Write your name here

Surname: StemUp Model Solution | Other names:

Pearson Edexcel Level 3 GCE

Centre Number | Candidate Number

Physics

Advanced Subsidiary
Paper 1: Core Physics I

Tuesday 23 May 2017 – Morning
Time: 1 hour 30 minutes

Paper Reference
8PH0/01

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.

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 Which of the following is **not** a vector quantity?

☐ **A** acceleration

☒ **B** distance

☐ **C** momentum

☐ **D** velocity

(Total for Question 1 = 1 mark)

2 Which of the following can be used to determine the magnitude of velocity?

☒ **A** area under an acceleration-time graph

☐ **B** area under a velocity-time graph

☐ **C** gradient of an acceleration-time graph

☐ **D** gradient of a velocity-time graph

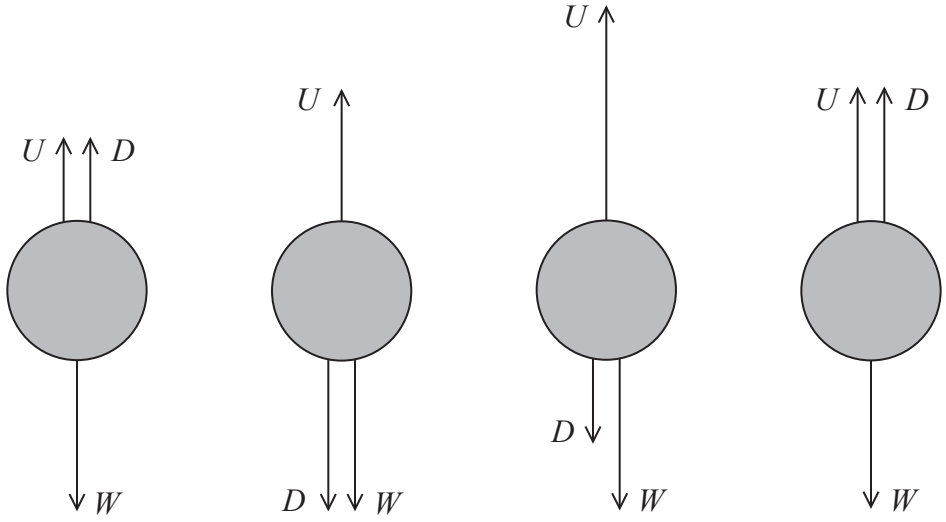
(Total for Question 2 = 1 mark)

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3 A small plastic bead is released below the surface of water and rises towards the surface.

The diagrams show the forces acting on the bead as it rises with constant velocity.

U = upthrust, D = drag, W = weight



Which diagram correctly represents the directions and relative magnitudes of the forces?

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

(Total for Question 3 = 1 mark)

4 A hair dryer is used for 3 minutes. The operating current is 6 A.

What charge flows in this time?

- ☒ **A** 0.03 C
- ☒ **B** 2 C
- ☒ **C** 18 C
- ☒ **D** 1080 C

(Total for Question 4 = 1 mark)

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5 A student is deriving an equation for the total resistance of resistors in series.

She writes the following steps but does not justify them.

Step 1 $V = V_1 + V_2$
Step 2 *but* $V = IR$
Step 3 *so* $IR = I_1R_1 + I_2R_2$
Step 4 *but* $I = I_1 = I_2$
Step 5 *Therefore* $R = R_1 + R_2$

Which step is justified using conservation of charge?

☒ **A** Step 1

☒ **B** Step 2

☒ **C** Step 3

☒ **D** Step 4

(Total for Question 5 = 1 mark)

6 A ball is kicked, giving it an initial velocity v at an angle of 35° to the vertical. The ball remains in the air for a time t.

Which of the following gives the distance travelled over the ground?

☒ **A** $vt\cos 35°$

☒ **B** $\dfrac{v\cos 35°}{t}$

☒ **C** $vt\sin 35°$

☒ **D** $\dfrac{v\sin 35°}{t}$

(Total for Question 6 = 1 mark)

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7 A series circuit consists of two resistors with resistances R_1 and R_2 and a battery of potential difference V.

