Please check the examination details below before entering your candidate information

Candidate surname	Other names
StemUp Model Solution	

Pearson Edexcel Level 3 GCE

Centre Number	Candidate Number

Tuesday 14 May 2019

Morning (Time: 1 hour 30 minutes)	Paper Reference **8PH0/01**

Physics

Advanced Subsidiary
Paper 1: Core Physics I

You must have:
Ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions in Sections A and B.
- Answer the questions in the spaces provided – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- You may use a scientific calculator.
- In questions marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or how they follow on from each other where appropriate.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- You are advised to show your working in calculations, including units where appropriate.

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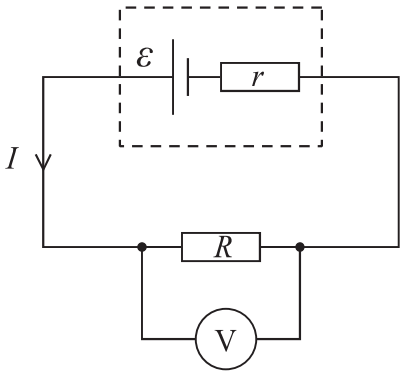
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SECTION A

Answer ALL questions.

All multiple choice questions must be answered with a cross ☒ in the box for the correct answer from A to D. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 A cell of e.m.f ε and internal resistance r is connected across a fixed resistor of resistance R. There is a current I in the circuit and a potential difference V across the fixed resistor.



The term 'lost volts' refers to the difference between the e.m.f. and the terminal potential difference.

Which of the following is an expression for the lost volts?

☒ **A** $I(R + r)$

☒ **B** Ir

☒ **C** IR

☒ **D** $I(R - r)$

(Total for Question 1 = 1 mark)

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2 A student measured the mass, in grams, of a small projectile, and its velocity in kilometres per hour.

To calculate the kinetic energy E_k of the projectile he substituted these quantities into the equation $E_k = ½ mv^2$.

Which of the following should the student multiply the answer by to obtain an answer in joules?

☒ **A** $\frac{1000}{3600^2}$

☐ **B** $\left(\frac{1000}{3600}\right)^2$

☐ **C** $\frac{3600^2}{1000}$

☐ **D** $\left(\frac{3600}{1000}\right)^2$

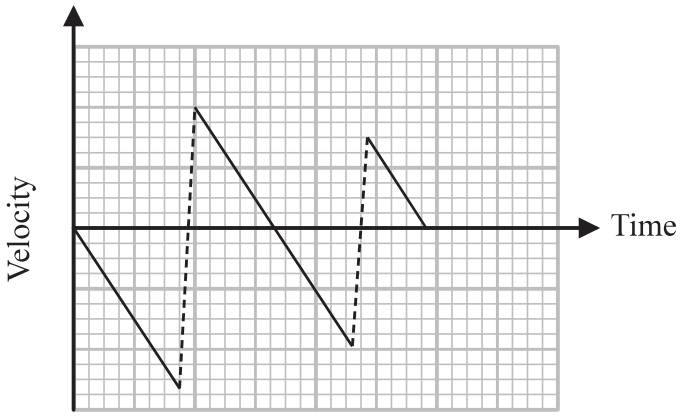
(Total for Question 2 = 1 mark)

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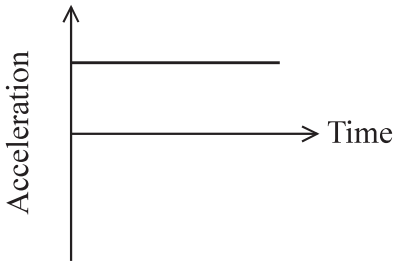
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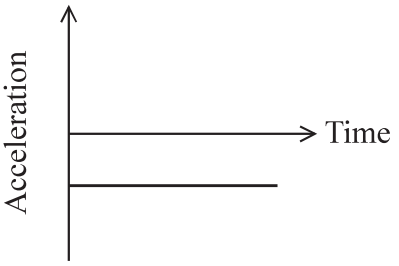
3 A ball is dropped vertically onto a horizontal surface and bounces twice before being caught. The graph shows how the velocity of the ball varies with time for the motion of the ball.



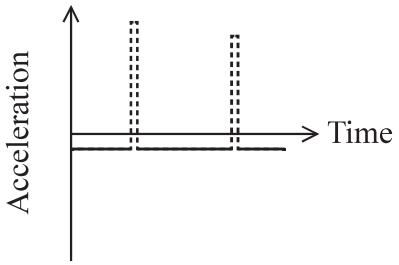
Which of the following is the acceleration-time graph for the motion of the ball?



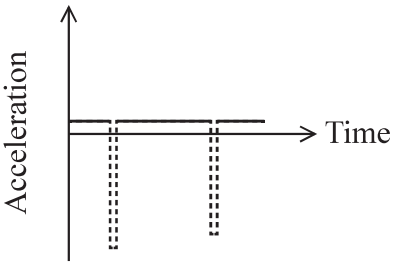
☒ **A**



☒ **B**



☒ **C**



☒ **D**

(Total for Question 3 = 1 mark)

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4 A potential difference V is applied across the ends of a conductor. The drift velocity of the charge carriers in the conductor is v.

Which of the following expressions gives the relationship between drift velocity and potential difference?

