if a ruler used as the inclined plane or as vertical support). [1]

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A k = F – m × (y-intercept) **or** k = F – (y-intercept) **or** k = F – (y-intercept) [1]

Do not allow lg-lg graphs.

speed at these two points using the speed camera and detector.
• Determine the acceleration by dividing the change of speed by the time taken. $a = \frac{\text{final velocity} - \text{initial velocity}}{\text{time taken}}$.

• Attach a magnet with the trolly and another magnet with the retord stand. The force of attraction will provide the force to trolley to move up the inclined ramp.

Data analysis :-
• Plot a graph of acceleration against $\sin\theta$.
• The given relationship is true if graph is a straight line with decreasing gradient. gradient = $-g$.
y-intercept = $\frac{F-k}{m}$

∴ $k = F - m(\text{y-intercept})$

Safety precaution :-
• Do not touch the trolley while it is moving on the ramp as it may injure the hands. Wear thick rubber gloves.
• Use a sand tray. The trolley will fall into it rather than falling on the bench.

Additional detail :-
• Use a large protactor to minimize error in measuring θ.
• Make large changes to the angle θ to have noticeable change in acceleration.
• Release the trolley from the same point everytime and use the same length of ramp for determining speed changes with time. The distance should be large for greater changes in speed.
• Use the same ramp everytime with minimum friction to have smooth movement of trolley.
• The force applied should be same and there should be no external forces like wind from fan.

Select page

HIGH MIDDLE LOW

Your Mark

1

Q1	Mark scheme
	Additional detail (6 marks)
	Relevant points might include: [6]
1	Keep mass of trolley constant/use same trolley.
2	Correct trigonometry relationship to determine sin θ or θ using marked lengths.
3	Use ruler to measure appropriate distance to determine a, e.g. length of slope, length of card for light gate method, position of motion sensor.
4	Equation to determine a from measurements taken appropriately with a as the subject.
5	Measurement of *F* for a valid method e.g. take reading from newton-meter or from stretched elastic/spring from extension (allow falling weight e.g. $F = mg$).
6	Use a constant extension to produce a constant force when using stretched spring/elastic.
7	Method to ensure the inclined plane is the same height each side of the plane or spirit level across plane or ensure force *F* (or string) is parallel to the plane.
8	Safety precaution linked to falling mass/trolley or spring/elastic breaking (not string).
9	Rearrangement of relationship into y = mx + c e.g. $ma = -mg\sin\theta + (F - k)$ **or** $a = g\sin\theta + \frac{F - K}{m}$ or correct y-intercept (subject must be y-axis).
10	Repeat experiment for each angle θ to find average for a.
	Do not allow vague computer methods.

EXAMINER COMMENTS

MARK SCHEME

1 A student is investigating the acceleration of a trolley moving up an inclined plane as shown in Fig. 1.1.

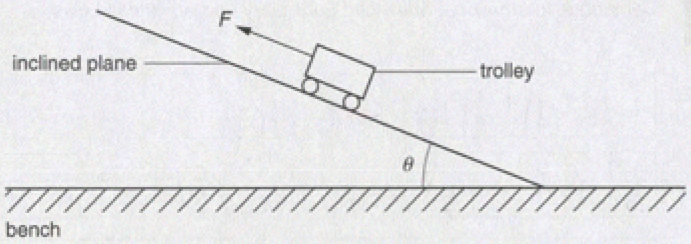

Fig. 1.1

The student is investigating the relationship between the acceleration a of the trolley and the angle θ of the inclined plane when a force F is applied to the trolley.

It is suggested that the relationship is

$$ma = F - (mg\sin\theta + k)$$

where g is the acceleration of free fall, m is the mass of the trolley and k is a constant.

Design a laboratory experiment to test the relationship between a and θ. Explain how your results could be used to determine a value for k. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

- the procedure to be followed,
- the measurements to be taken,
- the control of variables,
- the analysis of the data,
- any safety precautions to be taken.

[15]

$a = \frac{F}{m} - g\sin\theta + \frac{k}{m}$

Select page

HIGH MIDDLE LOW

Your Mark

1

Q1 Mark scheme

Planning (15 marks)

Defining the problem (2 marks)

P θ is the independent variable and a is the dependent variable, or vary θ and measure a. [1]

P Keep F constant. [1]

Methods of data collection (4 marks)

M Diagram showing inclined plane with labelled support (not if a ruler used as the inclined plane or as vertical support). [1]

M Method to measure angle e.g. use a protractor to measure θ or use a ruler to measure marked distances from which sin θ or θ may be determined. (Allow a labelled protractor in the correct position.) [1]

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M Use a balance to measure the mass of the trolley. [1]

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A Relationship is valid if the graph is a straight line and does **not** pass through the origin [1]

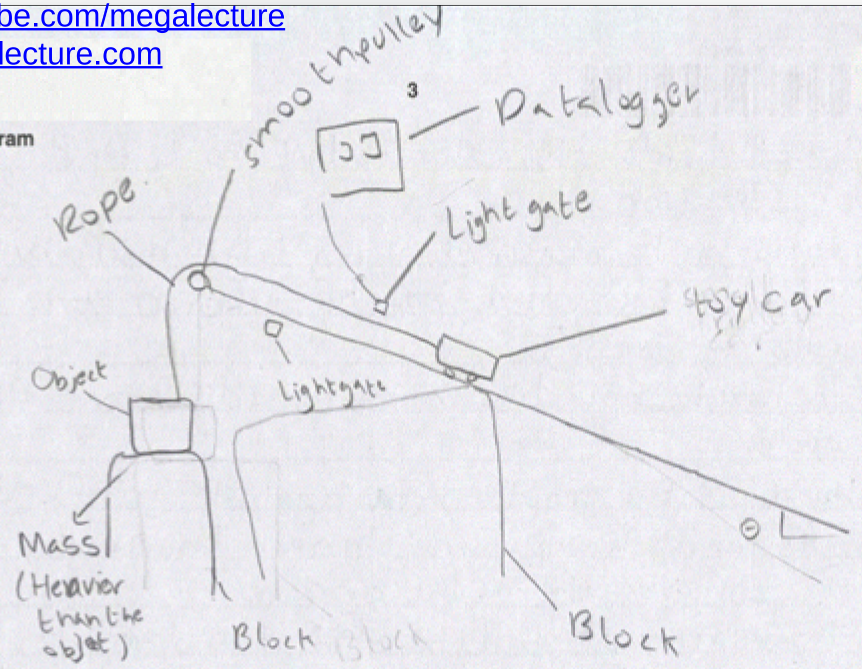
A k = F – m × (y-intercept) **or** k = F – (y-intercept) **or** k = F – (y-intercept) [1]

Do not allow lg-lg graphs.