Which of the following gives the potential difference across the resistor with resistance R_2?

☒ **A** $\frac{R_1}{R_2} V$

☒ **B** $\frac{R_2}{R_1} V$

☒ **C** $\frac{R_1}{R_1 + R_2} V$

☒ **D** $\frac{R_2}{R_1 + R_2} V$

(Total for Question 7 = 1 mark)

8 A light dependent resistor and a negative temperature coefficient thermistor are connected in series.

Which of the following combinations of illumination and temperature will result in the highest combined resistance?

☒ **A** dark and cold

☒ **B** dark and hot

☒ **C** light and cold

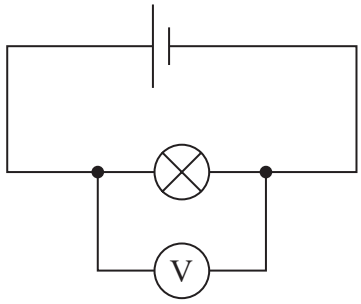
☒ **D** light and hot

(Total for Question 8 = 1 mark)

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9 A torch uses a 1.5 V dry cell. Over time, the light intensity produced by the torch decreases as the cell 'goes flat'.

(a) Student A sets up the following circuit in an attempt to measure the e.m.f. of a cell.



Explain why the voltmeter reading will **not** be the e.m.f. of the cell.

(2)

The cell has internal resistance, and a current flows through the cell in this circuit.

So there is a potential difference across the internal resistance ('lost volts'): $V = \varepsilon - Ir$, so the reading is less than the e.m.f.

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(b) Student B correctly determined the e.m.f. of an unused cell as 1.63 V and its internal resistance as 1.15 Ω.

He repeated this after the cell had been used for several weeks. When a voltmeter was connected directly across the used cell, the reading was 1.36 V.
A bulb of resistance 5.92 Ω was then connected across the used cell and the reading fell to 0.84 V.

Student A suggests that the cell goes flat as it is used because the e.m.f. decreases.
Student B suggests it is because the internal resistance increases.

Determine whether either student is correct about the changes in the cell as it goes flat.

(5)

With no load, the voltmeter (very high resistance) reads the e.m.f., so the used cell has $\varepsilon = 1.36$ V.

With the bulb: $I = V/R = 0.84 \text{ V} \div 5.92 \ \Omega = 0.142$ A

$\varepsilon = V + Ir$ so $1.36 = 0.84 + 0.142 \times r$

$r = 0.52 \div 0.142 = 3.7 \ \Omega$

The e.m.f. has decreased (1.63 V to 1.36 V) and the internal resistance has increased (1.15 Ω to 3.7 Ω), so both students are correct.

(Total for Question 9 = 7 marks)

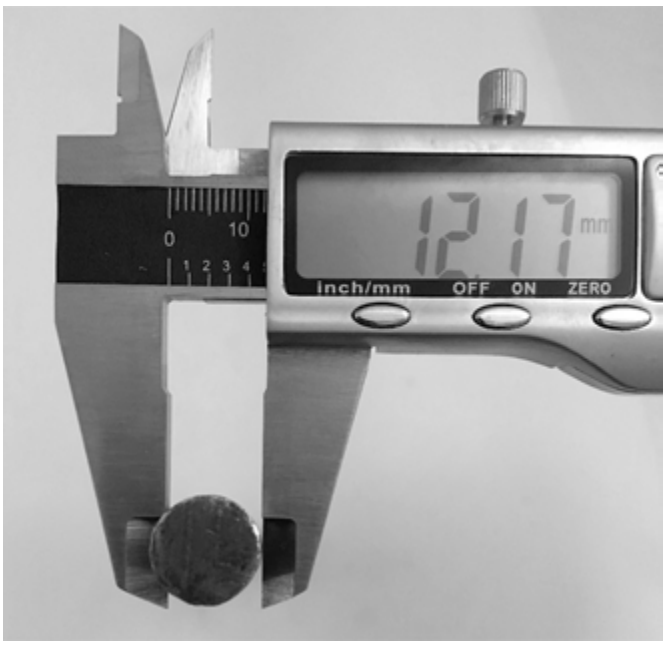
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10 The photographs show two types of caliper being used, in turn, to measure the diameter of an iron rod.