☒ **A** $v \propto \frac{1}{V}$

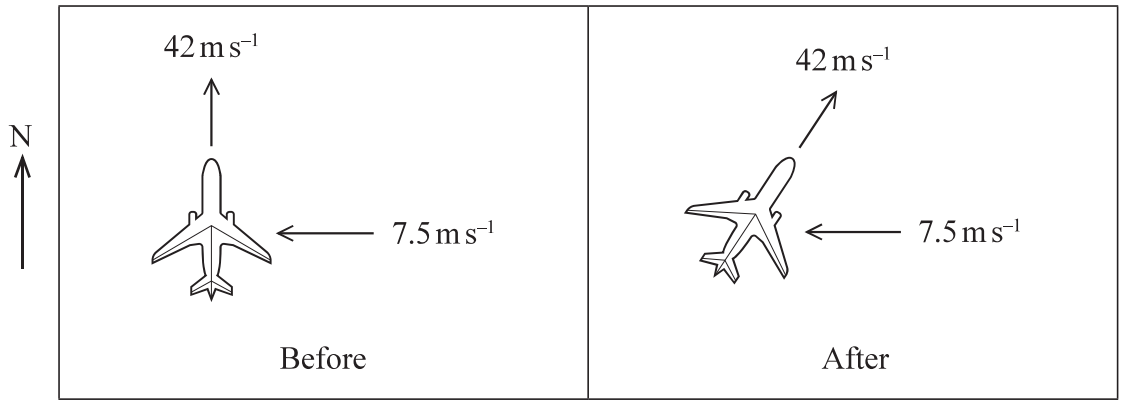
☒ **B** $v \propto \frac{1}{V^2}$

☒ **C** $v \propto V$

☒ **D** $v \propto V^2$

(Total for Question 4 = 1 mark)

5 A plane is travelling north at $42\,m\,s^{-1}$. It enters a region with a wind blowing from the east at $7.5\,m\,s^{-1}$. To keep travelling north, the plane turns towards the east, without changing the thrust, as shown.



Which of the following could be used to calculate the angle through which the plane turns?

☒ **A** $\cos^{-1}\left(\frac{42}{7.5}\right)$

☒ **B** $\sin^{-1}\left(\frac{7.5}{42}\right)$

☒ **C** $\tan^{-1}\left(\frac{7.5}{42}\right)$

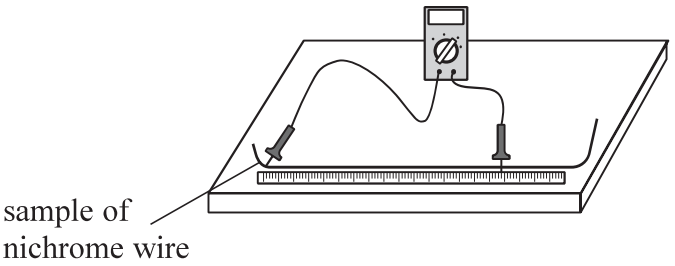
☒ **D** $\tan^{-1}\left(\frac{42}{7.5}\right)$

(Total for Question 5 = 1 mark)

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Questions 6 and 7 refer to the information below.

An ohmmeter was used to measure the resistance R of a length l of nichrome wire as shown. This was then repeated for different values of l.



6 The diameter of the wire was measured and the cross-sectional area A of the wire calculated.

A graph was plotted. The gradient of the graph was equal to the resistivity of nichrome.

Which row of the table shows the quantities which were plotted on the y-axis and the x-axis?

		y-axis	*x*-axis
☒	**A**	l	RA
☒	**B**	lA	R
☒	**C**	R	Al
☒	**D**	RA	l

(Total for Question 6 = 1 mark)

7 A metre rule was used to measure l.

The following measurements were recorded.

l_1 / cm	l_2 / cm	l_3 / cm
89.1	89.6	89.4

Which of the following is the most appropriate uncertainty to use for the length of the piece of wire?

☒ **A** ±0.1 cm

☒ **B** ±0.2 cm

☒ **C** ±0.3 cm

☒ **D** ±0.4 cm

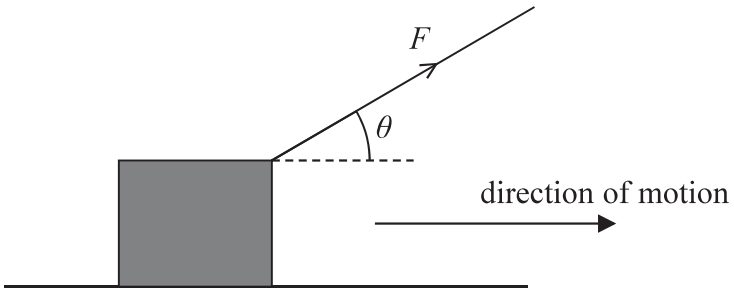
(Total for Question 7 = 1 mark)

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8 A rope is used to pull a box a distance d along a horizontal surface at a constant speed.

A force F is applied to the rope and the rope is at an angle θ to the horizontal.



Which of the following could be used to determine the work done on the box?

☒ **A** $\frac{Fd}{\cos\theta}$

☒ **B** $Fd\cos\theta$

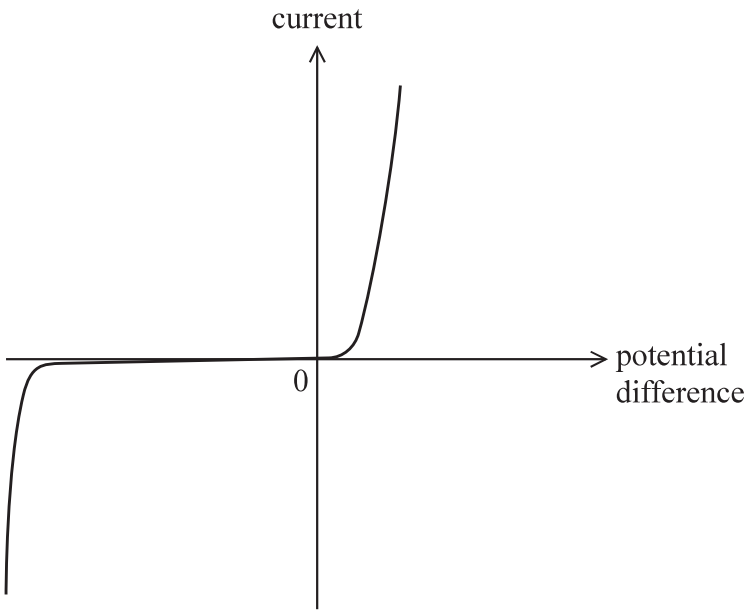
☒ **C** $\frac{Fd}{\sin\theta}$

☒ **D** $Fd\sin\theta$

(Total for Question 8 = 1 mark)

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9 The graph shows how current varies with potential difference for a component in a circuit.



