Please check the examination details below before entering your candidate information

Candidate surname: StemUp Model Solution

Other names:

Centre Number

Candidate Number

Pearson Edexcel Level 3 GCE

Wednesday 17 May 2023

Morning (Time: 1 hour 30 minutes)

Paper reference **8PH0/01**

Physics

Advanced Subsidiary

PAPER 1: Core Physics I

You must have:
Scientific calculator, ruler, protractor

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **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.*
- In the question 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.

Turn over ▶

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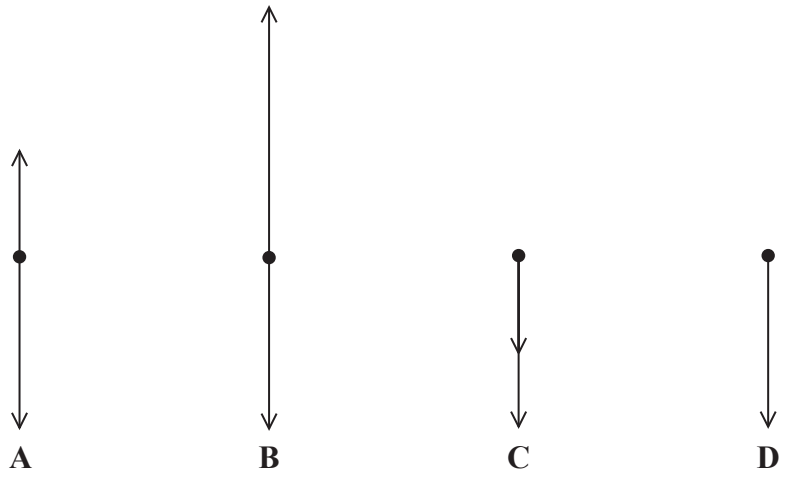
SECTION A

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 A student throws a ball vertically upwards.

Which of the following shows a free-body force diagram for the ball immediately after it leaves the student's hand?



☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 1 = 1 mark)

2 Which row of the table contains only scalar quantities?

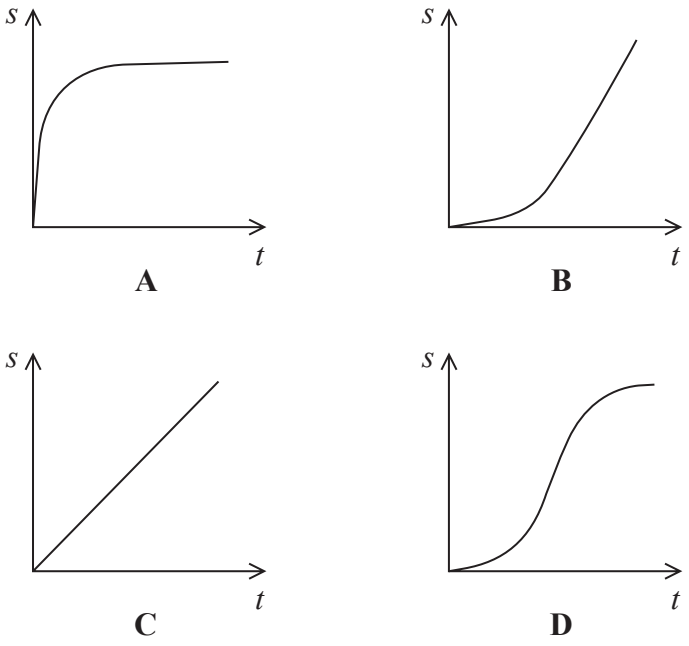
☒ **A**	speed	displacement	current
☒ **B**	energy	mass	momentum
☒ **C**	power	time	work done
☒ **D**	acceleration	work done	temperature

(Total for Question 2 = 1 mark)

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3 A ball falls from rest through glycerine and reaches terminal velocity.

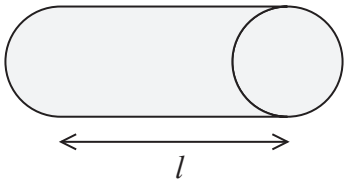
Which of the following graphs shows how displacement s varies with time t for the ball?



- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 3 = 1 mark)

4 A piece of conducting putty is shaped into a cylinder of uniform cross-sectional area, as shown. The length of the cylinder is l. The resistance between the two ends is 8.0 Ω.



The piece of putty is then rolled out until the length is $2l$.

Which of the following is now the value of the resistance between the two ends?

- ☒ **A** 2.0 Ω
- ☒ **B** 4.0 Ω
- ☒ **C** 16.0 Ω
- ☒ **D** 32.0 Ω

(Total for Question 4 = 1 mark)

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5 A car is travelling at a constant speed in a straight line along a horizontal road.

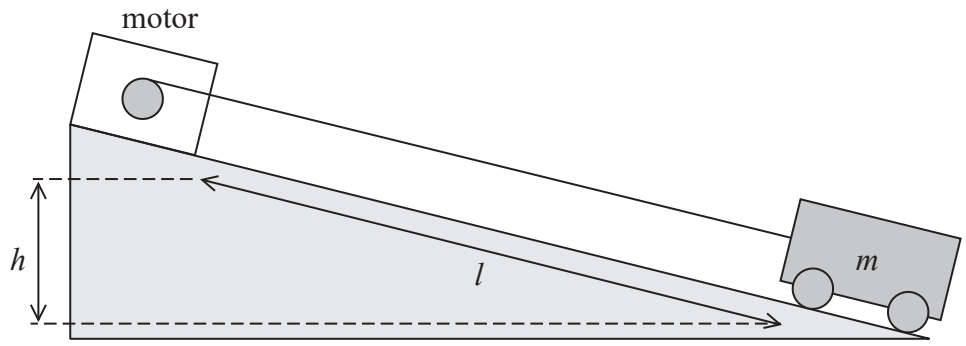
Which row of the table gives a Newton's third law pair of forces?