EXAMINER COMMENTS

MARK SCHEME

Diagram



Independent variable is the angle θ.
Dependent variable is the acceleration.
Control of variable is the force.

The mass will be at rest on the block at first and then the block will be removed so the trolley starts to move. The mass must be atleast twice times heavier than the trolley.
~~Mass of of the object~~ Weight of the object can be measured by a neuton metre and that will be our constant force.
To calculate velocity we will use light gates and a data logger.
We will measure the time using a stopwatch.
Time taken between the two light gates

Your Mark

1

Q1	Mark scheme

Planning (15 marks)

Defining the problem (2 marks)

P θ is the independent variable and a is the dependent variable, or vary θ and measure *a*. [1]

P Keep F constant. [1]

Methods of data collection (4 marks)

M Diagram showing inclined plane with labelled support (not if a ruler used as the inclined plane or as vertical support). [1]

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A k = F – m × (y-intercept) **or** k = F – (y-intercept) **or** k = F – (y-intercept) [1]

Do not allow lg-lg graphs.

We will divide the velocity by time to find acceleration.
Angle can be measured using trignometry by finding base and height using metre rule. $Tan^{-1}(\frac{h}{b})$
The lengths should be varied for a different angle.
We will plot a graph of a against gsinθ. A straight line passing through the origin will confirm the relationship.
The y intercept will be $\frac{F+k}{m}$, F and m are constant so we can find K.
For safety we should keep our feet away from the object as we let it go.

The angle can also be taken out using a protractor.
A smooth surface with little friction should be used.
We should take a large range of values for θ. ~~for better outcome~~
Acceleration can be worked out also by making free body diagrams for the object and the car. (Tension is the same).

Select page

HIGH | MIDDLE | LOW

Your Mark

1

Q1 Mark scheme

Additional detail (6 marks)

Relevant points might include: [6]

1. Keep mass of trolley constant/use same trolley.
2. Correct trigonometry relationship to determine sin θ or θ using marked lengths.
3. Use ruler to measure appropriate distance to determine a, e.g. length of slope, length of card for light gate method, position of motion sensor.
4. Equation to determine a from measurements taken appropriately with a as the subject.
5. Measurement of *F* for a valid method e.g. take reading from newton-meter or from stretched elastic/spring from extension (allow falling weight e.g. $F = mg$).
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8. Safety precaution linked to falling mass/trolley or spring/elastic breaking (not string).
9. Rearrangement of relationship into y = mx + c e.g. $ma = -mg \sin\theta + (F - k)$ **or**

   $a = g \sin\theta +$ or correct y-intercept (subject must be y-axis).
10. Repeat experiment for each angle *θ* to find average for a.

Do not allow vague computer methods.

EXAMINER COMMENTS

MARK SCHEME

1 A student is investigating the acceleration of a trolley moving up an inclined plane as shown in Fig. 1.1.

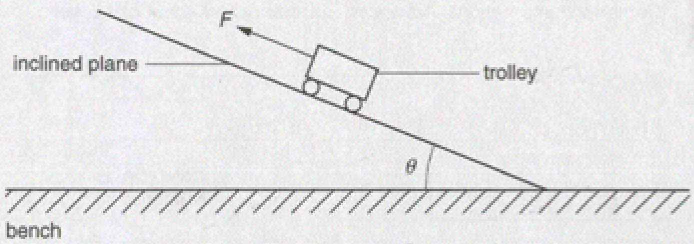

Fig. 1.1

The student is investigating the relationship between the acceleration a of the trolley and the angle θ of the inclined plane when a force F is applied to the trolley.

It is suggested that the relationship is

$$ma = F - (mg\sin\theta + k)$$

where g is the acceleration of free fall, m is the mass of the trolley and k is a constant.

Design a laboratory experiment to test the relationship between a and θ. Explain how your results could be used to determine a value for k. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

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- the measurements to be taken,
- the control of variables,
- the analysis of the data,
- any safety precautions to be taken.

[15]

Select page

HIGH MIDDLE LOW

Your Mark

1

Q1	Mark scheme	
Planning (15 marks)		
Defining the problem (2 marks)		
P	θ is the independent variable and a is the dependent variable, or vary θ and measure a.	[1]
P	Keep F constant.	[1]
Methods of data collection (4 marks)		
M	Diagram showing inclined plane with labelled support (not if a ruler used as the inclined plane or as vertical support).	[1]
M	Method to measure angle e.g. use a protractor to measure θ or use a ruler to measure marked distances from which sin θ or θ may be determined. (Allow a labelled protractor in the correct position.)	[1]
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M	Use a balance to measure the mass of the trolley.	[1]
Method of analysis (3 marks)		
A	Plot a graph of a against sin θ. **or** Plot a graph of ma against sin θ. **or** Plot a graph of ma against mg sin θ	[1]
A	Relationship is valid if the graph is a straight line and does **not** pass through the origin	[1]
A	k = F – m × (y-intercept) **or** k = F – (y-intercept) **or** k = F – (y-intercept)	[1]
Do not allow lg-lg graphs.		

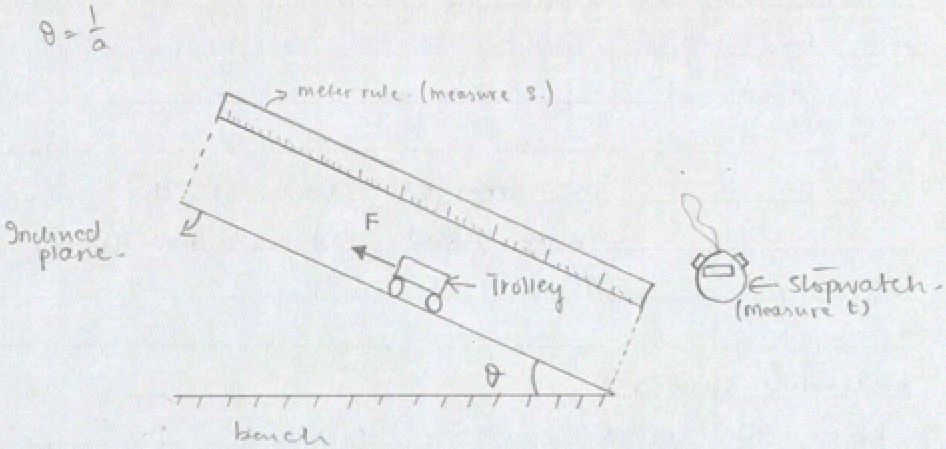
EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

Diagram



In this experiment; Angle θ is the independent variable while acceleration a, is the dependent variable. Keeping length of the plane constant. Measure angle θ using a protector, calculate change in ~~speed~~ velocity ~~over time~~ of the trolley moving up a inclined plane; v = s/t, where s is the length of plane and 't' can be measured using a stopwatch. The change in velocity over a period of time will be acceleration; a = v-u/t.
Take few sets of readings for the variations in acceleration of the trolley on increasing or decreasing the angle θ between bench and a plane.