Explain how the graph shows what the component is.

(3)

The component is a diode.

It conducts (allows current) in one direction only: for positive (forward) p.d.s there is a current.

The diode only conducts when the forward p.d. is beyond the threshold voltage of about 0.6 V, then the current rises steeply.

For negative p.d.s (reverse direction) the resistance is very high so the current is almost zero, until at a large reverse voltage (breakdown) it conducts in the reverse direction.

(Total for Question 9 = 3 marks)

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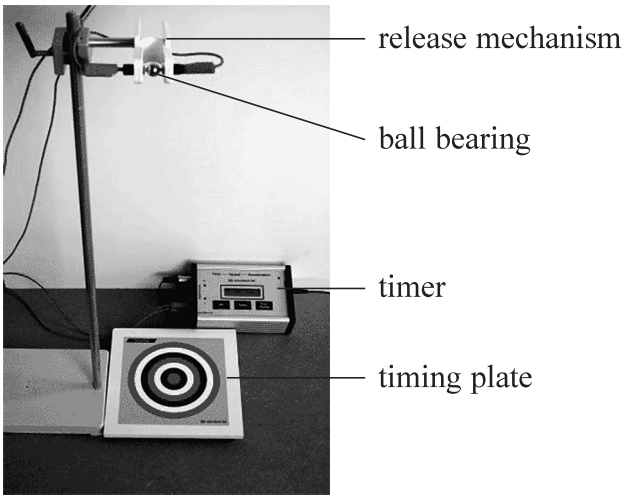
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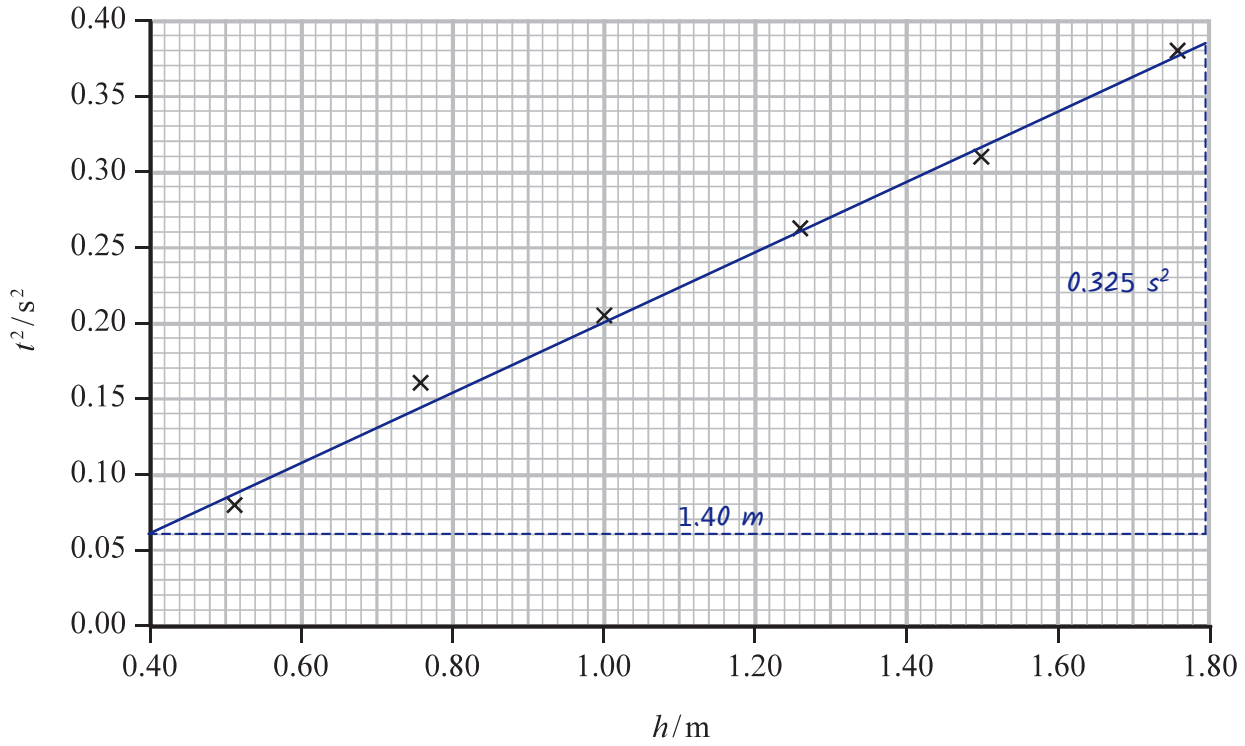
10 A student carried out an experiment to determine the acceleration of free-fall g using the apparatus shown in the photograph.

A ball bearing was released from a measured height h and a timer automatically started. On hitting a timing plate, the ball bearing stopped the timer and the time t was displayed on the timer. This was repeated for different values of h.



The uncertainty in t was ± 3%. The uncertainty in h was ± 1%.

The student plotted a graph of t^2 against h and used it to determine a value for g.



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The student concluded that her value for g was consistent with the accepted value.

Comment on the student's conclusion. Your answer should include a calculation of g from the student's data.

You may assume that the percentage uncertainty in your value of g is the same as if the value were calculated from just one pair of readings.

(5)

gradient = (0.385 − 0.060) s^2 ÷ (1.80 − 0.40) m = 0.325 ÷ 1.40 = 0.232 s^2 m^{-1}

$s = \frac{1}{2}gt^2$ so $t^2 = (2/g)h$, gradient = 2/g

$g = 2 \div 0.232 = 8.6$ m s^{-2}

% uncertainty in g = 2 × 3% + 1% = 7%

% difference = (9.81 − 8.6) ÷ 9.81 × 100 = 12%

(range of g = 8.6 ± 0.6, i.e. 8.0 to 9.2 m s^{-2})

The 12% difference is greater than the 7% uncertainty (9.81 m s^{-2} is outside the range 8.0 to 9.2 m s^{-2}), so the value is not consistent with the accepted value and the student's conclusion is wrong.