Caliper 1



diameter = 12.17 mm

Caliper 2



diameter = 12.2 mm

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(a) State the resolution of each of the calipers and compare their use for measuring the diameter of the rod.

(4)

Caliper 1 (digital) has a resolution of 0.01 mm. Caliper 2 (vernier) has a resolution of 0.1 mm.

Caliper 1 gives a direct reading, whereas caliper 2 needs a judgement of which scale lines are aligned and can have parallax error.

Caliper 1 has a lower percentage uncertainty, but the diameter of the rod will vary along its length, so the extra resolution of caliper 1 is not really needed (irrelevant).

(b) The value obtained from caliper 2 was used to determine the cross-sectional area of the rod and the electrical properties of the rod were investigated.

Calculate the drift velocity for the charge carriers in the rod when the current in the rod is 1.9 A.

diameter of rod = 12.2 mm
charge carrier density for iron = $1.7 \times 10^{29}\ m^{-3}$

(3)

$A = \pi d^2/4 = \pi \times (12.2 \times 10^{-3}\ m)^2 \div 4 = 1.17 \times 10^{-4}\ m^2$

$I = nAvq$ so $v = I \div nAq$

$v = 1.9 \div (1.7 \times 10^{29} \times 1.17 \times 10^{-4} \times 1.6 \times 10^{-19})$

Drift velocity = $6.0 \times 10^{-7}\ m\ s^{-1}$

(Total for Question 10 = 7 marks)

11 A motorist received a speeding penalty notice, from the police, for a short journey along 120 m of road.

(a) The car's specification states that the minimum time for the car to accelerate from 0 to 60 miles per hour is 9.5 seconds.

Show that the maximum value for the average acceleration of the car over 9.5 s is about 3 m s^{-2}.

1 mile = 1600 m

(2)

60 mph = 60 × 1600 m ÷ 3600 s = 26.7 m s^{-1}

v = u + at: a = (26.7 − 0) ÷ 9.5 s = 2.8 m s^{-2} (about 3 m s^{-2})

(b) The police recorded a maximum speed for the car of 20 m s^{-1}.

The motorist knows that the speed at the start and at the end of the 120 m journey was zero.

Assume that the car had:

- constant positive acceleration, equal to the value in part (a), for the first 60 m of the journey
- constant negative acceleration of the same magnitude for the final 60 m of the journey.

Determine whether the motorist should challenge the penalty notice.

(3)

$v^2 = u^2 + 2as = 0 + 2 \times 2.8 \text{ m s}^{-2} \times 60 \text{ m} = 336 \text{ m}^2 \text{ s}^{-2}$

v = 18.3 m s^{-1} (maximum speed the car could reach)

(For 20 m s^{-1} the car would need a = 20^2 ÷ (2 × 60) = 3.3 m s^{-2}, more than the car can manage.)

18.3 m s^{-1} is lower than the 20 m s^{-1} recorded by the police, so the motorist should challenge the penalty notice.

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(c) Explain why the assumptions about the acceleration in (b) may **not** be correct in practice.

(2)

Air resistance increases with speed, so the resultant force and the acceleration decrease at higher speeds (acceleration is not constant).

The car could brake with a greater negative acceleration (braking force) than its positive acceleration.

(Total for Question 11 = 7 marks)

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12 A student investigates how the efficiency of an electric motor being used to raise a load varies with the weight of the load.

The time taken for the motor to lift a load from the floor to the maximum height was measured using a stopwatch. The load was varied by adding weights, each marked '1.00 N'.

(a) The spreadsheet shows the student's results (columns A to E) and calculation (column F).

	A	B	C	D	E	F
1	load / N	current / A	potential difference / V	time / s	change in height / m	efficiency
2	2.00	1.8	4.6	1.52	0.825	0.13
3	3.00	1.9	4.4	2.05	0.825	0.14
4	4.00	2.1	4.3	2.19	0.825	0.17
5	5.00	2.3	5.1	2.26	0.825	0.16
6	6.00	2.5	4.5	2.48	0.825	0.18
7	7.00	3.1	5.2	2.17	0.825	0.17
8	8.00	3.7	4.8	2.68	0.825	0.14
9	9.00	3.9	4.8	3.36	0.825	0.12
10	10.00	4.2	4.7	3.72	0.825	0.11

Explain how the value in cell F4 has been determined using the results obtained.

