Please check the examination details below before entering your candidate information

Candidate surname: StemUp Model Solution

Other names:

Pearson Edexcel Level 3 GCE

Centre Number

Candidate Number

Time 1 hour 30 minutes

Paper reference **8PH0/01**

Physics

Advanced Subsidiary

PAPER 1: Core Physics I

You must have:
Scientific calculator, 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 follow on from each other where appropriate.
- The list of data, formulae and relationships is printed at the end of this booklet.

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.
- Good luck with your examination.

Turn over ▶

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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 Select the row of the table that identifies an SI base unit and a derived unit.

		Base unit	Derived unit
☒	**A**	coulomb	ampere
☒	**B**	joule	volt
☒	**C**	newton	kilogram
☒	**D**	second	watt

(Total for Question 1 = 1 mark)

2 A constant current maintained in a copper wire causes the temperature of the wire to increase.

Which of the following does **not** increase?

☒ **A** amplitude of vibration of the lattice ions

☒ **B** number of conduction electrons per unit volume

☒ **C** rate of collision of conduction electrons with lattice ions

☒ **D** rate of energy transfer from conduction electrons to lattice ions

(Total for Question 2 = 1 mark)

3 A car of mass 1.5×10^3 kg is travelling at a speed of 25 m s^{-1}. The driver applies the brakes and the car comes to rest.

Which of the following gives the decrease in kinetic energy, in joules, as the car is brought to rest?

☒ **A** $750 \times (25)^2$

☒ **B** $750 \times \left(\frac{25}{2}\right)^2$

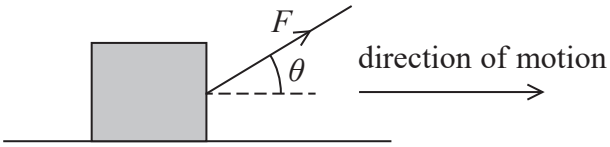
☒ **C** $1500 \times (25)^2$

☒ **D** $1500 \times \left(\frac{25}{2}\right)^2$

(Total for Question 3 = 1 mark)

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4 A rope is used to apply a force F to a box as shown. The box is pulled a distance d along a horizontal surface.



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

☒ **A** $Fd \sin\theta$

☒ **B** $\dfrac{Fd}{\sin\theta}$

☒ **C** $Fd \cos\theta$

☒ **D** $\dfrac{Fd}{\cos\theta}$

(Total for Question 4 = 1 mark)

5 A torch is switched on for 5 minutes. The current in the torch bulb is 6 mA.

Which of the following gives the charge, in coulombs, that flows in this time?

☒ **A** $6 \times 10^{-3} \times 5$

☒ **B** $\dfrac{6 \times 10^{-3}}{5}$

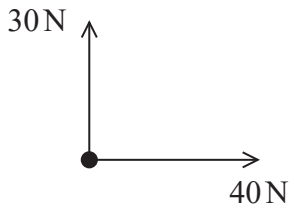
☒ **C** $\dfrac{6}{300}$

☒ **D** $6 \times 10^{-3} \times 300$

(Total for Question 5 = 1 mark)

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6 The diagram shows the two forces acting on a point mass.



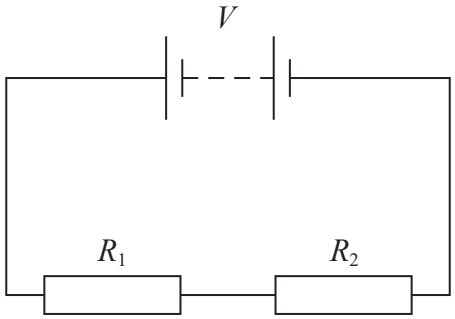
The mass accelerates.

Which of the following gives the angle between the direction of the acceleration and the 40 N force?

- ☒ **A** $\cos^{-1}(30/40)$
- ☒ **B** $\sin^{-1}(40/50)$
- ☒ **C** $\tan^{-1}(30/40)$
- ☒ **D** $\tan^{-1}(40/50)$

(Total for Question 6 = 1 mark)

7 Two resistors of resistance R_1 and R_2 are connected to a battery as shown.
The terminal potential difference of the battery is V.