Your Mark

1

Q1 Mark scheme

Planning (15 marks)

Defining the problem (2 marks)

P θ is the independent variable and a is the dependent variable, or vary θ and measure *a*. [1]

P Keep F constant. [1]

Methods of data collection (4 marks)

M Diagram showing inclined plane with labelled support (not if a ruler used as the inclined plane or as vertical support). [1]

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M Use a balance to measure the mass of the trolley. [1]

Method of analysis (3 marks)

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A Relationship is valid if the graph is a straight line and does **not** pass through the origin [1]

A k = F – m × (y-intercept) **or** k = F – (y-intercept) **or** k = F – (y-intercept) [1]

Do not allow lg-lg graphs.

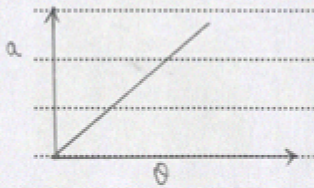
EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

Record the values of θ, sin θ and acceleration in the table and sketch a graph of a and θ



The straight line of the graph ~~and~~ starting ~~Sho~~ proves this relationship.

Additional details:-
keep the mass and g constant. The force applied should be ~~keep~~ same ~~for~~ throughout the experiment

Your Mark

1

Q1 Mark scheme

Additional detail (6 marks)

Relevant points might include: [6]

1 Keep mass of trolley constant/use same trolley.

2 Correct trigonometry relationship to determine sin θ or θ using marked lengths.

3 Use ruler to measure appropriate distance to determine a, e.g. length of slope, length of card for light gate method, position of motion sensor.

4 Equation to determine a from measurements taken appropriately with a as the subject.

5 Measurement of *F* for a valid method e.g. take reading from newton-meter or from stretched elastic/spring from extension (allow falling weight e.g. $F = mg$).

6 Use a constant extension to produce a constant force when using stretched spring/elastic.

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9 Rearrangement of relationship into y = mx + c
e.g. $ma = -mg \sin\theta + (F - k)$ **or**

$a = g \sin\theta +$ or correct y-intercept (subject must be y-axis).

10 Repeat experiment for each angle θ to find average for a.

Do not allow vague computer methods.

EXAMINER COMMENTS

MARK SCHEME

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Cambridge Assessment International Education

Interactive

Interactive Example Candidate Responses Paper 5 (May/June 2016), Question 2

Cambridge International AS & A Level Physics 9702

Version 1.0

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Please follow the link below to register your interest.

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2 A student is investigating how the resistance of a wire depends on the diameter of the wire.

The circuit is set up as shown in Fig. 2.1.

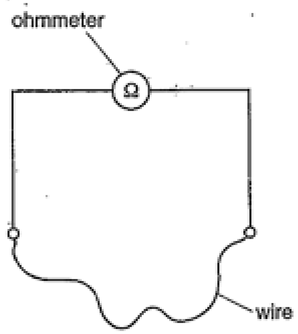

Fig. 2.1

The resistance R of the wire is measured using an ohmmeter.

The experiment is repeated for wires of the same material and same length L but different diameter d.

It is suggested that R and d are related by the equation

$$R = \frac{4\rho L}{\pi d^2}$$

where ρ is a constant.

(a) A graph is plotted of R on the y-axis against $\frac{1}{d^2}$ on the x-axis.

Determine an expression for the gradient.

$R = \frac{4\rho L}{\pi} \times \frac{1}{d^2}$

$m = \frac{4\rho L}{\pi}$

gradient = $\frac{4\rho L}{\pi}$ [1]

Your Mark

2(a)

2(b)

2(c)(i)

2(c)(ii)

2(c)(iii)

2(d)(i)

2(d)(ii)

2(e)

Q2 Mark scheme

	Mark	Expected Answer	Additional Guidance
(a)	A1	$\frac{4\rho L}{\pi}$	
(b)	T1	$\frac{1}{d^2}$ / 10^6 m^{-2}	
	T2	1.2 or 1.21 3.2 or 3.19 4.7 or 4.73 6.9 or 6.93 9.8 or 9.77 14 or 13.7	All values to 2 s.f. or 3 s.f. Allow a mixture of significant figures. Must be values in table.
	U1	From ± 0.03 to ± 1	Allow more than one significant figure. Allow zero for first uncertainty and up to 1.2 for largest uncertainty.
(c)(i)	G1	Six points plotted correctly	Must be within half a small square. Do not allow "blobs". ECF allowed from table.
	U2	Error bars in $\frac{1}{d^2}$ plotted correctly	All error bars to be plotted. Length of bar must be accurate to less than half a small square and symmetrical.

1.2075 ± 0.03

3.1337 ± 0.11

(b) Values of d and R are given in Fig. 2.2.

d/10^{-3}m	R/Ω	$\frac{1}{d^2}$/10^6 m^{-2}
0.91 ± 0.01	1.6	1.21 ± 0.03
0.56 ± 0.01	4.4	3.19 ± 0.1
0.46 ± 0.01	6.6	4.73 ± 0.2
0.38 ± 0.01	9.7	6.93 ± 0.4
0.32 ± 0.01	13.9	9.77 ± 0.6
0.27 ± 0.01	19.5	13.72 ± 1

Fig. 2.2

Calculate and record values of $\frac{1}{d^2}$/10^6 m^{-2} in Fig. 2.2.

Include the absolute uncertainties in $\frac{1}{d^2}$. [3]

(c) (i) Plot a graph of R/Ω against $\frac{1}{d^2}$/10^6 m^{-2}.