		Force 1	Force 2
☒	**A**	normal force of car on road	friction between wheels and road
☒	**B**	normal force of car on road	normal force of road on car
☒	**C**	weight of car	normal force of car on road
☒	**D**	weight of car	normal force of road on car

(Total for Question 5 = 1 mark)

6 The diagram shows an electric motor pulling a truck of mass m along a slope. The truck moves through a vertical height h and a distance l along the slope, during a time t.

There is a potential difference V across the motor and a current I in the motor.



Which of the following expressions gives the efficiency of the motor?

☒ **A** $\frac{VIt}{mgl}$

☒ **B** $\frac{VIt}{mgh}$

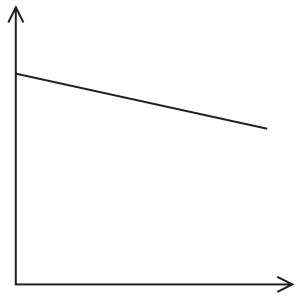
☒ **C** $\frac{mgl}{VIt}$

☒ **D** $\frac{mgh}{VIt}$

(Total for Question 6 = 1 mark)

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7 A student investigated the e.m.f. and internal resistance of a battery. The student produced the following sketch graph.



Which row of the table gives the quantities plotted?

		y-axis	*x*-axis
☒	**A**	e.m.f.	circuit resistance
☒	**B**	e.m.f.	current
☒	**C**	terminal potential difference	circuit resistance
☒	**D**	terminal potential difference	current

(Total for Question 7 = 1 mark)

8 A ball is thrown vertically upwards at a velocity of $6.0\,\text{m}\,\text{s}^{-1}$.

Which of the following gives the maximum height, in m, reached by the ball?

☒ **A** $\dfrac{6.0^2}{2 \times 9.81}$

☒ **B** $\dfrac{6.0^2}{2 \times (-9.81)}$

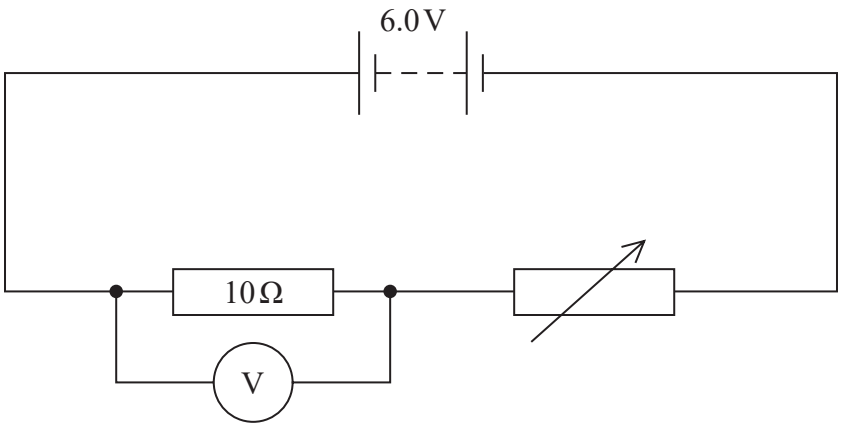
☒ **C** $\dfrac{6.0}{2 \times 9.81}$

☒ **D** $\dfrac{6.0}{2 \times (-9.81)}$

(Total for Question 8 = 1 mark)

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9 A student connects the circuit shown. The battery has negligible internal resistance.



The student increases the resistance of the variable resistor from 0 Ω to 40 Ω.

Determine the range of readings on the voltmeter.

At 0 Ω there is no p.d. across the variable resistor, so V = 6.0 V

At 40 Ω: total R = 10 + 40 = 50 Ω, potential divider: V = (10 Ω ÷ 50 Ω) × 6.0 V

= 1.2 V

Maximum reading on voltmeter = 6.0 V

Minimum reading on voltmeter = 1.2 V

(Total for Question 9 = 3 marks)

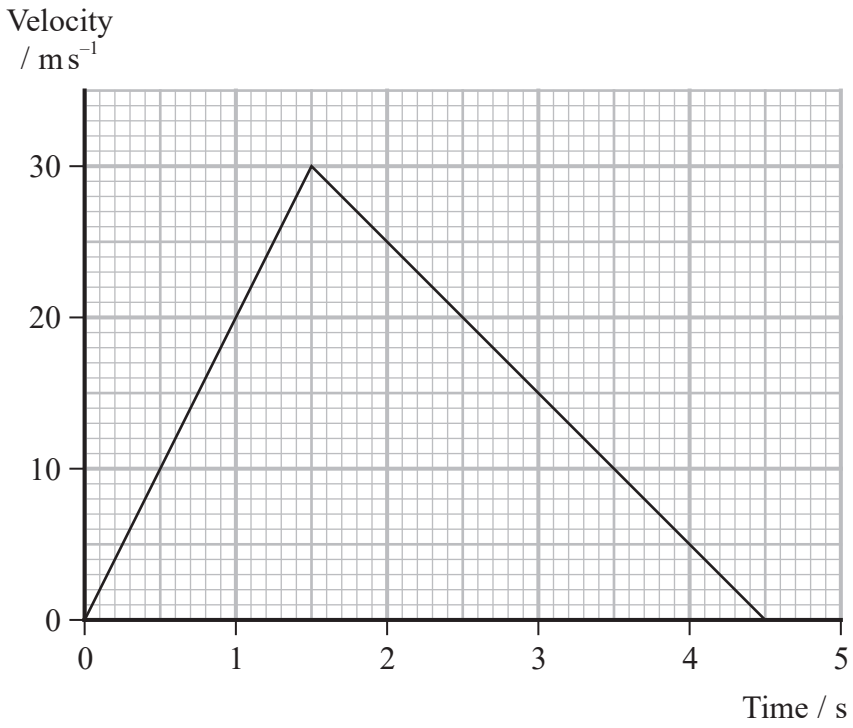
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10 A model rocket accelerates vertically upwards then decelerates due to gravity until it reaches a maximum height.