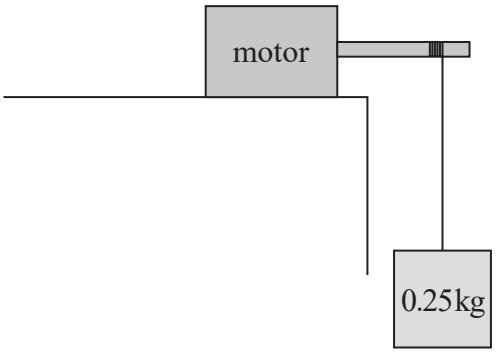
Which of the following gives the potential difference across the resistor of resistance R_1?

- ☒ **A** $\frac{R_1}{R_2} \times V$
- ☒ **B** $\frac{R_1}{R_1 + R_2} \times V$
- ☒ **C** $\frac{R_2}{R_1} \times V$
- ☒ **D** $\frac{R_2}{R_1 + R_2} \times V$

(Total for Question 7 = 1 mark)

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8 A motor is used to lift an object as shown. The object is raised through a vertical height of 75 cm at a constant speed of $0.40\,m\,s^{-1}$.



Which of the following gives the rate of increase of potential energy of the object in watts?

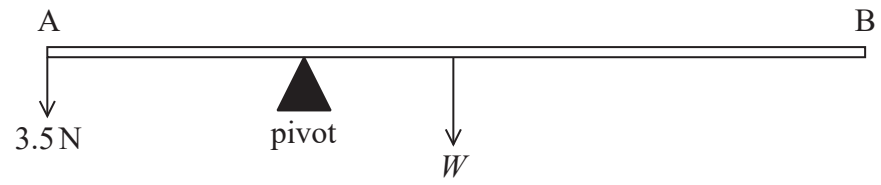
- ☒ **A** $0.25 \times 9.81 \times 0.40$
- ☒ **B** 0.25×0.75
- ☒ **C** $0.25 \times 9.81 \times 0.75$
- ☒ **D** $0.5 \times 0.25 \times (0.40)^2$

(Total for Question 8 = 1 mark)

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9 A uniform rigid rod AB of length 1.50 m has a weight W of 6.5 N. A force of 3.5 N applied at A balances the rod on a pivot as shown.

Diagram not to scale



Calculate the distance of the pivot from A when the rod is in equilibrium.

(2)

W acts at the centre of the rod, 0.75 m from A. Let the pivot be x from A.

Moments about pivot: 3.5 N × x = 6.5 N × (0.75 m − x)

3.5x + 6.5x = 4.875 N m, so 10x = 4.875

x = 0.4875 m

Distance of pivot from A = 0.49 m

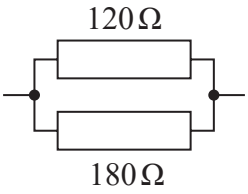
(Total for Question 9 = 2 marks)

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10 Two resistors are connected as shown.



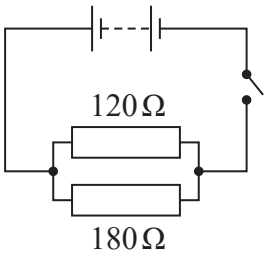
(a) Show that the resistance of the combination is about 70 Ω.

(2)

$1/R = 1/R_1 + 1/R_2 = 1/120\ \Omega + 1/180\ \Omega = 0.0139\ \Omega^{-1}$

$R = 1/0.0139\ \Omega^{-1} = 72.0\ \Omega$, which is about 70 Ω

(b) This resistor combination is connected to a battery of e.m.f. ε and internal resistance r.



The switch is closed for 5 minutes.

Calculate the energy dissipated in the resistor combination.