Include error bars for $\frac{1}{d^2}$. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the absolute uncertainty in your answer.

Line of best fit

(4.73, 6.6) (13.72, 19.5)

triangle drawn

$\frac{19.5 - 6.6}{(13.72 - 4.73) \times 10^6} = 1.43 \times 10^{-6}$

worst acceptable straight line

(1.18, 1.6) (14.72, 19.5)

$\frac{19.5 - 1.6}{(14.72 - 1.18) 10^6} = 1.32 \times 10^{-6}$

absolute uncertainty: $(1.43 - 1.32) 10^{-6}$
$= 0.11 \times 10^{-6}$

$(1.43 \pm 0.1)\ 10^{-6}$

gradient = ~~1.43~~ ....[2]

Select page

HIGH MIDDLE LOW

Your Mark

2(a)

2(b)

2(c)(i)

2(c)(ii)

2(c)(iii)

2(d)(i)

2(d)(ii)

2(e)

Q2 Mark scheme

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(a)	A1	$\frac{4\rho L}{\pi}$	
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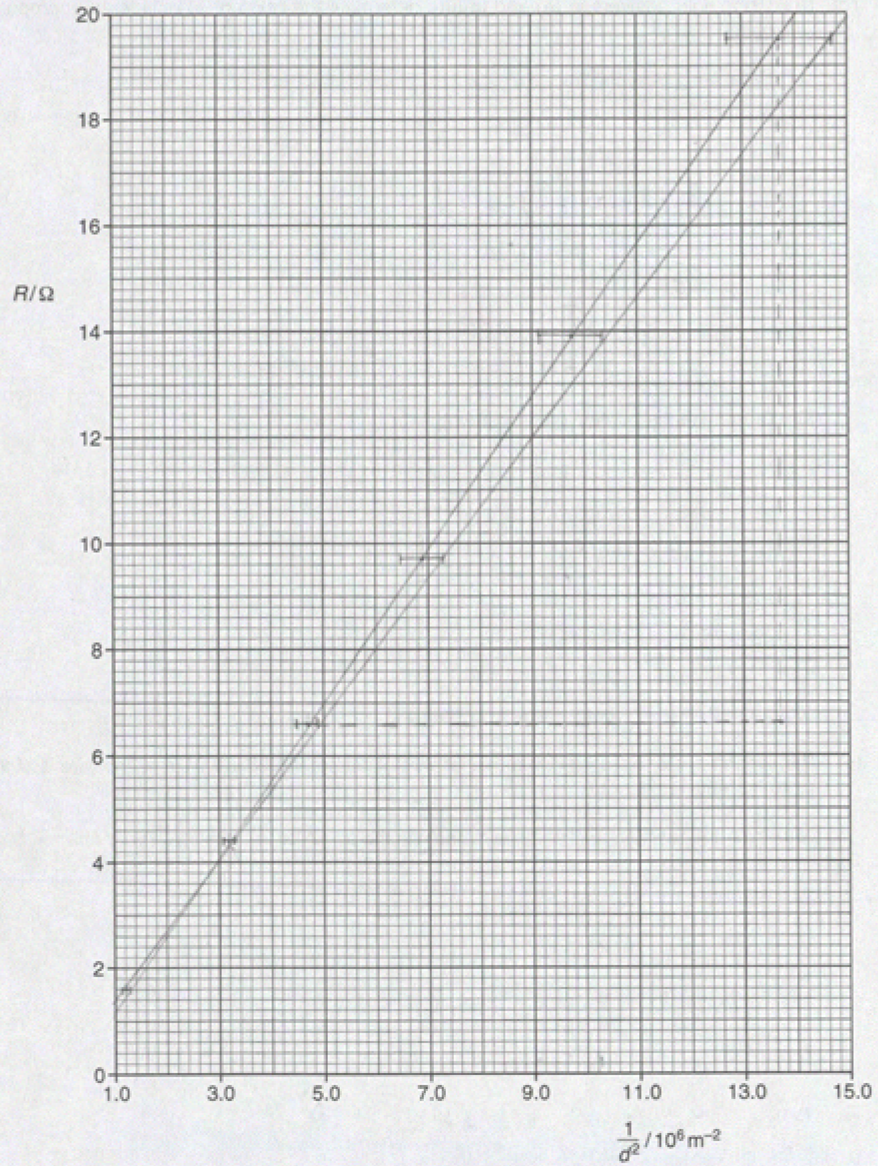
EXAMINER COMMENTS

MARK SCHEME



Your Mark

2(a)

2(b)

2(c)(i)

2(c)(ii)

2(c)(iii)

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2(e)

Q2	Mark scheme		
	Mark	**Expected Answer**	**Additional Guidance**
(c)(ii)	G2	Line of best fit	Lower end of line must pass between (2.6, 4.0) and (3.0, 4.0) and upper end of line must pass between (12.4, 18.0) and (13.0, 18.0).
	G3	Worst acceptable straight line. Steepest or shallowest possible line that passes through all the error bars.	Line should be clearly labelled or dashed. Examiner judgement on worst acceptable line. Must be steepest/shallowest line. Mark scored only if error bars are plotted.
(c)(iii)	C1	Gradient of line of best fit	The triangle used should be at least half the length of the drawn line. Check the read-offs. Work to half a small square. Do not penalise POT. (Should be about 1.4 –1.5 × 10^{-6}.)
	U3	Absolute uncertainty in gradient	Method of determining absolute uncertainty: difference in worst gradient and gradient.
(d)(i)	C2		Must use gradient value. Do not penalise POT (Should be about 1 × 10–6.)
	C3	Ω m	Correct unit and correct power of ten.
(d)(ii)	U4	Percentage uncertainty in *ρ*	Percentage uncertainty in gradient + 1%.
(e)	C4	*R* in the range 25.5 to 28.4 and given to 2 or 3 s.f.	Allow 26 or 27 or 28. Allow ECF for POT error in **(d)(i)** e.g. 2.7 × 10^7.
	U5	Absolute uncertainty in R	Percentage uncertainty must be greater than 8.6%.

$\rho = \frac{m \times \pi}{4L}$

8

$\rho = \frac{m\pi}{4L}$ $\quad \frac{\Omega}{m^{-2}} = \Omega m^2 = \Omega m$

(d) (i) Using your answers to **(a)** and **(c)(iii)**, determine the value of ρ. Include an appropriate unit.