(a) A velocity-time graph for the rocket until it reaches maximum height is shown.



Show that the rocket reaches a maximum height of about 68 m.

(2)

Height = area under the velocity-time graph (triangle)

Height = ½ × 4.5 s × 30 m s^{-1} = 67.5 m ≈ 68 m

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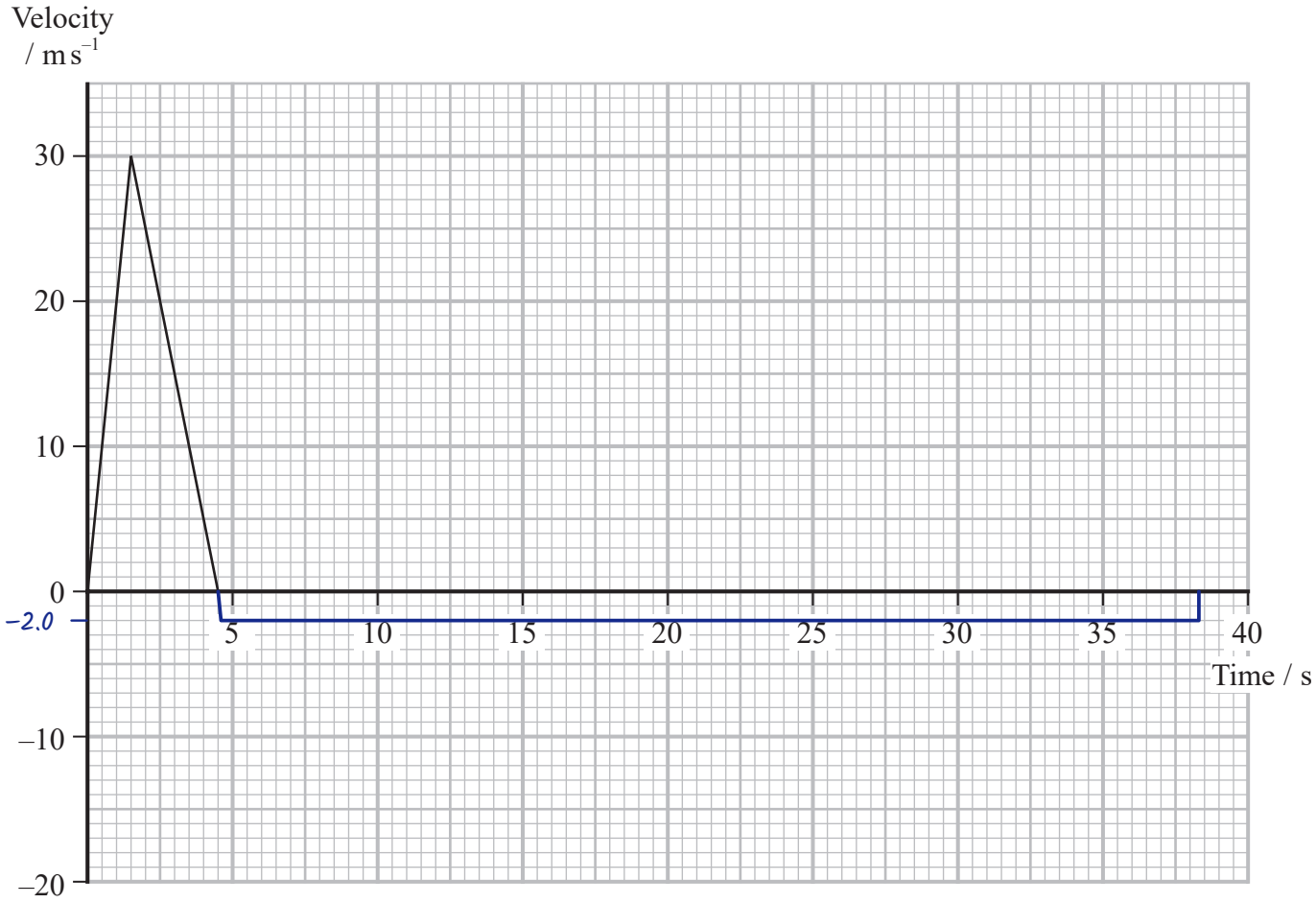
(b) When the rocket reaches the maximum height of 68 m, a parachute opens. Almost instantly, the rocket reaches a terminal velocity of 2.0 m s^{-1}.

Complete the velocity-time graph below for the motion of the rocket until it reaches the ground.