$\varepsilon = 9.0\,\text{V}$
$r = 2.5\,\Omega$

(4)

$I = \varepsilon/(R + r) = 9.0\ \text{V} / (72\ \Omega + 2.5\ \Omega) = 0.121\ \text{A}$

$P = I^2R = (0.121\ \text{A})^2 \times 72\ \Omega = 1.05\ \text{W}$

$t = 5 \times 60\ \text{s} = 300\ \text{s}$

$E = Pt = 1.05\ \text{W} \times 300\ \text{s} = 315\ \text{J} \approx 320\ \text{J}$

Energy dissipated in resistor combination = 320 J

(Total for Question 10 = 6 marks)

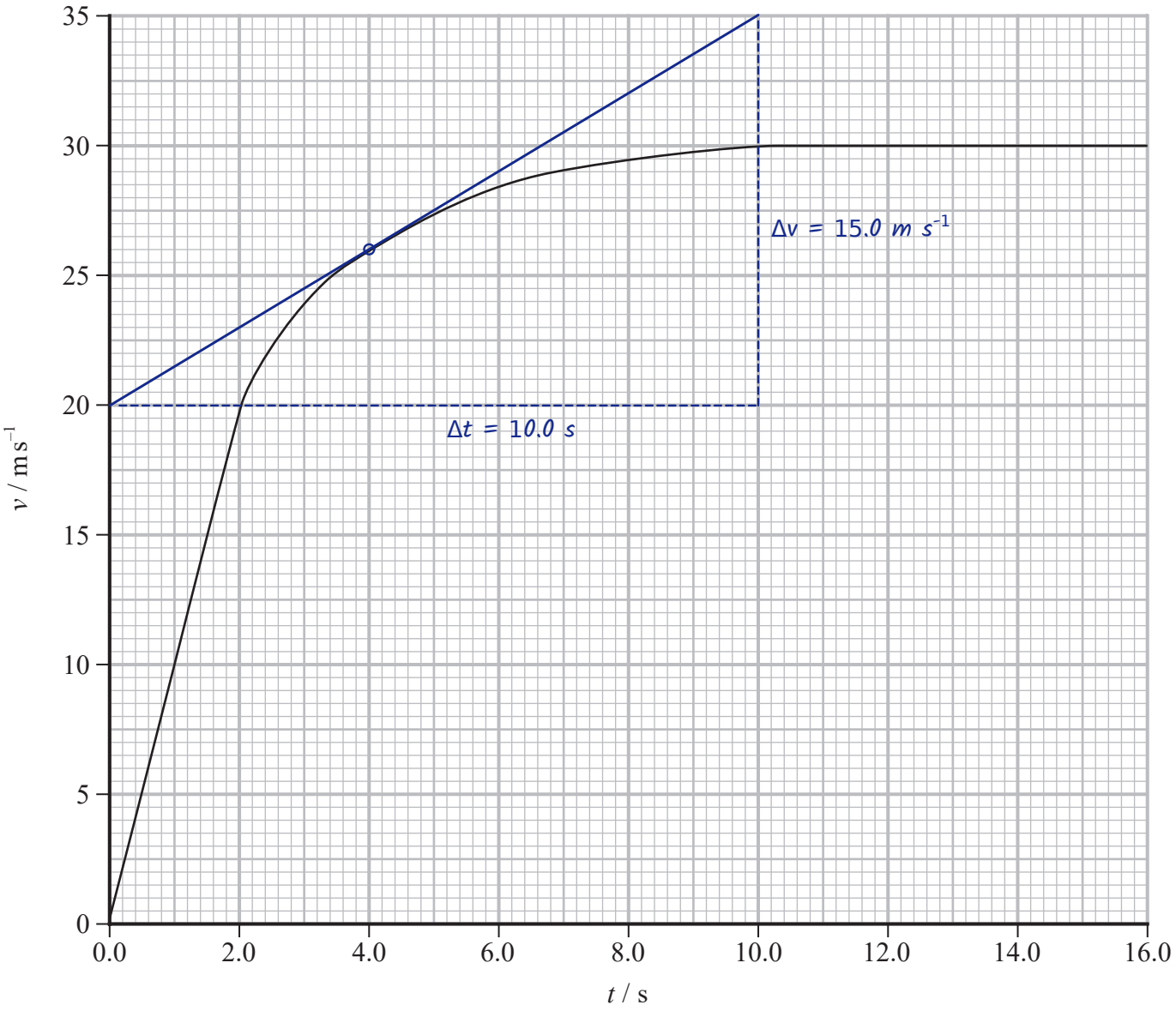
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11 A skydiver made a skydive from a plane.