Data: $L = 1.00 \pm 0.01$ m.

$m = \frac{4\rho L}{\pi}$ $\qquad \rho = 1.13 \times 10^{-6}\ \Omega m$

$1.43 \times 10^{-6} = \frac{4 \rho \times 1}{\pi}$

ρ = ...$1.13 \times 10^{-6}\ \Omega m$...... [2]

(ii) Determine the percentage uncertainty in ρ.

$\frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + \frac{\Delta L}{L}$ $\qquad$ % uncertainty $= 0.09 \times 100 = 9\%$

$\frac{\Delta\rho}{\rho} = \frac{0.1 \times 10^{-6}}{1.43 \times 10^{-6}} + \frac{0.01}{1}$

$\frac{\Delta\rho}{\rho} = 0.09$

percentage uncertainty in ρ = ...9...... % [1]

(e) The experiment is repeated with a thinner wire of diameter 0.23 ± 0.01 mm. The wire is of the same material and length.

Determine the resistance R of the wire. Include the absolute uncertainty in your answer.

$R = \frac{4\rho L}{\pi d^2}$

$R = \frac{4 \times (1.13 \times 10^{-6}) \times 1}{\pi \times 0.23^2} = 2.71 \times 10^{-5}$

$\frac{\Delta R}{R} = \frac{\Delta\rho}{\rho} + \frac{\Delta L}{L} + 2\frac{\Delta d}{d}$ $\qquad \Delta R = 5.42 \times 10^{-6}$

$= 0.09 + \frac{0.01}{1} + 2\left(\frac{0.01}{0.23}\right)$ $\qquad R$ = ...$(2.71 \pm 0.5) \times 10^{-5}$...... Ω [2]

$= 0.2$

[Total: 15]

Select page

HIGH MIDDLE LOW

Your Mark

2(a)
2(b)
2(c)(i)
2(c)(ii)
2(c)(iii)
2(d)(i)
2(d)(ii)
2(e)

Q2 Mark scheme

	Mark	Expected Answer	Additional Guidance
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(e)	C4	R in the range 25.5 to 28.4 and given to 2 or 3 s.f.	Allow 26 or 27 or 28. Allow ECF for POT error in **(d)(i)** e.g. 2.7 × 10^7.
	U5	Absolute uncertainty in R	Percentage uncertainty must be greater than 8.6%.

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

2 A student is investigating how the resistance of a wire depends on the diameter of the wire.

The circuit is set up as shown in Fig. 2.1.

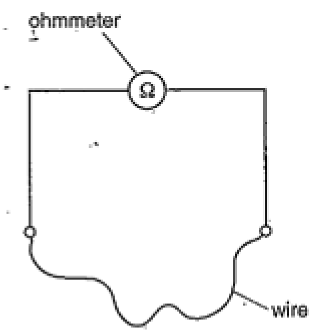

Fig. 2.1

The resistance R of the wire is measured using an ohmmeter.

The experiment is repeated for wires of the same material and same length L but different diameter d.

It is suggested that R and d are related by the equation

$$R = \frac{4\rho L}{\pi d^2}$$

where ρ is a constant.

(a) A graph is plotted of R on the y-axis against $\frac{1}{d^2}$ on the x-axis.

Determine an expression for the gradient.

$R = \frac{4\rho L}{\pi d^2}$

$R = \left(\frac{4\rho L}{\pi}\right)\frac{1}{d^2}$

gradient = $\frac{4\rho L}{\pi}$ ...[1]

Your Mark

2(a)
2(b)
2(c)(i)
2(c)(ii)
2(c)(iii)
2(d)(i)
2(d)(ii)
2(e)

Q2 Mark scheme

	Mark	Expected Answer	Additional Guidance
(a)	A1	$\frac{4\rho L}{\pi}$	
(b)	T1	$\frac{1}{d^2}$ / 10^6 m^{-2}	
	T2	1.2 or 1.21 3.2 or 3.19 4.7 or 4.73 6.9 or 6.93 9.8 or 9.77 14 or 13.7	All values to 2 s.f. or 3 s.f. Allow a mixture of significant figures. Must be values in table.
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EXAMINER COMMENTS

MARK SCHEME

(b) Values of d and R are given in Fig. 2.2.

d / 10^{-3} m	R / Ω	$\frac{1}{d^2}$ / 10^6 m^{-2}
0.91 ± 0.01	1.6	~~1.21 ± 0.03~~ 1.20 ± 0.03
0.56 ± 0.01	4.4	~~3.19 ± 0.11~~ 3.20 ± 0.10
0.46 ± 0.01	6.6	~~4.73 ± 0.20~~ 4.70 ± 0.20
0.38 ± 0.01	9.7	~~6.93 ± 0.35~~ 6.90 ± 0.40
0.32 ± 0.01	13.9	~~9.77 ± 0.58~~ 9.80 ± 0.60
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Fig. 2.2

Calculate and record values of $\frac{1}{d^2}$ / 10^6 m^{-2} in Fig. 2.2.

Include the absolute uncertainties in $\frac{1}{d^2}$. [3]

(c) **(i)** Plot a graph of R/Ω against $\frac{1}{d^2}$ / 10^6 m^{-2}.

Include error bars for $\frac{1}{d^2}$. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the absolute uncertainty in your answer.

Gradient of best fit = $\frac{19-5}{(13.4-3.6)\times10^6}$ = $\frac{14}{9.8\times10^6}$ = 1.43×10^{-6} Ω m^{-2}

Gradient of the worst fit: $\frac{18.6-2}{(14-1.4)\times10^6}$ = $\frac{16.6}{1.26\times10^7}$ = 1.32×10^{-6} Ω m^{-2}

Absolute uncertainty = $(1.43-1.32)\times10^{-6}$ = 0.11×10^{-6}

gradient = $(1.43 \pm 0.11)\times10^{-6}$ Ω m^{-2} [2]

Select page

HIGH MIDDLE LOW

Your Mark

2(a) 2(b) 2(c)(i) 2(c)(ii) 2(c)(iii) 2(d)(i) 2(d)(ii) 2(e)