(2)

Time to fall at 2.0 m s^{-1} = 67.5 m ÷ 2.0 m s^{-1} = 33.8 s

so it lands at 4.5 s + 33.8 s = 38.3 s

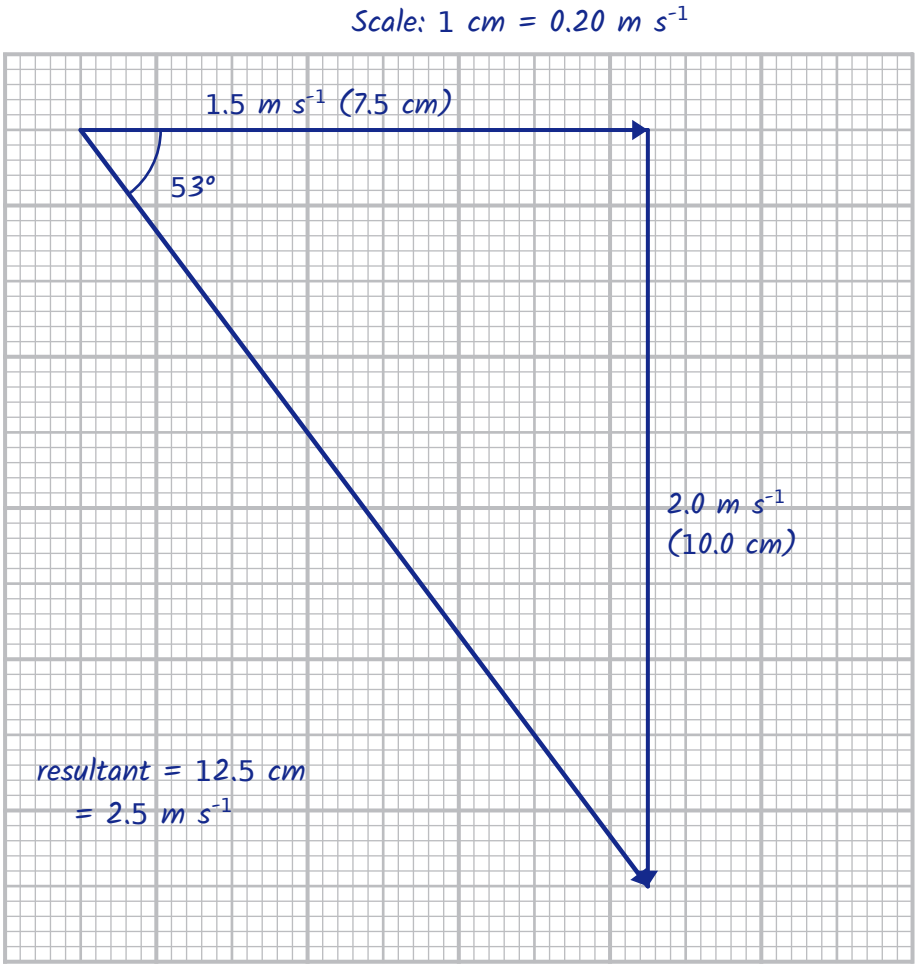


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(c) The rocket is fired upwards a second time when the wind is blowing. The rocket falls with a vertical velocity of $2.0\,m\,s^{-1}$ and a horizontal velocity of $1.5\,m\,s^{-1}$.

Determine the velocity of the rocket by drawing a scaled vector diagram.

(4)



Magnitude of velocity = 2.5 $m\,s^{-1}$

Angle to the horizontal of velocity = 53 °

(Total for Question 10 = 8 marks)

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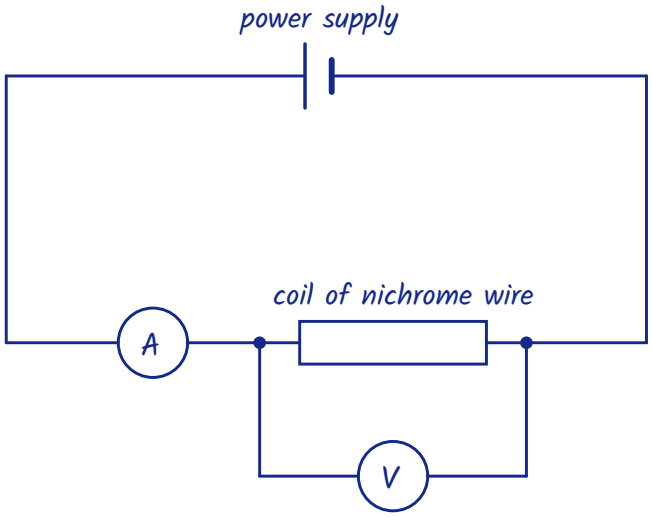
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11 A student investigates how the resistance of a length of nichrome wire changes with temperature.

(a) The student takes measurements to determine the resistance of the wire at different temperatures.

(i) Draw a diagram of the circuit the student could use.

(1)



(ii) The wire has a thin electrically insulating coating so that it can be coiled up without causing a short circuit.

The student places the coil of wire into a water bath so the temperature of the wire can be varied.

Describe how the student could determine the temperature of the wire accurately.

(2)

Measure the temperature of the water with a thermometer placed close to the coil.

Stir the water and wait for the coil to reach thermal equilibrium, and use a small current so the wire is not heated by the current.

(b) Explain, in terms of particle behaviour, why the resistance of the nichrome wire changes as temperature increases.

(4)

As the temperature increases, the (lattice) ions gain kinetic energy and vibrate with greater amplitude.

The frequency of collisions between the conduction electrons and the ions increases.

So the drift velocity of the electrons decreases, so the current decreases for the same p.d.

Since R = V/I, the resistance of the nichrome wire increases.

(Total for Question 11 = 7 marks)

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12 A wire-wound resistor consists of a long length of wire wound around an insulating core. A technician finds a wire-wound constantan resistor labelled 80 Ω.