(Source: © Sky Antonio/Shutterstock)

The graph shows how the velocity v of the skydiver varied with time t, from the instant she left the plane to the instant just before the parachute opened.



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(a) Determine the acceleration of the skydiver when $t = 4.0$ s.

(3)

Tangent drawn to the curve at $t = 4.0$ s (on the graph).

gradient = $\Delta v / \Delta t$ = (35.0 − 20.0) m s^{-1} / (10.0 − 0.0) s

a = 15.0 / 10.0 = 1.5 m s^{-2}

Acceleration of skydiver = 1.5 m s^{-2}

(b) Determine an approximate value for the displacement of the skydiver over the first 16.0 s of the skydive.

(3)

Displacement = area under the velocity-time graph.

1 large square = 2.0 s × 5 m s^{-1} = 10 m

Number of large squares under the line ≈ 42

s = 42 × 10 m = 420 m

Displacement of skydiver = 420 m

(Total for Question 11 = 6 marks)

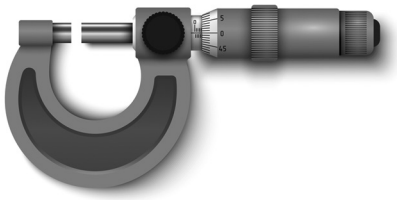
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12 The resistivity of a metal is an important property of wire used in an electric circuit.

(a) A student carried out an experiment to determine the resistivity of a type of wire. He used a micrometer to measure the diameter d of the wire.



(Source: © Viktor Chursin/Shutterstock)

He recorded the following values.

d_1 / mm	d_2 / mm	d_3 / mm	d_4 / mm
1.40	1.44	1.42	1.41

(i) Calculate the percentage uncertainty in the mean diameter of the wire.

(3)

Mean d = (1.40 + 1.44 + 1.42 + 1.41) mm / 4 = 1.42 mm

Uncertainty = half the range = (1.44 − 1.40) mm / 2 = 0.02 mm

% uncertainty = (0.02 mm / 1.42 mm) × 100% = 1.41%

% uncertainty in mean diameter of wire = 1.4 %

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(ii) The student used an ohmmeter to measure the resistance R of a 1.65 m length of the wire.

He looked up the resistivity values of some materials.

Material	Titanium	Constantan	Stainless Steel
Resistivity / $10^{-7}\,\Omega\,m$	4.2	4.7	6.9

Identify the material of the wire.

$R = 0.72\,\Omega$

(3)

$A = \pi r^2 = \pi \times (0.71 \times 10^{-3}\ m)^2 = 1.58 \times 10^{-6}\ m^2$

$R = \rho l/A$, so $\rho = RA/l = 0.72\ \Omega \times 1.58 \times 10^{-6}\ m^2 / 1.65\ m$

$\rho = 6.9 \times 10^{-7}\ \Omega\ m$

This matches the value for stainless steel, so the wire is stainless steel.

(b) Nichrome wire is often used in heating elements. Nichrome wire is used to make a coil for a 65 W mains powered heater. The nichrome wire has a resistance per metre of $87.5\,\Omega\,m^{-1}$.

Calculate the length of wire required.

potential difference across the coil = 230 V

(3)

$P = V^2/R$, so $R = V^2/P = (230\ V)^2 / 65\ W = 814\ \Omega$

length = R / resistance per metre = $814\ \Omega / 87.5\ \Omega\ m^{-1}$

$l = 9.30\ m$

Length of wire required = 9.3 m

(Total for Question 12 = 9 marks)

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13 Two ice skaters are gliding across the horizontal ice surface at an ice rink.