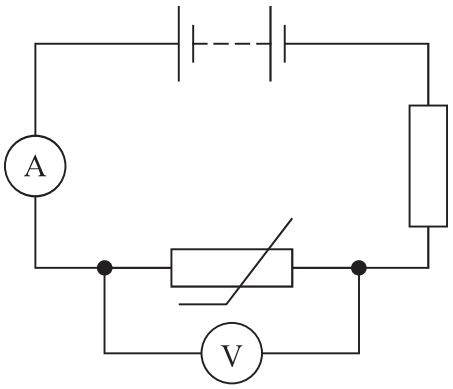
(Total for Question 10 = 5 marks)

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11 A student investigated the effect of temperature on the resistance of a thermistor, using the circuit shown.



(a) The voltmeter was an analogue voltmeter of resistance 45 kΩ.

The thermistor was placed in a beaker of ice and the current and potential difference (p.d.) at a temperature of 0 °C were recorded.

The manufacturer of the thermistor states that at 0 °C the thermistor has a resistance of 9.7 kΩ.

(i) Comment on the suitability of using the analogue voltmeter for measuring the p.d. across the thermistor. Your answer should include a suitable calculation.

(3)

Total resistance of the parallel combination: 1/R = 1/9.7 kΩ + 1/45 kΩ

R = 7.98 kΩ = 8.0 kΩ

This is significantly less than 9.7 kΩ: the current through the voltmeter is 9.7/45 = 22% of the thermistor current, which is significant, so the analogue voltmeter is unsuitable.

(ii) Explain why connecting the voltmeter across both the ammeter and the thermistor would improve the experiment. The ammeter had negligible resistance.

(2)

In the original circuit current flows through the voltmeter, so the ammeter reads more than the thermistor current.

In the new arrangement the ammeter would read only the current passing through the thermistor (current through ammeter = current through thermistor).

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(b) A negative temperature coefficient thermistor was used in this circuit.

With reference to the charge carriers in the thermistor, explain what happens to the p.d. across the thermistor as the temperature increases.

(3)

As the temperature increases the number of (free) charge carriers (electrons) in the thermistor increases, so its resistance decreases.

The thermistor resistance as a proportion of the total resistance decreases (the current increases so the p.d. across the fixed resistor increases).

So the p.d. across the thermistor decreases.

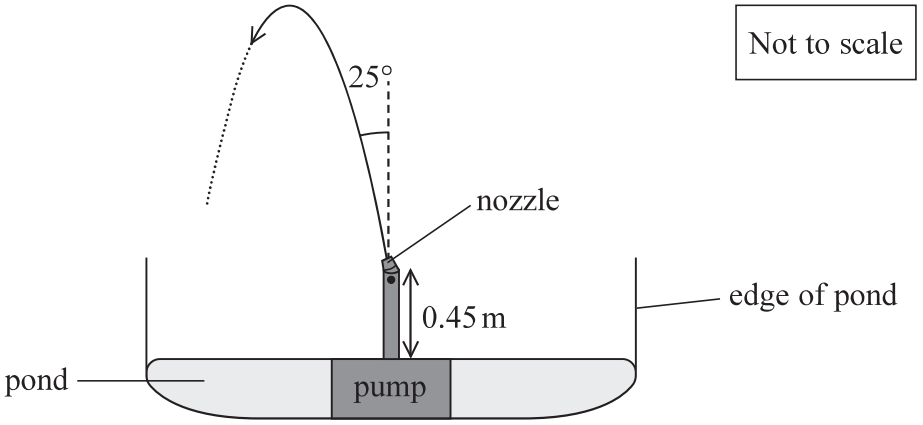
(Total for Question 11 = 8 marks)

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12 A garden pond contains a water fountain. The fountain consists of a pump and nozzle and is used to create a jet of water which falls back into the pond as shown. The top of the edge of the pond is level with the nozzle.



The water is lifted through a height of 0.45 m before it leaves the nozzle at an angle of 25° to the vertical.

(a) The efficiency of the pump is 76%.

Show that the water leaves the nozzle at a speed of about 8 m s^{-1}.

mass of water leaving the pump each second = 3.5 kg s^{-1}
power of pump = 160 W

(5)

efficiency = useful power output ÷ total power input

useful output power = 0.76 × 160 W = 121.6 W

Each second: $E_{grav} = mgh = 3.5 \times 9.81 \times 0.45 = 15.5$ J

$E_k = ½mv^2 = ½ \times 3.5 \times v^2$

output power = E_{grav}/1 s + E_k/1 s

$121.6 = 15.5 + 1.75v^2$

$v^2 = 106.1 \div 1.75 = 60.6$

v = 7.8 m s^{-1} (about 8 m s^{-1})

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(b) Determine the minimum horizontal distance that the nozzle should be placed from the edge of the pond so that the water falls back into the pond. It can be assumed that air resistance is negligible.

(4)

$u_h = 7.8 \sin 25° = 3.30 \text{ m s}^{-1}$ $u_v = 7.8 \cos 25° = 7.07 \text{ m s}^{-1}$

Lands at the same level: $s = ut + \frac{1}{2}at^2$

$0 = 7.07t - \frac{1}{2} \times 9.81 \times t^2$

$t = 2 \times 7.07 \div 9.81 = 1.44 \text{ s}$

horizontal distance $s = u_h t = 3.30 \times 1.44 = 4.75 \text{ m}$

Minimum horizontal distance = 4.8 m

(c) The minimum horizontal distance calculated in (b) is an overestimate because air resistance was ignored.

Explain another reason for the distance calculated to be an overestimate.