Q2	Mark scheme		
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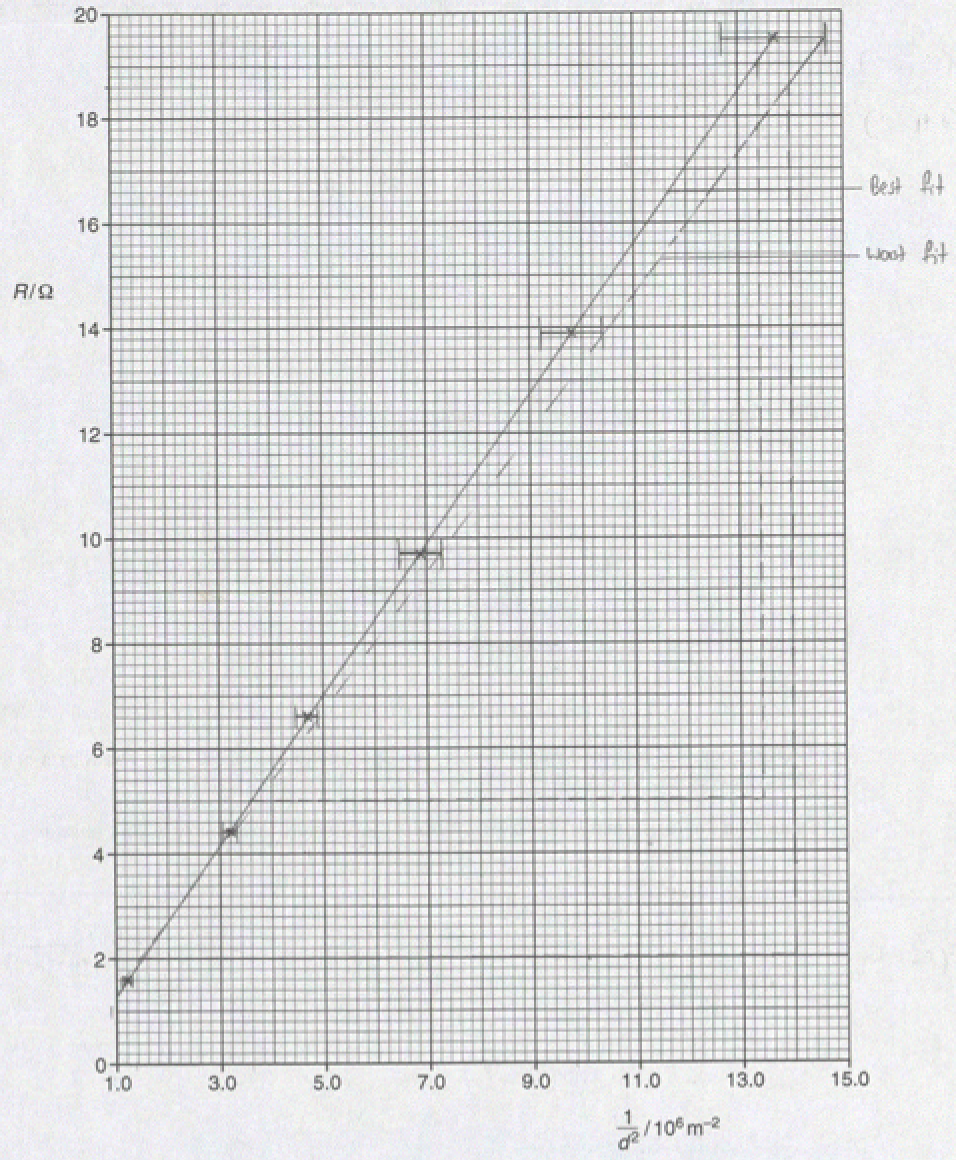
EXAMINER COMMENTS

MARK SCHEME



Select page

HIGH MIDDLE LOW

Your Mark

2(a)

2(b)

2(c)(i)

2(c)(ii)

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Q2	Mark scheme		
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(d)(ii)	U4	Percentage uncertainty in ρ	Percentage uncertainty in gradient + 1%.
(e)	C4	R in the range 25.5 to 28.4 and given to 2 or 3 s.f.	Allow 26 or 27 or 28. Allow ECF for POT error in **(d)(i)** e.g. 2.7 × 10^7.
	U5	Absolute uncertainty in R	Percentage uncertainty must be greater than 8.6%.

EXAMINER COMMENTS

MARK SCHEME

(d) (i) Using your answers to (a) and (c)(iii), determine the value of ρ. Include an appropriate unit.

Data: $L = 1.00 \pm 0.01$ m.

$\text{Gradient} = \frac{4\rho L}{\pi}$

$\frac{4\rho L}{\pi} = 1.43\times10^{-6}$

$\frac{\rho(4)(1)}{\pi} = 1.43\times10^{-6}$

$\rho = \frac{(1.43\times10^{-6})(\pi)}{4}$

$= 1.12\times10^{-6}$

ρ = 1.12×10^{-6} ....[2]

(ii) Determine the percentage uncertainty in ρ.

$\frac{\Delta\rho}{\rho} = \frac{\Delta G}{G} + \frac{\Delta L}{L}$

$= \frac{0.11\times10^{-6}}{1.43\times10^{-6}} + \frac{0.01}{1.00}$

= ~~0.07692~~

= 0.087

$\% = \frac{\Delta\rho}{\rho}\times100$

$= 0.087\times100$

$= 8.7\%$

percentage uncertainty in ρ = 8.7 .... % [1]

(e) The experiment is repeated with a thinner wire of diameter 0.23 ± 0.01 mm. The wire is of the same material and length.

Determine the resistance R of the wire. Include the absolute uncertainty in your answer.

$R = \left(\frac{4\rho L}{\pi}\right)\frac{1}{d^2}$

$R = (G_s)\frac{1}{d^2}$

$= (1.43\times10^{-6})\left(\frac{1}{(0.23\times10^{-3})^2}\right)$

$= 27.03$

$R = (G_w)\frac{1}{d^2}$

$= (1.32\times10^{-6})\left(\frac{1}{(0.23\times10^{-3})^2}\right)$

≈ 24.95

Absolute uncertainty = 27.03 − 24.95
= 2.08

R = 27.03 ± 2.08 .... Ω [2]

[Total: 15]

Your Mark

2(a)

2(b)

2(c)(i)

2(c)(ii)

2(c)(iii)

2(d)(i)

2(d)(ii)

2(e)

Q2 Mark scheme

	Mark	Expected Answer	Additional Guidance
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(c)(iii)	C1	Gradient of line of best fit	The triangle used should be at least half the length of the drawn line. Check the read-offs. Work to half a small square. Do not penalise POT. (Should be about 1.4 – 1.5 × 10^{-6}.)
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(e)	C4	R in the range 25.5 to 28.4 and given to 2 or 3 s.f.	Allow 26 or 27 or 28. Allow ECF for POT error in **(d)(i)** e.g. 2.7 × 10^{7}.
	U5	Absolute uncertainty in R	Percentage uncertainty must be greater than 8.6%.