(Source: © ITAR-TASS News Agency/Alamy Stock Photo)

(a) Initially the skaters move together with a speed of $5.6\,m\,s^{-1}$.

The male skater pushes the female skater forwards. After being pushed, she has a forward speed of $7.5\,m\,s^{-1}$.

Calculate the speed of the male skater immediately after pushing the female skater forwards.

mass of male skater = 66 kg
mass of female skater = 52 kg

(3)

Momentum before = (66 + 52) kg × 5.6 m s^{-1} = 661 kg m s^{-1}

Momentum after = 66 kg × v + 52 kg × 7.5 m s^{-1} = 66v + 390

Momentum is conserved: 66v + 390 = 661

v = (661 − 390) kg m s^{-1} / 66 kg = 4.11 m s^{-1}

Speed of male skater = 4.1 m s^{-1}

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(b) Explain why the male skater experiences a change in his velocity when he pushes the female skater forwards.
You should make reference to Newton's laws of motion in your explanation.

(4)

When the male skater pushes, he exerts a forward force on the female skater.

According to Newton's third law, the female skater exerts an equal and opposite (backward) force on the male skater.

So there is now a resultant (backward) force acting on the male skater.

According to Newton's first and second laws ($F = ma$), a resultant force causes an acceleration, so the male skater decelerates: his velocity decreases from 5.6 m s^{-1} to 4.1 m s^{-1}.

(c) When the male skater pushes the female skater forwards, the total kinetic energy of the skaters increases.

Explain why kinetic energy is not conserved in this interaction.

(2)

The male skater does work on the female skater as he pushes her; energy is transferred from (the chemical energy store in) his muscles.

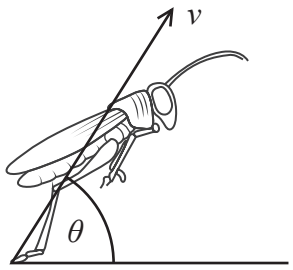
So there is an increase in the total kinetic energy of the skaters, which is why kinetic energy is not conserved.

(Total for Question 13 = 9 marks)

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14 Grasshoppers can jump up to twenty times their length to escape predators. The magnitude of the launch velocity v does not vary significantly for a given grasshopper, so the length of the jump mostly depends on the launch angle θ.

The diagram shows a grasshopper at the instant it launches.



(Source: adapted from http://gclipart.com/grasshopper-clipart_28241/)

(a) The grasshopper jumps from rest on level ground. The launch velocity is $2.6\,\text{m}\,\text{s}^{-1}$ at an angle of 57° to the horizontal.

(i) Show that the vertical component of the launch velocity is about $2\,\text{m}\,\text{s}^{-1}$.

(1)

$v_{vertical} = v \sin\theta = 2.6\ m\ s^{-1} \times \sin 57° = 2.18\ m\ s^{-1} \approx 2\ m\ s^{-1}$

(ii) Assess whether the horizontal distance travelled by the grasshopper in the jump is about 20 times the grasshopper's length.

length of grasshopper = 5.0 cm

(5)

Vertical: at the top v = 0, using $v = u + at$: $0 = 2.18 - 9.81t$, so $t = 0.222$ s

Total time in air = 2 × 0.222 s = 0.445 s

Horizontal component = $v \cos\theta = 2.6\ m\ s^{-1} \times \cos 57° = 1.42\ m\ s^{-1}$

Horizontal: $s = ut + \frac{1}{2}at^2$ with $a = 0$, $s = 1.42\ m\ s^{-1} \times 0.445\ s = 0.630\ m$

Number of body lengths = 0.630 m / 0.050 m = 12.6

12.6 is much less than 20, so the jump is not about 20 times the grasshopper's length.

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(b) Grasshoppers with longer legs accelerate to their launch velocity over a longer time.

Leg length has a negligible effect on both the mass of a grasshopper and the energy released in a jump.

Explain how leg length affects the force exerted on the ground during a jump.

(4)

The energy released does not change and the mass is the same, so the final (launch) velocity is the same.

With longer legs the same increase in velocity takes place over a longer time, so the acceleration is smaller ($a = \Delta v/\Delta t$).