(2)

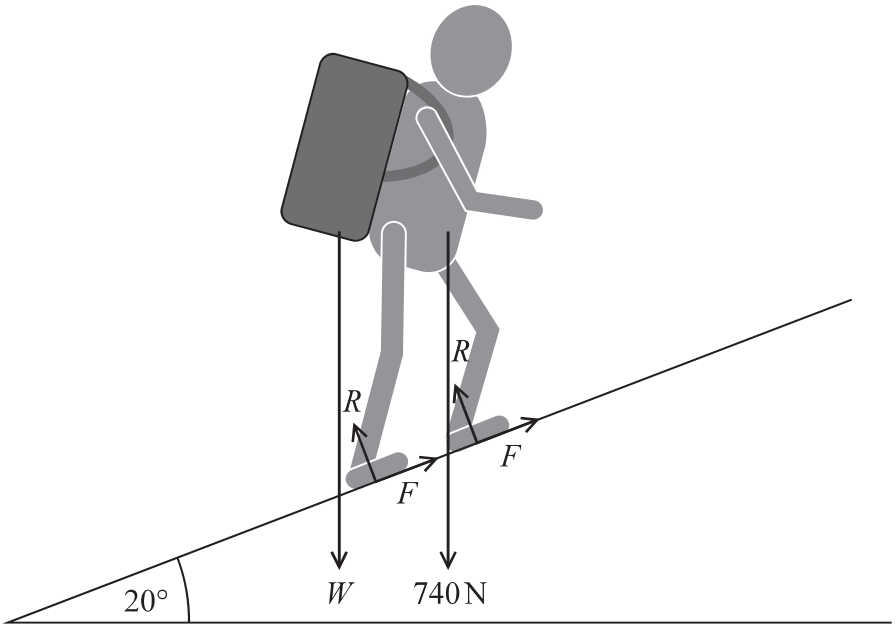
There is friction between the water and the pipes (and nozzle) of the fountain.

This will reduce the (initial) velocity of the water leaving the nozzle, so the distance travelled is less.

(Total for Question 12 = 11 marks)

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13 A hiker of weight 740 N walks up a hill carrying a large bag of weight W. The hiker stops for a moment in the position shown.



The normal force R of the ground on the hiker is the same at each foot. The frictional force between each foot and the ground is F. The hill is at an incline of 20° to the horizontal.

(a) An expression for the components of force perpendicular to the ground acting on the hiker is

$$740\cos 20 + W\cos 20 - 2R = 0$$

(i) Explain why this expression is correct.

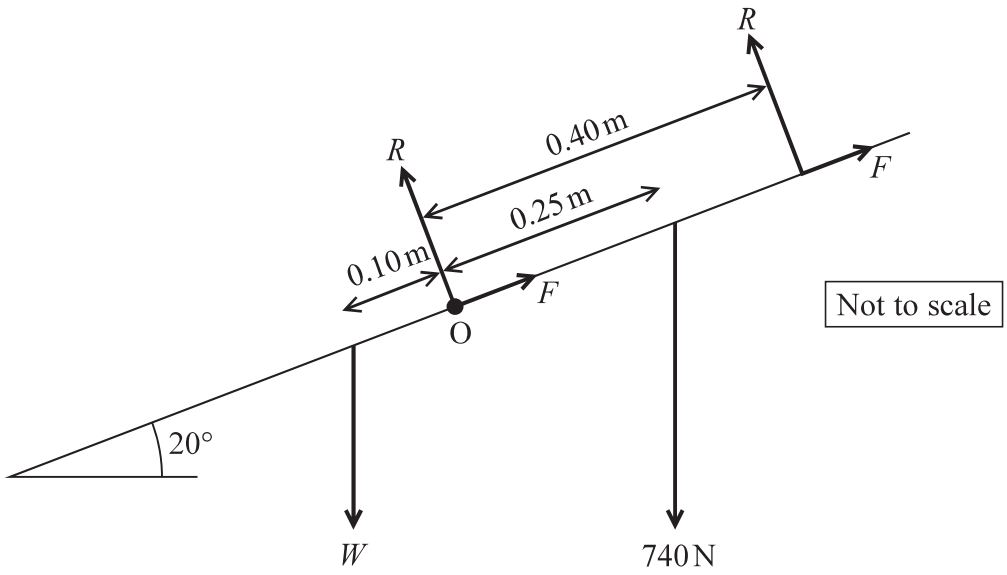
(2)

740cos20 is the component of the weight of the hiker perpendicular to the ground and Wcos20 is the perpendicular component of the weight of the bag.

2R is the push (normal reaction force) of the ground on the hiker's two feet, and as the hiker is stationary the resultant force is zero ($\Sigma F = 0$), so the components sum to zero.

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(ii) The diagram shows the lines of action of the forces acting on the hiker and backpack. Position O represents the middle of the back foot of the hiker.



Determine W. You should take moments about O.

(6)

Taking moments about O (R at the back foot has no moment):

Moment of the weight of the hiker = 740 × 0.25 × cos 20 = 173.8 N m (clockwise)

Moment of the weight of the bag = W × 0.10 × cos 20 = 0.0940W N m

Moment of R at the front foot = R × 0.40 = 0.40R N m

Principle of moments: 173.8 = 0.40R + 0.0940W

so R = 434.6 − 0.235W

From (a): 2R = 740cos20 + Wcos20, so R = 347.7 + 0.470W

434.6 − 0.235W = 347.7 + 0.470W

0.705W = 86.9

W = 123 N

$W =$ 123 N

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(b) The hiker repacks his bag, placing the heavier items at the bottom of the bag.

Explain why this may cause R on the front foot to decrease.

(2)

The centre of gravity of the bag moves lower and to the left (backwards), so the perpendicular distance of the bag's weight from O is greater.

The moment of the bag about O increases, so the moment of R (and the size of R) on the front foot decreases to preserve equilibrium.