Select page

HIGH MIDDLE LOW

2 A student is investigating how the resistance of a wire depends on the diameter of the wire.

The circuit is set up as shown in Fig. 2.1.

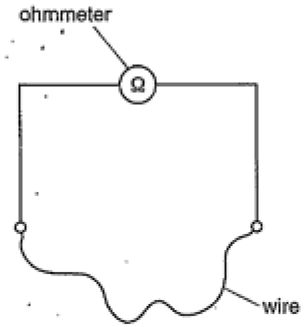

Fig. 2.1

The resistance R of the wire is measured using an ohmmeter.

The experiment is repeated for wires of the same material and same length L but different diameter d.

It is suggested that R and d are related by the equation

$$R = \frac{4\rho L}{\pi d^2}$$

where ρ is a constant.

(a) A graph is plotted of R on the y-axis against $\frac{1}{d^2}$ on the x-axis.

Determine an expression for the gradient.

$R = \frac{4\rho L}{\pi d^2}$ $y = mx + c$ $R = \frac{4\rho}{\pi} \cdot \frac{1}{d^2} + c$

$y = mx + c$

$R = \frac{4\rho L}{\pi} \frac{1}{d^2}$

gradient = $\frac{4\rho}{\pi}$ ....[1]

Your Mark

2(a)

2(b)

2(c)(i)

2(c)(ii)

2(c)(iii)

2(d)(i)

2(d)(ii)

2(e)

Q2 Mark scheme

	Mark	Expected Answer	Additional Guidance
(a)	A1	$\frac{4\rho L}{\pi}$	
(b)	T1	$\frac{1}{d^2}$ / 10^6 m^{-2}	
	T2	1.2 or 1.21 3.2 or 3.19 4.7 or 4.73 6.9 or 6.93 9.8 or 9.77 14 or 13.7	All values to 2 s.f. or 3 s.f. Allow a mixture of significant figures. Must be values in table.
	U1	From ± 0.03 to ± 1	Allow more than one significant figure. Allow zero for first uncertainty and up to 1.2 for largest uncertainty.
(c)(i)	G1	Six points plotted correctly	Must be within half a small square. Do not allow "blobs". ECF allowed from table.
	U2	Error bars in $\frac{1}{d^2}$ plotted correctly	All error bars to be plotted. Length of bar must be accurate to less than half a small square and symmetrical.

EXAMINER COMMENTS

MARK SCHEME

(b) Values of d and R are given in Fig. 2.2.

d/10^{-3}m	R/Ω	$\frac{1}{d^2}$ / 10^{6} m^{-2}
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0.46 ± 0.01	6.6	4.73 ± 0.21
0.38 ± 0.01	9.7	6.93 ± 0.36
0.32 ± 0.01	13.9	9.77 ± 0.61
0.27 ± 0.01	19.5	13.72 ± 1.02

Fig. 2.2

Calculate and record values of $\frac{1}{d^2}$/10^6 m^{-2} in Fig. 2.2.

Include the absolute uncertainties in $\frac{1}{d^2}$. [3]

(c) (i) Plot a graph of R/Ω against $\frac{1}{d^2}$/10^6 m^{-2}.

Include error bars for $\frac{1}{d^2}$. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the absolute uncertainty in your answer.

best fit

$\frac{y^2-y^1}{x^2-x_1} = \frac{19-4}{(13.4-3.6)\times10^6} = \frac{15}{9.4\times10^6}$

$= 1.60 \times 10^{-6}$

$\frac{y^2-y^1}{x^2-x_1} = \frac{19-5}{(12.4-4.2)\times10^6} = \frac{14}{8.2\times10^6}$

$= 1.7\times10^{-6}$

$= 1.60 - 1.7$

$= 1\times10^{-7}$

gradient = (1.60 ± 0.1) x10^{-6} [2]

Select page

HIGH | MIDDLE | LOW

Your Mark

2(a)

2(b)

2(c)(i)

2(c)(ii)

2(c)(iii)

2(d)(i)

2(d)(ii)

2(e)

Q2 Mark scheme

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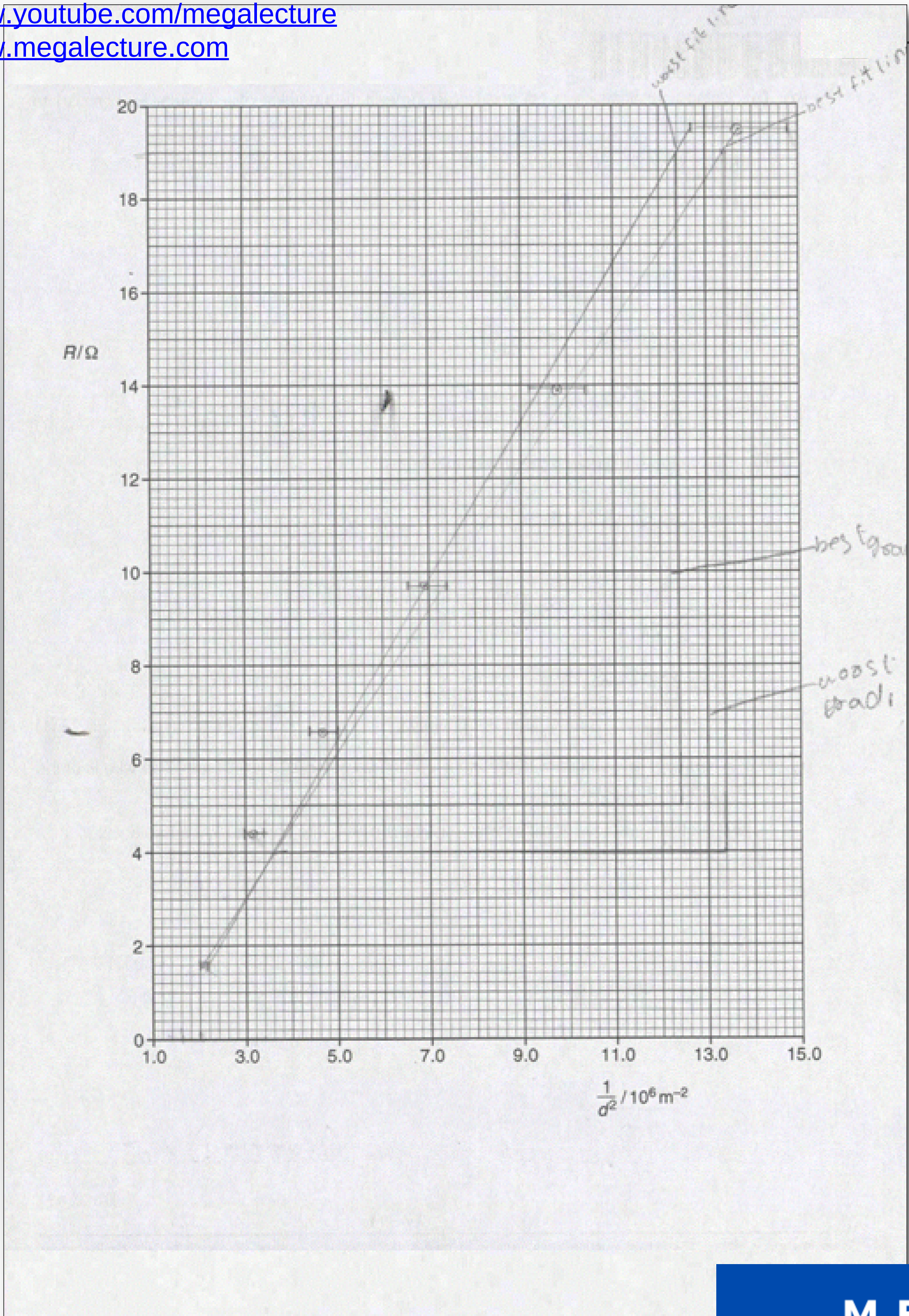
EXAMINER COMMENTS