(a) Calculate the length of the constantan wire used to make the resistor.

resistivity of constantan wire at room temperature = 4.9×10^{-7} Ω m
diameter of wire = 0.28 mm

(3)

$A = \pi d^2/4 = \pi \times (0.28 \times 10^{-3}\ m)^2 / 4 = 6.2 \times 10^{-8}\ m^2$

$R = \rho l/A$ so $l = RA/\rho = (80\ \Omega \times 6.16 \times 10^{-8}\ m^2) / 4.9 \times 10^{-7}\ \Omega\ m$

$l = 10.1\ m$

Length = 10 m

(b) A potential difference of 9.8 V is applied across the resistor and the current in the resistor is 0.12 A.

Deduce whether the value labelled on the resistor is supported by these data.

uncertainty in the potential difference = ±0.1 V
uncertainty in the current = ±0.01 A

(4)

$R = V/I = 9.8\ V \div 0.12\ A = 82\ \Omega$

% uncertainty in $I = (0.01 \div 0.12) \times 100 = 8.3$ %

% uncertainty in $V = (0.1 \div 9.8) \times 100 = 1.0$ %

% uncertainty in $R = 8.3$ % + 1.0 % = 9.3 %, so uncertainty in $R = \pm 8\ \Omega$

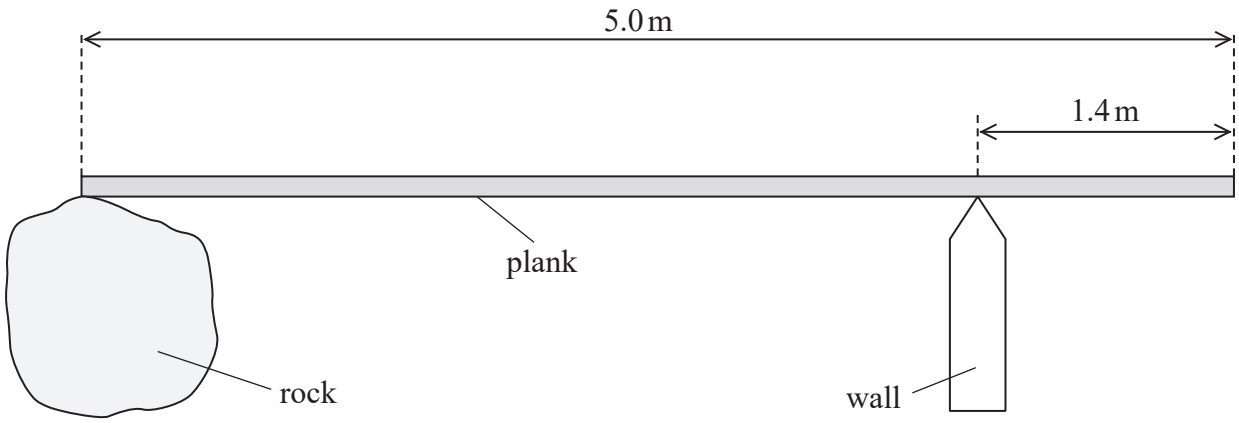
Lower limit of $R = 82\ \Omega \times (1 - 0.093) = 74\ \Omega$ (upper limit 90 Ω)

80 Ω is within 74 Ω to 90 Ω, so the label is supported by the data.

(Total for Question 12 = 7 marks)

13 Some students used a plank to make a bridge to cross a stream. The plank rested on a rock and a wall as shown.

Assume the plank is uniform.



(a) (i) Show that the weight of the plank is about 250 N.

mass of plank = 25 kg

(1)

$W = mg = 25\ kg \times 9.81\ N\ kg^{-1} = 245\ N \approx 250\ N$

(ii) Determine the force exerted by the wall on the plank.

(3)

Taking moments about the rock: the plank's weight acts at its centre, 2.5 m from the rock; the wall is 5.0 − 1.4 = 3.6 m from the rock.

Principle of moments: F × 3.6 m = 245 N × 2.5 m

F = 612.5 N m ÷ 3.6 m = 170 N

Force exerted by wall on plank = 170 N

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(b) A student of weight 550 N states that the plank will tip if she walks from the rock to the other end of the plank.

Justify the student's statement.

(3)

When the plank is about to tip about the wall, the support force at the rock = 0.

Moments about the wall: anticlockwise moment of plank's weight = 245 N × (2.5 − 1.4) m = 270 N m

With her at the end, clockwise moment = 550 N × 1.4 m = 770 N m

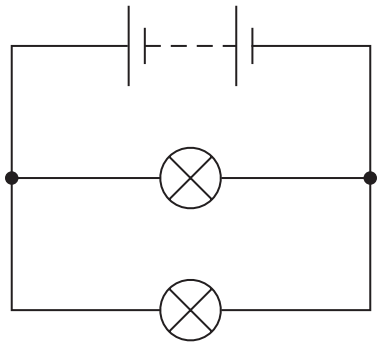
770 N m > 270 N m, so the plank will tip (it tips once she is 0.49 m past the wall), so she is correct.

(Total for Question 13 = 7 marks)

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***14** A student connects a filament bulb to a battery. The battery has internal resistance.

The student connects an identical bulb in parallel with the first bulb, as shown.



He continues to connect identical bulbs in parallel.

The student observes that the bulbs get dimmer as more bulbs are connected. He also observes that the temperature of the battery increases.

Explain these observations.

Each extra bulb in parallel provides another path for the current, so the total resistance of the circuit decreases.

So the current in the battery (total current) increases, since $I = \varepsilon/(R + r)$.