(Total for Question 13 = 10 marks)

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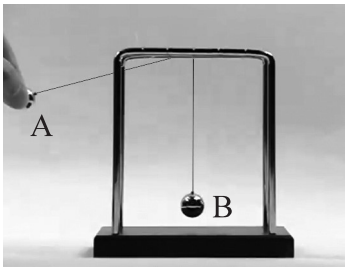
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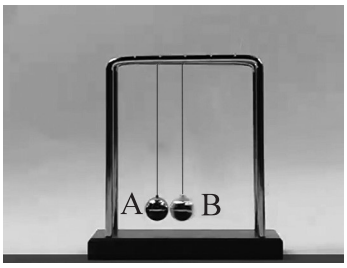
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14 Two small identical solid metal spheres, A and B, are suspended by light inextensible threads from a frame.

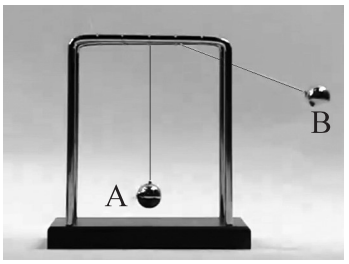
*(a) Sphere A is pulled to one side as shown and released. Sphere A collides with sphere B and stops and sphere B swings upwards. The time intervals between the photographs below are the same.



Photograph 1



Photograph 2



Photograph 3

Using Newton's laws of motion, explain the motion of the spheres during the collision in terms of the forces acting on them.

(6)

On impact, sphere A applies a force to sphere B.

According to Newton's third law, sphere B applies an equal and opposite force to sphere A.

This force on A acts in the opposite direction to A's motion, so it opposes the motion of sphere A.

By Newton's second law (F = ma) the resultant force on A causes A to decelerate, so A stops.

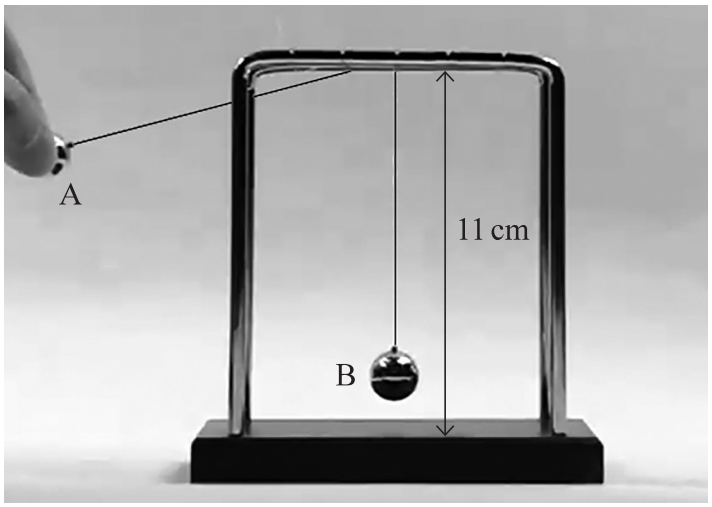
The resultant force on sphere B (in the direction A was moving) accelerates B, so B moves off and swings upwards.

The forces act for the same time and are equal in size, so the impulse on each sphere is the same and the change in momentum (and speed, as the masses are equal) is the same for each sphere: A loses the speed that B gains.

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(b) The photograph shows sphere A just before it was released.



Determine the momentum of sphere A just before the collision. You should take measurements from the photograph.

height of frame = 11 cm
mass of sphere = 0.022 kg

(5)

On the photograph: height of frame = 4.8 cm, initial decrease in height of A = 2.9 cm

actual decrease in height = 2.9 × 11 ÷ 4.8 = 6.6 cm = 0.066 m

E_k gained = E_{grav} lost: $\frac{1}{2}mv^2 = mgh$

$v = \sqrt{(2gh)} = \sqrt{(2 \times 9.81 \times 0.066)} = 1.14\ m\ s^{-1}$

$p = mv = 0.022 \times 1.14 = 0.025\ kg\ m\ s^{-1}$

Momentum of sphere A = $0.025\ kg\ m\ s^{-1}$

(Total for Question 14 = 11 marks)

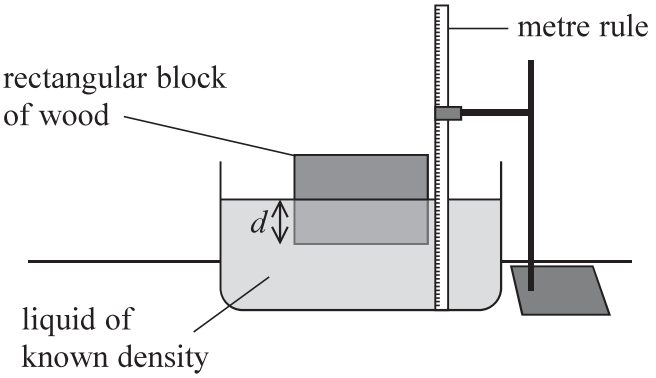
TOTAL FOR SECTION A = 56 MARKS

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SECTION B

Answer all questions.

15 A student investigated the flotation of a solid rectangular block of wood on the surface of liquids with different densities. A metre rule immersed in the liquid was used to measure the depth d of the block below the surface of the liquid as shown. The wood had a density ρ_S and the block was of height x.



The student predicted that the relationship between the density ρ_L of the liquid and the depth d of the block below the liquid would be

$$\rho_L = \frac{\rho_S x}{d}$$

(a) The student's results are shown in the table.

She decided to check her prediction by plotting a graph of ρ_L against $\frac{1}{d}$.

Plot the graph on the grid opposite, using the additional column of the table for your processed data.