By $F = ma$, a smaller force is exerted by the legs during the jump.

So (by Newton's third law) a smaller force is exerted on the ground.

(c) In a recent study it was discovered that grasshoppers, living in an environment with hunting spiders, increase their launch velocity on average by 20%. The jump length of these grasshoppers was more than doubled.

Assess whether a 20% increase in launch velocity alone is sufficient to double the jump length.

(4)

New launch velocity = 1.2v, so both the vertical and horizontal components increase by a factor of 1.2.

Vertical component × 1.2, so the time in the air ($t = 2v \sin\theta / g$) increases by a factor of 1.2.

Horizontal component × 1.2, so the horizontal distance $s = (v \cos\theta) \times t$ increases by a factor of $1.2 \times 1.2 = 1.44$ (jump length $\propto v^2$).

So the jump length increases by only 44%, not 100%; a 20% increase in launch velocity alone is not sufficient to double the jump length.

(Total for Question 14 = 14 marks)

TOTAL FOR SECTION A = 54 MARKS

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SECTION B

Answer ALL questions in the spaces provided.

15 A force meter measures force by making use of Hooke's Law.

The extension of a spring inside the force meter allows the magnitude of the force applied to be read from a scale.

(a) The spring in one type of force meter extends by 5.5 cm when a force of 2.5 N is applied.

(i) Show that the stiffness of the spring is about 50 N m^{-1}.

(2)

$\Delta F = k\Delta x$, so $k = \Delta F / \Delta x = 2.5\ N / 0.055\ m$

$k = 45.5\ N\ m^{-1}$, which is about $50\ N\ m^{-1}$

(ii) Two identical force meters of this type support a mass of 0.400 kg as shown.

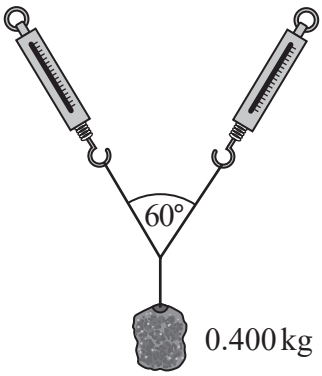


Diagram not to scale

(Source: adapted from https://image.slidesharecdn.com/balancedunbalancedgravityfriction-170509114658/95/balanced-unbalanced-gravity-friction-14-638.jpg?cb=1494330595)

Calculate the extension Δx of each spring.

(4)

$W = mg = 0.400\ kg \times 9.81\ N\ kg^{-1} = 3.92\ N$

Each spring is at 30° to the vertical: $2T \cos 30° = 3.92\ N$

$T = 3.92\ N / (2 \times \cos 30°) = 2.26\ N$

$\Delta x = T/k = 2.26\ N / 45.5\ N\ m^{-1} = 0.0498\ m$

$\Delta x =$ 0.050 m

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*(b) A beaker of water is placed on a balance and a rock is hung from a force meter as shown in diagram 1.

The initial reading on the balance is *R*, and the initial reading on the force meter is *F*. The rock is lowered gently into the beaker of water until it is completely submerged.