Because the battery has internal resistance, the p.d. across the internal resistance (Ir, the lost volts) increases.

So the terminal p.d. of the battery, $V = \varepsilon - Ir$, decreases. This is the p.d. across each bulb, so the power of each bulb (V^2/R) decreases and the bulbs get dimmer.

The greater current in the battery means more power is transferred in the internal resistance ($P = I^2r$).

So more thermal energy is transferred in the battery, and its temperature increases.

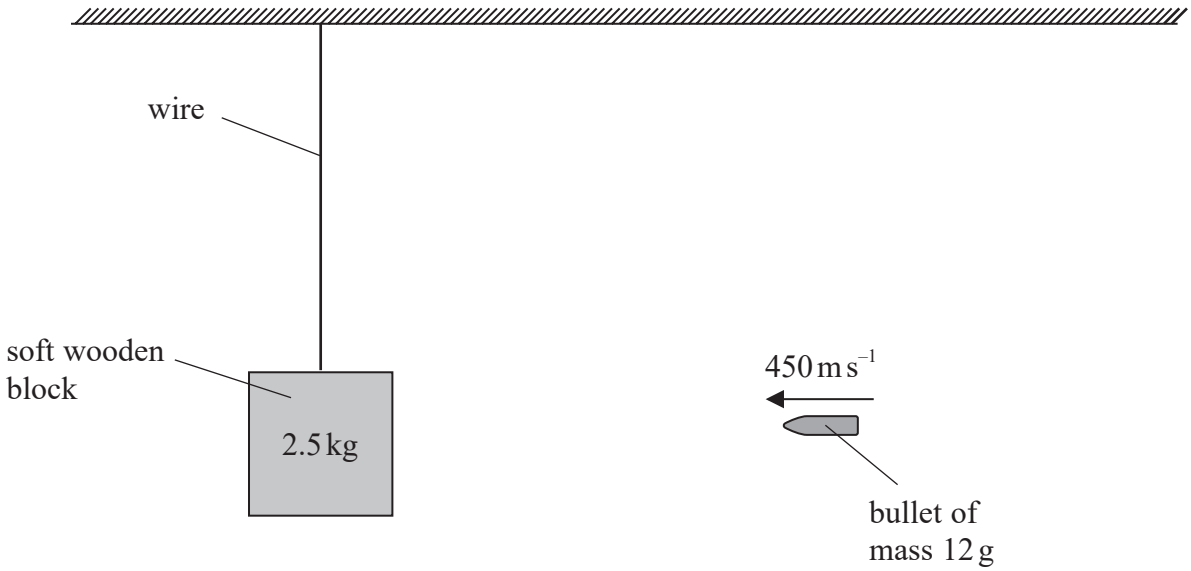
(Total for Question 14 = 6 marks)

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15 A bullet of mass 12 g moved at a speed of 450 m s^{-1}. The bullet hit a soft wooden block of mass 2.5 kg which was attached to a wire, as shown. The bullet became stuck in the wooden block which swung upwards.



(a) (i) Show that the momentum of the bullet is about 5 kg m s^{-1}.

(2)

$p = mv = 0.012\ kg \times 450\ m\ s^{-1}$

$p = 5.4\ kg\ m\ s^{-1} \approx 5\ kg\ m\ s^{-1}$

(ii) Determine the maximum change in vertical height of the wooden block.

(3)

Conservation of momentum: $5.4\ kg\ m\ s^{-1} = (2.5 + 0.012)\ kg \times v$, so $v = 2.15\ m\ s^{-1}$

$\frac{1}{2}mv^2 = mgh$ so $h = v^2/2g = (2.15\ m\ s^{-1})^2 / (2 \times 9.81\ m\ s^{-2})$

$h = 0.24\ m$

Maximum change in vertical height = 0.24 m

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(b) The soft wooden block was replaced with a hard steel block of the same mass.

An identical bullet was fired at the steel block with the same speed as before. The bullet rebounded from the steel block.

Explain why the steel block moved through a greater maximum vertical height than the wooden block.

(5)

The bullet rebounds, so its final velocity (momentum) is in the opposite direction, i.e. negative, instead of zero.

So the change in momentum of the bullet is greater than when it stuck in the wooden block.

Momentum is conserved, so the change in momentum (the momentum gained) of the steel block is greater.

The steel block has the same mass, so it has a greater initial velocity and so a greater initial kinetic energy.

This kinetic energy is transferred to gravitational potential energy, so the steel block gains more E_{grav} and rises through a greater maximum vertical height.

(Total for Question 15 = 10 marks)

TOTAL FOR SECTION A = 56 MARKS

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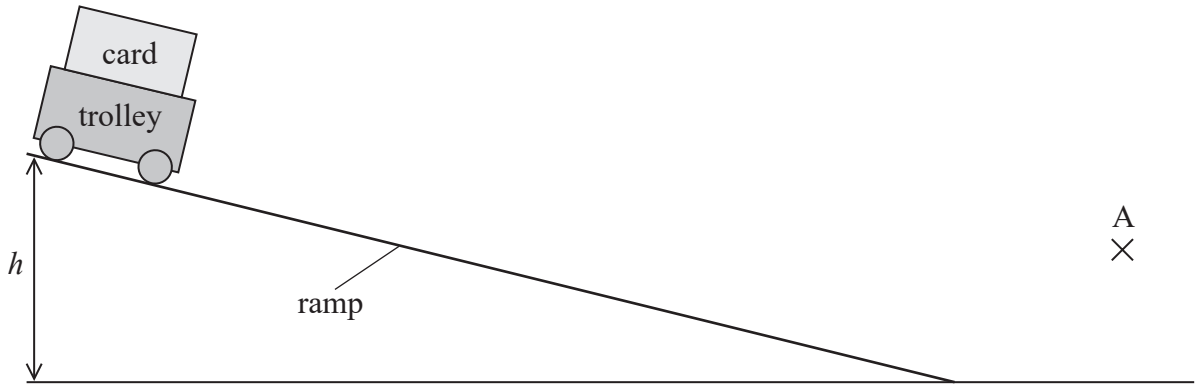
SECTION B

Answer ALL questions in the spaces provided.