MARK SCHEME



Your Mark

2(a)
2(b)
2(c)(i)
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Q2	Mark scheme		
	Mark	**Expected Answer**	**Additional Guidance**
(c)(ii)	G2	Line of best fit	Lower end of line must pass between (2.6, 4.0) and (3.0, 4.0) and upper end of line must pass between (12.4, 18.0) and (13.0, 18.0).
	G3	Worst acceptable straight line. Steepest or shallowest possible line that passes through all the error bars.	Line should be clearly labelled or dashed. Examiner judgement on worst acceptable line. Must be steepest/shallowest line. Mark scored only if error bars are plotted.
(c)(iii)	C1	Gradient of line of best fit	The triangle used should be at least half the length of the drawn line. Check the read-offs. Work to half a small square. Do not penalise POT. (Should be about 1.4 –1.5 × 10^{-6}.)
	U3	Absolute uncertainty in gradient	Method of determining absolute uncertainty: difference in worst gradient and gradient.
(d)(i)	C2		Must use gradient value. Do not penalise POT (Should be about 1 × 10–6.)
	C3	Ω m	Correct unit and correct power of ten.
(d)(ii)	U4	Percentage uncertainty in *ρ*	Percentage uncertainty in gradient + 1%.
(e)	C4	*R* in the range 25.5 to 28.4 and given to 2 or 3 s.f.	Allow 26 or 27 or 28. Allow ECF for POT error in **(d)(i)** e.g. 2.7 × 10^7.
	U5	Absolute uncertainty in R	Percentage uncertainty must be greater than 8.6%.

(d) (i) Using your answers to (a) and (c)(iii), determine the value of ρ. Include an appropriate unit.

Data: $L = 1.00 \pm 0.01$ m.

$R = \frac{4\rho L}{\pi d^2}$ $\quad P = \frac{5.03\times10^{-6}}{4}$

$g = \frac{4P}{\pi}$ $\quad P = 1.25\times10^{-6}$

$(1.6\times10^{-6}) = \frac{4P}{\pi}$

$5.03\times10^{-6} = 4P$

ρ = 1.26 × 10⁻⁶ [2]

(ii) Determine the percentage uncertainty in ρ.

$\frac{\Delta L}{L} = \frac{2\Delta L}{L}$ $\quad \frac{0.025}{1.26}\times100$

$\frac{\Delta L}{1.26\times10^{-6}} = \frac{2\times0.01}{1.00}$

0.025×10^{-6}

percentage uncertainty in ρ = 1.98 % [1]

(e) The experiment is repeated with a thinner wire of diameter 0.23 ± 0.01 mm. The wire is of the same material and length.

Determine the resistance R of the wire. Include the absolute uncertainty in your answer.

$R = \frac{4\rho L}{\pi d^2}$ $\quad \frac{\Delta L}{L} = \frac{2\Delta L}{L}$

$= \frac{4(1.26\times10^{-6})(1.00)}{\pi\, 0.23}$ $\quad \frac{\Delta L}{6.97\times10^{-6}} = \frac{2\times0.01}{1.00}$

$= 1.39\times10^{-7}$

$= \frac{5.04\times10^{-6}}{\pi\, 0.23}$

$= 6.97\times10^{-6}$

R = $(6.97 \pm 0.1)\times10^{-6}$ Ω [2]

[Total: 15]

Select page

HIGH MIDDLE LOW

Your Mark

2(a)
2(b)
2(c)(i)
2(c)(ii)
2(c)(iii)
2(d)(i)
2(d)(ii)
2(e)

Q2	Mark scheme		
	Mark	**Expected Answer**	**Additional Guidance**
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	G3	Worst acceptable straight line. Steepest or shallowest possible line that passes through all the error bars.	Line should be clearly labelled or dashed. Examiner judgement on worst acceptable line. Must be steepest/shallowest line. Mark scored only if error bars are plotted.
(c)(iii)	C1	Gradient of line of best fit	The triangle used should be at least half the length of the drawn line. Check the read-offs. Work to half a small square. Do not penalise POT. (Should be about 1.4 – 1.5 × 10^{-6}.)
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(d)(ii)	U4	Percentage uncertainty in ρ	Percentage uncertainty in gradient + 1%.
(e)	C4	R in the range 25.5 to 28.4 and given to 2 or 3 s.f.	Allow 26 or 27 or 28. Allow ECF for POT error in **(d)(i)** e.g. 2.7 × 10^7.
	U5	Absolute uncertainty in R	Percentage uncertainty must be greater than 8.6%.

EXAMINER COMMENTS

MARK SCHEME

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