(5)

Liquid	ρ_L / kg m^{-3}	d / m	d^{-1} / m^{-1}
Honey	1420	0.035	28.6
Corn syrup	1330	0.040	25.0
Seawater	1030	0.050	20.0
Vegetable oil	920	0.055	18.2
Baby oil	830	0.060	16.7

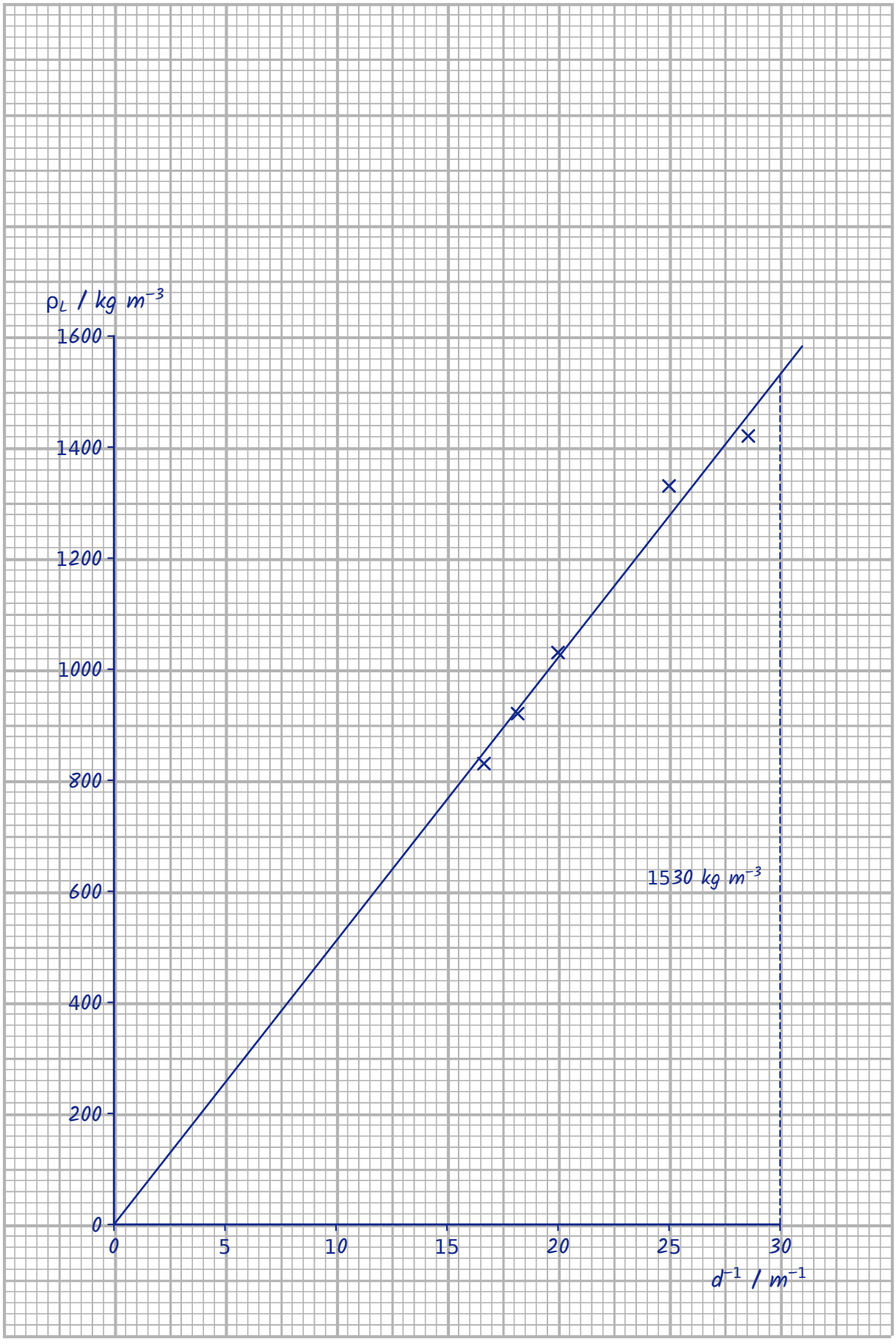
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(b) Explain how the data supports the student's prediction.

(2)

The graph of ρ_L against 1/d is a straight line through the origin, so ρ_L is (directly) proportional to 1/d, as predicted by $\rho_L = \rho_s x \times (1/d)$ since $\rho_s x$ is constant.

(c) The table gives the densities of several different types of wood.

Wood	Density / kg m^{-3}
Birch	670
Chestnut	570
Oak	780
Poplar	350

Deduce the type of wood from which the block was made.

$x = 9.0\,\text{cm}$

(4)

gradient from line of best fit = 1530 kg m^{-3} ÷ 30 m^{-1} = 51 kg m^{-2}

gradient = $\rho_s x$, x = 9.0 cm = 0.090 m

ρ_s = 51 ÷ 0.090 = 570 kg m^{-3} (567 kg m^{-3})

This matches the density of chestnut (570 kg m^{-3}), so the block was made of chestnut.

(Total for Question 15 = 11 marks)

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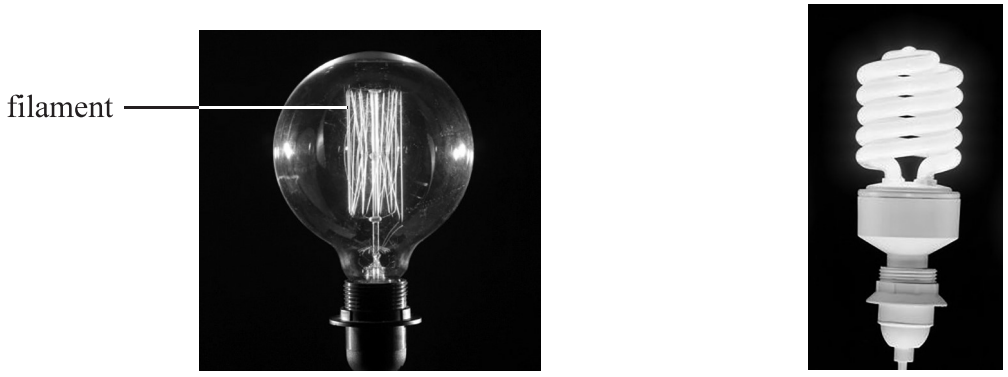
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16 Filament and fluorescent are two types of light bulb.