16 A student released a trolley from the top of a ramp of length of about 1.5 m, as shown.

The student investigated how the speed v of the trolley at the bottom of the ramp varied as the height h of the ramp was increased.

The student placed a light gate connected to a data logger at position A to measure v as the card passed through the light gate.



(a) Describe how the student could measure h accurately.

(2)

Use a metre rule to measure h from the bench to the top of the ramp.

Use a set square (or a plumb line) against the rule to ensure the metre rule is vertical,

and read at eye level.

(b) The student derived the following equation for the motion of the trolley

$$h = \frac{v^2}{2g}$$

where g is the acceleration due to gravity.

(i) Explain why plotting a graph of h against v^2 will produce a straight line.

(2)

$h = (1/2g) \times v^2$ compares with $y = mx + c$, with $y = h$, $x = v^2$ and $c = 0$.

The gradient = $1/2g$, which is constant (g is constant), so the graph is a straight line through the origin.

(ii) The student varied h and measured corresponding values of v. The results are recorded below.

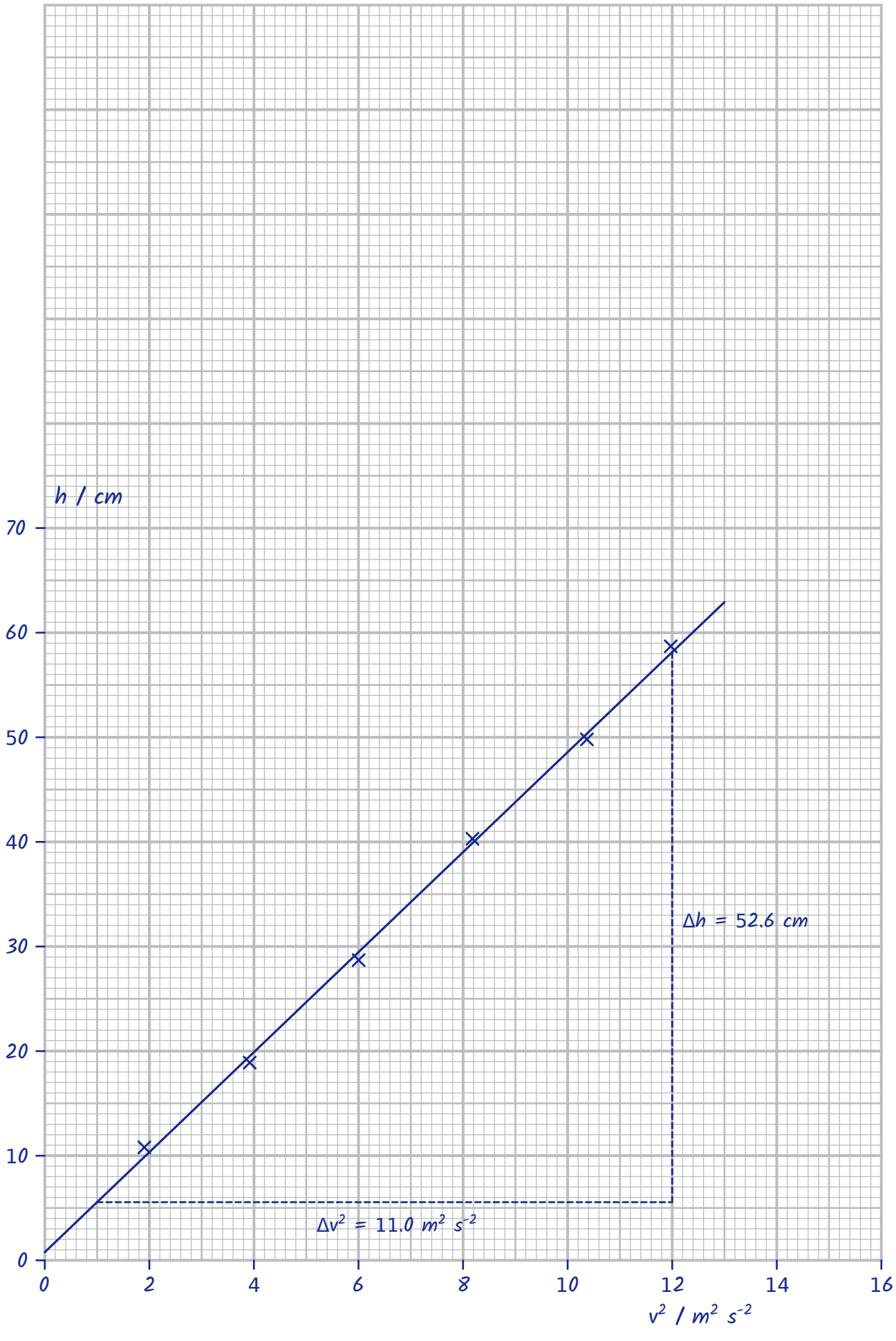
h / cm	v / m s^{-1}	v^2 / m^2 s^{-2}
10.8	1.38	1.90
18.9	1.98	3.92
28.7	2.45	6.00
40.3	2.86	8.18
49.8	3.22	10.4
58.7	3.46	12.0

Plot a graph of h on the y-axis against v^2 on the x-axis on the grid opposite. Use the additional column in the table for your processed data.