(3)

efficiency = useful energy output ÷ total energy input

Energy output = GPE gained = load × height = 4.00 N × 0.825 m = 3.30 J

Energy input = electrical energy = IVt = 2.1 A × 4.3 V × 2.19 s = 19.8 J

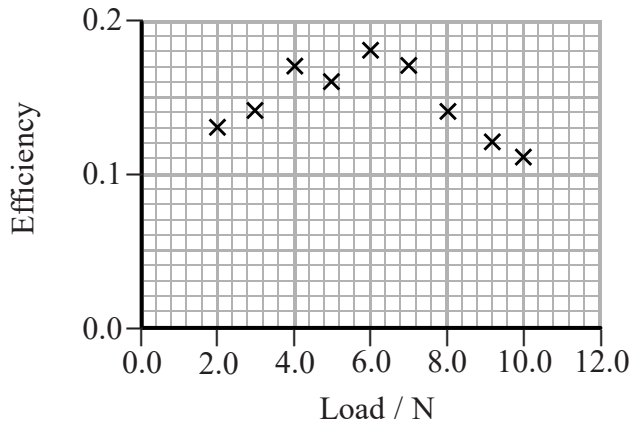
efficiency = 3.30 J ÷ 19.8 J = 0.167 = 0.17

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(b) The student uses the spreadsheet to plot a graph.



The student concludes that 'the efficiency of the motor increases with the weight of the load up to a maximum when the load is 6.00 N'.

Critcise the student's investigation and conclusion.

(5)

The times are very short to be measured with a stopwatch, so reaction time gives a large uncertainty; a light gate (data logger) should be used.

Other variables, such as the potential difference (or current), should have been controlled; the p.d. varies from 4.3 V to 5.2 V.

Repeat readings should have been taken and a mean calculated.

There is an anomaly at about 5 N that has not been checked or repeated.

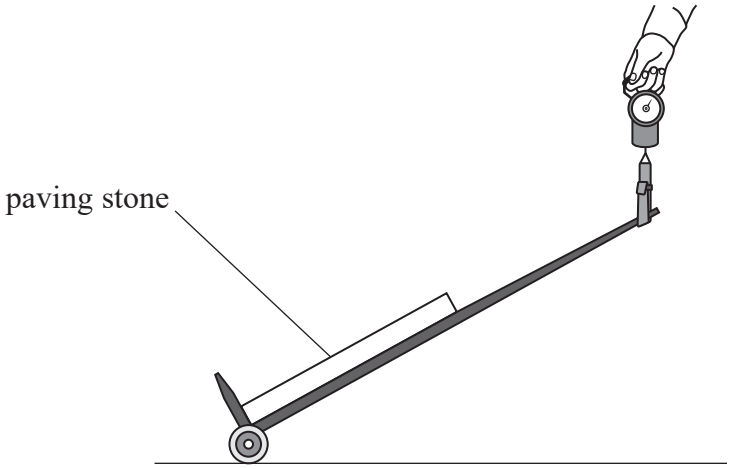
Readings at smaller weight intervals around 6 N are needed to locate the maximum, so the student cannot claim the maximum is at 6.00 N.

The conclusion also ignores the decrease in efficiency after 6 N, so it is incomplete.

(Total for Question 12 = 8 marks)

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13 A gardener used a trolley to move a paving stone.



A force meter was attached to the handle of the trolley.

The gardener recorded the following measurements when the trolley was at rest in the position shown in the diagram.

mass of trolley and paving stone = 18.5 kg

length of trolley = 97 cm

force on handle = 50 N

(a) Determine the distance of the centre of gravity of the loaded trolley from the wheels.