Filament light bulbs contain a tightly coiled wire filament, surrounded by an inert gas and encased in a thin glass bulb. When the potential difference (p.d.) across the bulb is sufficient, the filament heats up, emitting visible light.

Fluorescent light bulbs use a long tube of glass containing a small amount of mercury. When a sufficient p.d. is applied across the ends of the tube, electrons moving through the tube cause the mercury to become a vapour and emit photons in the ultraviolet part of the electromagnetic spectrum. The collisions of these photons with the phosphor coating of the tube result in the emission of photons of visible light.



Filament bulb

Fluorescent bulb

(a) (i) Explain how the wire in the filament lamp gets hot when a p.d. is applied.

(2)

When the p.d. is applied, the moving (free) electrons collide with the lattice ions of the wire.

They transfer energy to the ions, so the ions vibrate with larger amplitude (speed) and the temperature of the wire increases.

(ii) Explain how the fluorescent bulb emits photons when sufficient p.d is applied.

(2)

Electrons moving through the tube collide with the mercury atoms and excite electrons in the mercury atoms to higher energy levels.

Energy is released in the form of (ultraviolet) photons as the electrons move back down (de-excite) to the ground state; these photons excite the phosphor atoms which de-excite and release photons of visible light.

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(b) A filament bulb contains a tungsten filament of diameter 3.8×10^{-5} m and uncoiled length 1.6 m. As the temperature of the filament increases, the resistance of the filament increases to a maximum which is 14 times greater than the initial resistance at room temperature.

(i) Determine the power of the filament at maximum brightness.

p.d. across filament = 240 V
resistivity of tungsten at room temperature = $5.6 \times 10^{-8}\,\Omega$m

(5)

$A = \pi d^2/4 = \pi \times (3.8 \times 10^{-5})^2 \div 4 = 1.134 \times 10^{-9}\ m^2$

$R = \rho l/A = 5.6 \times 10^{-8} \times 1.6 \div 1.134 \times 10^{-9} = 79.0\ \Omega$

$R_{max} = 14 \times 79.0 = 1106\ \Omega$

$P = V^2/R = 240^2 \div 1106 = 52.1\ W$

Power = 52 W

(ii) Filament bulbs are designed to last for thousands of hours of use. Over time the filament may wear away, becoming thinner at one point. This can cause the filament to melt and break at that point.

Assess whether the filament is more likely to break as the bulb is switched on or when it is in use.

(4)

The p.d. is constant (240 V). When the bulb is switched on the filament is cold, so its resistance is lowest and the current is the greatest.

As $P = V^2/R$ (or $P = I^2R$, where the change in current has more effect as it is squared), the power transferred is greatest when R is lowest.

So the heating effect is greatest (especially at the thin point) when the bulb is switched on, so the filament is more likely to break when it is switched on.

(Total for Question 16 = 13 marks)

TOTAL FOR SECTION B = 24 MARKS
TOTAL FOR PAPER = 80 MARKS

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List of data, formulae and relationships

Acceleration of free fall	$g = 9.81\ \text{m s}^{-2}$	(close to Earth's surface)
Electron charge	$e = -1.60 \times 10^{-19}\ \text{C}$	
Electron mass	$m_e = 9.11 \times 10^{-31}\ \text{kg}$	
Electronvolt	$1\ \text{eV} = 1.60 \times 10^{-19}\ \text{J}$	
Gravitational field strength	$g = 9.81\ \text{N kg}^{-1}$	(close to Earth's surface)
Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$	
Speed of light in a vacuum	$c = 3.00 \times 10^{8}\ \text{m s}^{-1}$	

Mechanics

Kinematic equations of motion

$$s = \frac{(u + v)t}{2}$$

$v = u + at$

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

$v^2 = u^2 + 2as$

Forces

$\Sigma F = ma$

$$g = \frac{F}{m}$$

$W = mg$

$moment\ of\ force = Fx$

Momentum

$p = mv$

Work, energy and power

$\Delta W = F\Delta s$

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

$\Delta E_{grav} = mg\Delta h$

$$P = \frac{E}{t}$$

$$P = \frac{W}{t}$$

$$\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}}$$

$$\text{efficiency} = \frac{\text{useful power output}}{\text{total power input}}$$

Electric circuits

Potential difference

$$V = \frac{W}{Q}$$

Resistance

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

Electrical power and energy

$P = VI$

$P = I^2R$

$$P = \frac{V^2}{R}$$

$W = VIt$

Resistivity

$$R = \frac{\rho l}{A}$$

Current

$$I = \frac{\Delta Q}{\Delta t}$$

$I = nqvA$

Materials

Density

$$\rho = \frac{m}{V}$$

Stokes' law

$F = 6\pi\eta r v$

Hooke's law

$F = k\Delta x$

Pressure

$$p = \frac{F}{A}$$

Young modulus

$$\text{Stress } \sigma = \frac{F}{A}$$

$$\text{Strain } \varepsilon = \frac{\Delta x}{x}$$

$$E = \frac{\sigma}{\varepsilon}$$

Elastic strain energy

$\Delta E_{el} = \frac{1}{2} F \Delta x$

Waves and Particle Nature of Light

Wave speed

$v = f\lambda$

Speed of a transverse wave on a string

$$v = \sqrt{\frac{T}{\mu}}$$

Intensity of radiation

$$I = \frac{P}{A}$$

Power of a lens

$$P = \frac{1}{f}$$

$P = P_1 + P_2 + P_3 + \ldots$

Thin lens equation

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

Magnification for a lens

$$m = \frac{\text{image height}}{\text{object height}} = \frac{v}{u}$$

Diffraction grating

$n\lambda = d \sin\theta$

Refractive index

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$$n = \frac{c}{v}$$

Critical angle

$$\sin C = \frac{1}{n}$$

Photon model

$E = hf$

Einstein's photoelectric equation

$hf = \phi + \frac{1}{2} m v_{max}^2$

de Broglie wavelength

$$\lambda = \frac{h}{p}$$

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