(5)

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(iii) The student used her results to plot a graph and determine a value for g.

She concluded that her value was consistent with the value of g given on the data sheet at the back of this paper.

Comment on the student's conclusion.

(3)

Large triangle: gradient = 0.526 m ÷ 11.0 m^2 s^{-2} = 0.0478 s^2 m^{-1}

gradient = 1/2g so g = 1 ÷ (2 × 0.0478) = 10.5 m s^{-2}

This differs from 9.81 m s^{-2} by about 7 %, so the student's value is not consistent

with the data sheet value and her conclusion is not valid.

(Total for Question 16 = 12 marks)

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17 An empty lift is positioned at the first floor of a building. It is suspended by 6 identical steel cables of length 50 m.

(a) Calculate the extension of each lift cable.

cross-sectional area of a cable = $3.1 \times 10^{-4}\,m^2$
Young modulus of steel = 200 GPa
weight of lift = 12 kN

(3)

Tension in each cable $F = 12 \times 10^3\ N \div 6 = 2.0 \times 10^3\ N$

$\sigma = F/A = 2.0 \times 10^3\ N \div 3.1 \times 10^{-4}\ m^2 = 6.45 \times 10^6\ Pa$

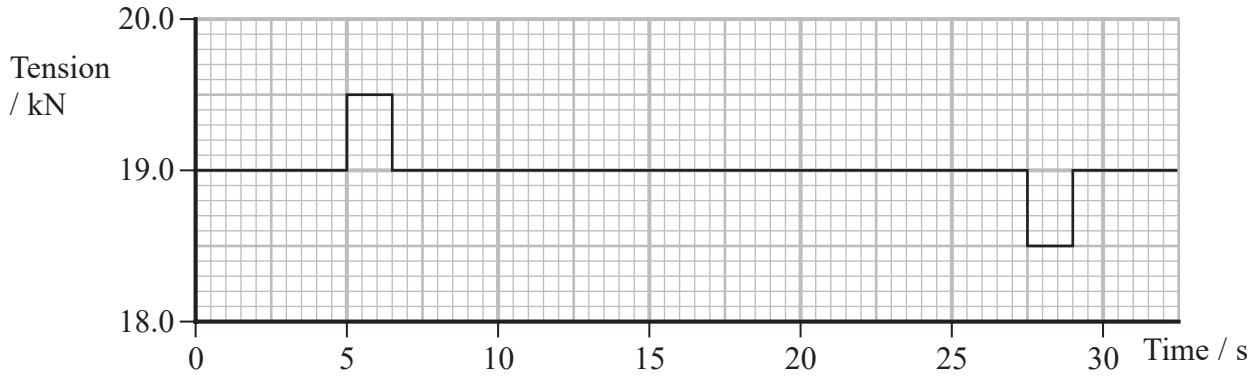
$E = \sigma/\varepsilon$ so $\varepsilon = 6.45 \times 10^6\ Pa \div 200 \times 10^9\ Pa = 3.23 \times 10^{-5}$

$\varepsilon = \Delta x/x$ so $\Delta x = 3.23 \times 10^{-5} \times 50\ m = 1.61 \times 10^{-3}\ m$

Extension = $1.6 \times 10^{-3}\ m$

(b) Ten people enter the lift. After 5 seconds the lift starts to move upwards and stops at the top floor of the building.

The graph shows the total tension force in the cables during this time.



(i) Calculate the total mass of the people in the lift.

weight of lift = 12 kN

(3)

When stationary, total tension = total weight = 19.0 kN

Weight of people = 19.0 kN − 12 kN = 7.0 kN

$m = W/g = 7.0 \times 10^3\ N \div 9.81\ N\ kg^{-1} = 714\ kg$

Mass of people = 710 kg

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(ii) Explain the motion of the lift between 5 s and 29 s.

(3)

From 5 s to 6.5 s the tension (19.5 kN) is greater than the weight (19.0 kN), so there is a resultant upward force and the lift accelerates upwards.

From 6.5 s to 27.5 s the tension equals the weight, so the resultant force is zero and the lift travels upwards at constant speed.

From 27.5 s to 29 s the tension (18.5 kN) is less than the weight, so the resultant force is downwards and the lift decelerates to rest.

(c) When the lift is empty, a technician removes one of the cables for maintenance.

Assess how removing one cable would affect the extension of the remaining cables.

(3)

The total force (weight of the lift) stays the same but is shared between 5 cables, so the tension in each remaining cable increases (from 2.0 kN to 2.4 kN).

The cross-sectional area of each cable does not change, so the stress ($\sigma = F/A$) in each cable increases.

E is constant, so the strain increases and the extension of each remaining cable is greater (by a factor of 6/5, to about 1.9×10^{-3} m).

(Total for Question 17 = 12 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

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

$$v = u + at$$

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

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

Forces

$$\Sigma F = ma$$

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

$$W = mg$$

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

Momentum

$$p = mv$$

Work, energy and power

$$\Delta W = F\Delta s$$

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

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

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

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

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

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

Electricity

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

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

$$I = nqvA$$

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Materials

Density

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

Stokes' law

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

Hooke's law

$$\Delta F = k\Delta x$$

Young modulus

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

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

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

Elastic strain energy

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

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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