(3)

Moments about the wheels: $W \times x \cos\theta = 50\ N \times 0.97\ m \times \cos\theta$

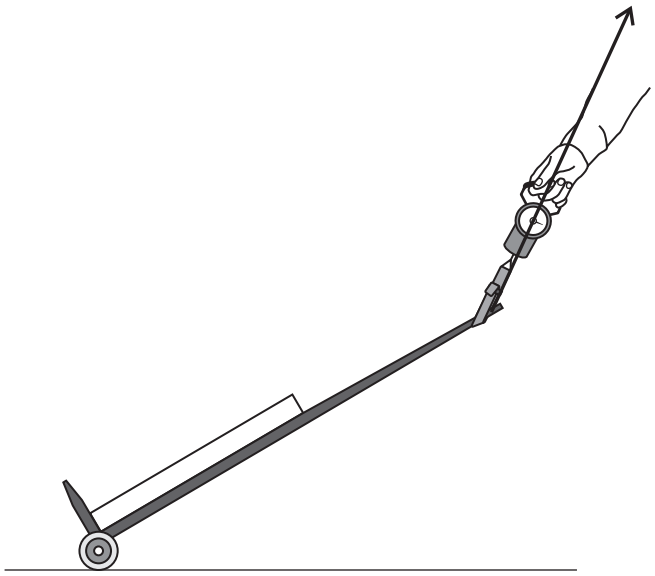
$(18.5\ kg \times 9.81\ N\ kg^{-1}) \times x = 50\ N \times 0.97\ m$

$x = 48.5\ N\ m \div 181.5\ N = 0.267\ m$

Distance = 27 cm

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(b) The gardener then pulled the trolley and measured the applied force while the trolley was moving.



The direction of the applied force is 25° to the vertical, as shown by the arrow.

(i) Calculate the magnitude of the applied force.

Assume the magnitude of the vertical component of the force remains at 50 N.

(2)

vertical component = F cos 25° so 50 N = F cos 25°

F = 50 N ÷ cos 25° = 55.2 N

Magnitude of applied force = 55 N

(ii) The gardener continues to walk and pulls the trolley a distance of 15 m in a time of 4.2 s.

Calculate the power developed while pulling the trolley.

(3)