Diagram not to scale

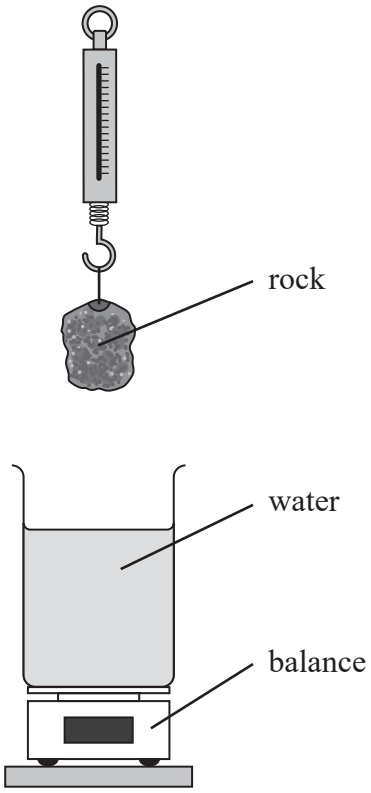


Diagram 1

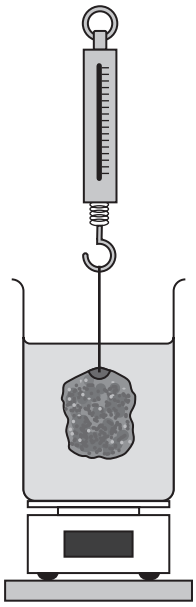


Diagram 2

(Source: adapted from https://passnownow.com/wp-content/uploads/2014/06/upthrust)

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Explain any changes in the readings R and F as the rock is lowered into the water as shown in diagram 2.

(6)

As the rock is lowered into the water it displaces water, so there is an upthrust on the rock (upthrust = weight of water displaced).

The upthrust acts upwards, so the net downward force on the force meter (weight – upthrust) is reduced, so F decreases.

As more of the rock goes under, more water is displaced and the upthrust increases, so F keeps decreasing until it reaches a minimum once the rock is fully submerged; after that F stays constant.

By Newton's third law the water exerts the upthrust on the rock, so the rock pushes downwards on the water with an equal and opposite force.

So there is an extra downward force on the beaker and therefore on the balance, so R increases.

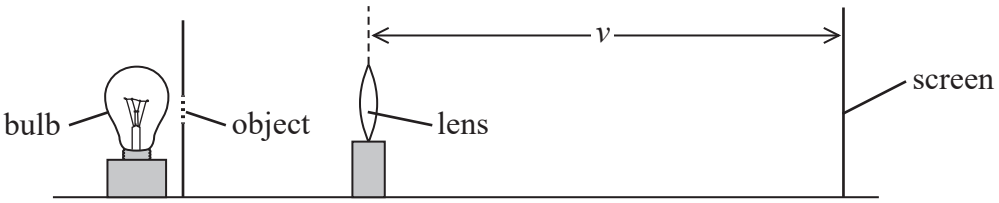
R increases to a maximum once the rock is fully submerged. The increase in R equals the decrease in F (both equal the upthrust).

(Total for Question 15 = 12 marks)

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16 A student carried out an experiment to determine the focal length of a converging lens. The student used a bulb to illuminate an object as shown. The converging lens produced an image of the object on a screen. The student adjusted the position of the screen until the image was in focus.

He repeated the procedure for different distances between the object and the lens. The distance v from the lens to the screen was measured for each lens position.



The student measured the height h_o of the object and the height h_i of the corresponding image on the screen for each lens position. The magnification m was calculated.

To determine the focal length f of the lens the student used the equation

$$m = \frac{v}{f} - 1$$

(a) Explain why a graph of m on the y-axis and v on the x-axis should be a straight line.

(2)

Compare m = (1/f)v − 1 with y = gx + c: y is m and x is v.

The gradient is 1/f, which is a constant (intercept −1), so the graph is a straight line.

(b) The student obtained the following data.