Force in direction of motion = 55.2 N × sin 25° = 23.3 N

W = Fs = 23.3 N × 15 m = 350 J

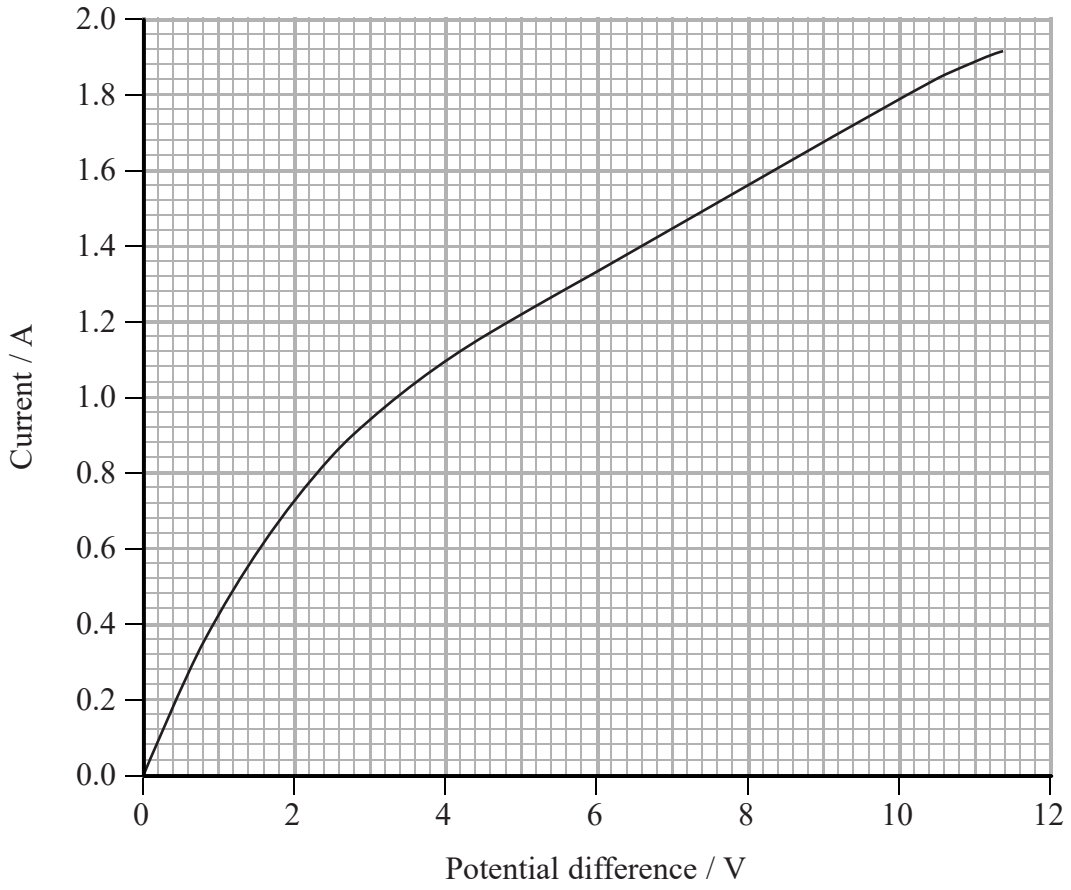
P = W/t = 350 J ÷ 4.2 s = 83.2 W

Power = 83 W

(Total for Question 13 = 8 marks)

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14 The graph shows how the current through a filament bulb varies with the potential difference across the bulb.



(a) Determine the resistance of the filament bulb when the potential difference is 7.0 V.

(2)

From the graph, at V = 7.0 V the current I = 1.44 A

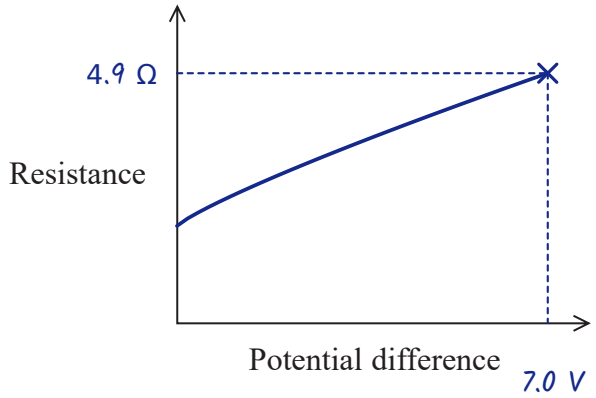
R = V/I = 7.0 V ÷ 1.44 A = 4.86 Ω

Resistance = 4.9 Ω

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(b) Sketch a graph of resistance against potential difference for the filament bulb over the range 0 V to 7 V.

(3)



*(c) Explain the variation of resistance with potential difference for the filament bulb in terms of particle behaviour.

(6)

As the potential difference increases, the current increases, so the electrons (charge carriers) gain more energy and are accelerated to higher speeds between collisions.

There is therefore a greater energy transfer when the electrons collide with the lattice ions, which increases the temperature of the filament.

As the temperature increases, the lattice ions vibrate with greater amplitude.

So the rate of collisions between the electrons and the lattice ions increases (greater chance of collision, shorter distance between collisions), which opposes the flow of the electrons and the resistance increases.

Because of this increase in resistance, the current does not increase in proportion to the potential difference (the ratio I/V decreases), so the I-V graph curves and R increases with V.

(Total for Question 14 = 11 marks)

TOTAL FOR SECTION A = 56 MARKS

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SECTION B

Answer ALL questions.

15 (a) Solar sails are a form of propulsion for spacecraft. The sail is made of a thin sheet of reflective material. When photons of light from the Sun reflect from the material a force is exerted on the sail. The photons reflect with a momentum equal to their initial momentum but in the opposite direction.

(i) Show that a single photon of frequency 1.5×10^{15} Hz has a momentum of about 3×10^{-27} N s.

(2)

$\lambda = h/p$ and $c = f\lambda$, so $p = h/\lambda = hf/c$

$p = 6.63 \times 10^{-34}$ J s $\times$ 1.5×10^{15} Hz $\div$ 3.00×10^{8} m s^{-1}

$p = 3.3 \times 10^{-27}$ N s (about 3×10^{-27} N s)

(ii) Hence determine the momentum transferred to the solar sail by this photon.