object height, h_o = 2.04 cm

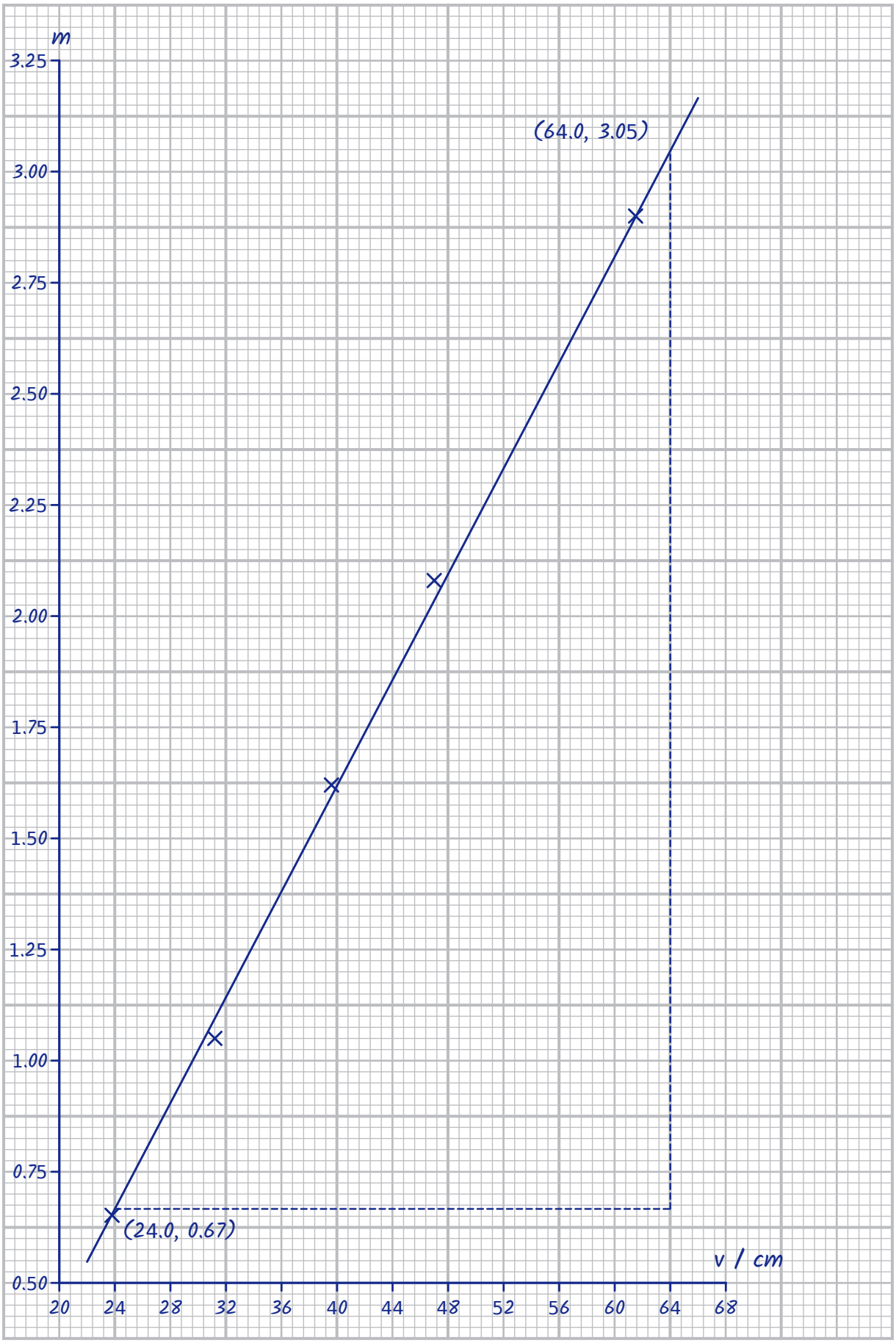
v / cm	h_i / cm	m
61.5	5.92	2.90
47.0	4.24	2.08
39.6	3.30	1.62
31.2	2.15	1.05
23.8	1.33	0.652

(i) Complete the table and plot a graph of m against v on the grid opposite.

(6)

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(ii) Determine a value for f.

(3)

Using a large triangle on the line of best fit:

gradient = (3.05 − 0.67) / (64.0 − 24.0) cm = 2.38 / 40.0 cm = 0.0595 cm^{-1}

gradient = 1/f, so f = 1 / 0.0595 cm^{-1} = 16.8 cm

f = 16.8 cm

(c) If the distance from object to the lens is less than a certain value, no image is produced on the screen.

Explain why.

(3)

Only a real image can be produced on a screen.

If the object is closer to the lens than the focal length f, the light still diverges after passing through the lens.

So the rays never meet: a virtual image is formed, which cannot be seen on a screen.

(Total for Question 16 = 14 marks)

TOTAL FOR SECTION B = 26 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

$$\Sigma F = ma$$

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

$$W = mg$$

$$\text{moment of force} = Fx$$

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

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

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

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

de Broglie wavelength

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

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