(1)

$\Delta p = p - (-p) = 2 \times 3.3 \times 10^{-27}$ N s

Momentum transferred = 6.6×10^{-27} N s

(b) An alternative method of producing a momentum change is being investigated. Researchers have suggested that 'larger changes in momentum could be produced by directing laser light at graphene oxide'. Electrons are emitted from the graphene oxide surface, resulting in a force being exerted on the graphene oxide in the opposite direction.

A researcher has suggested that one possible mechanism for the emission of the electrons is the photoelectric effect.

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(i) Show that the maximum velocity for a photoelectron emitted after absorption of a photon of light of frequency 1.5×10^{15} Hz is about 8×10^{5} m s^{-1}.

work function of graphene oxide = 6.7×10^{-19} J

(3)

$hf = 6.63 \times 10^{-34}\ J\ s \times 1.5 \times 10^{15}\ Hz = 9.95 \times 10^{-19}\ J$

$hf = \varphi + \frac{1}{2}mv^2_{max}$; $\frac{1}{2}mv^2_{max} = 9.95 \times 10^{-19} - 6.7 \times 10^{-19} = 3.25 \times 10^{-19}\ J$

$3.25 \times 10^{-19}\ J = \frac{1}{2} \times 9.11 \times 10^{-31}\ kg \times v^2_{max}$

$v_{max} = 8.4 \times 10^{5}\ m\ s^{-1}$ (about $8 \times 10^{5}\ m\ s^{-1}$)

(ii) Hence calculate the momentum of the photoelectron.

(2)

$p = mv = 9.11 \times 10^{-31}\ kg \times 8.45 \times 10^{5}\ m\ s^{-1}$

$p = 7.7 \times 10^{-25}\ N\ s$

Momentum of photoelectron = $7.7 \times 10^{-25}\ N\ s$

(c) Explain whether the suggestion in (b) that 'larger changes in momentum could be produced by directing laser light at graphene oxide' is true.

(2)

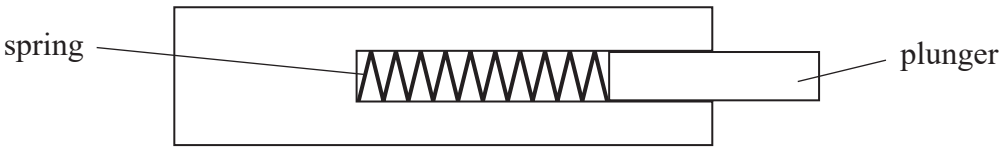
By conservation of momentum, the change in momentum of the graphene oxide is equal (and opposite) to the momentum of the emitted photoelectron.

7.7×10^{-25} N s is much larger (over 100 times) than the 6.6×10^{-27} N s transferred by a reflected photon, so the suggestion is true.

(Total for Question 15 = 10 marks)

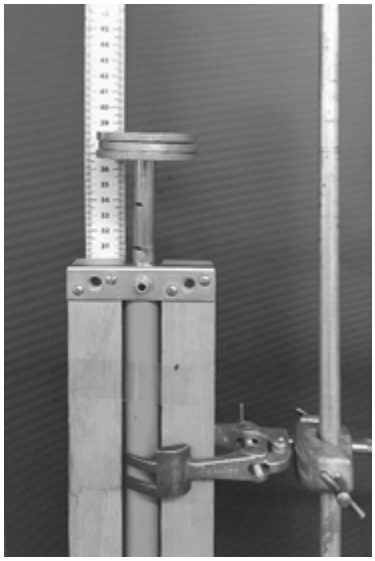
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16 A school dynamics trolley has a plunger attached to a spring. When the plunger is pushed in, the spring is compressed. When the plunger is released, it is pushed back out by the spring.



(a) A student investigated the spring to determine whether it obeys Hooke's law in compression.

The trolley was placed vertically in front of a scale and weights were added in turn to the top of the plunger, as shown. The position of the end of the plunger was recorded each time.



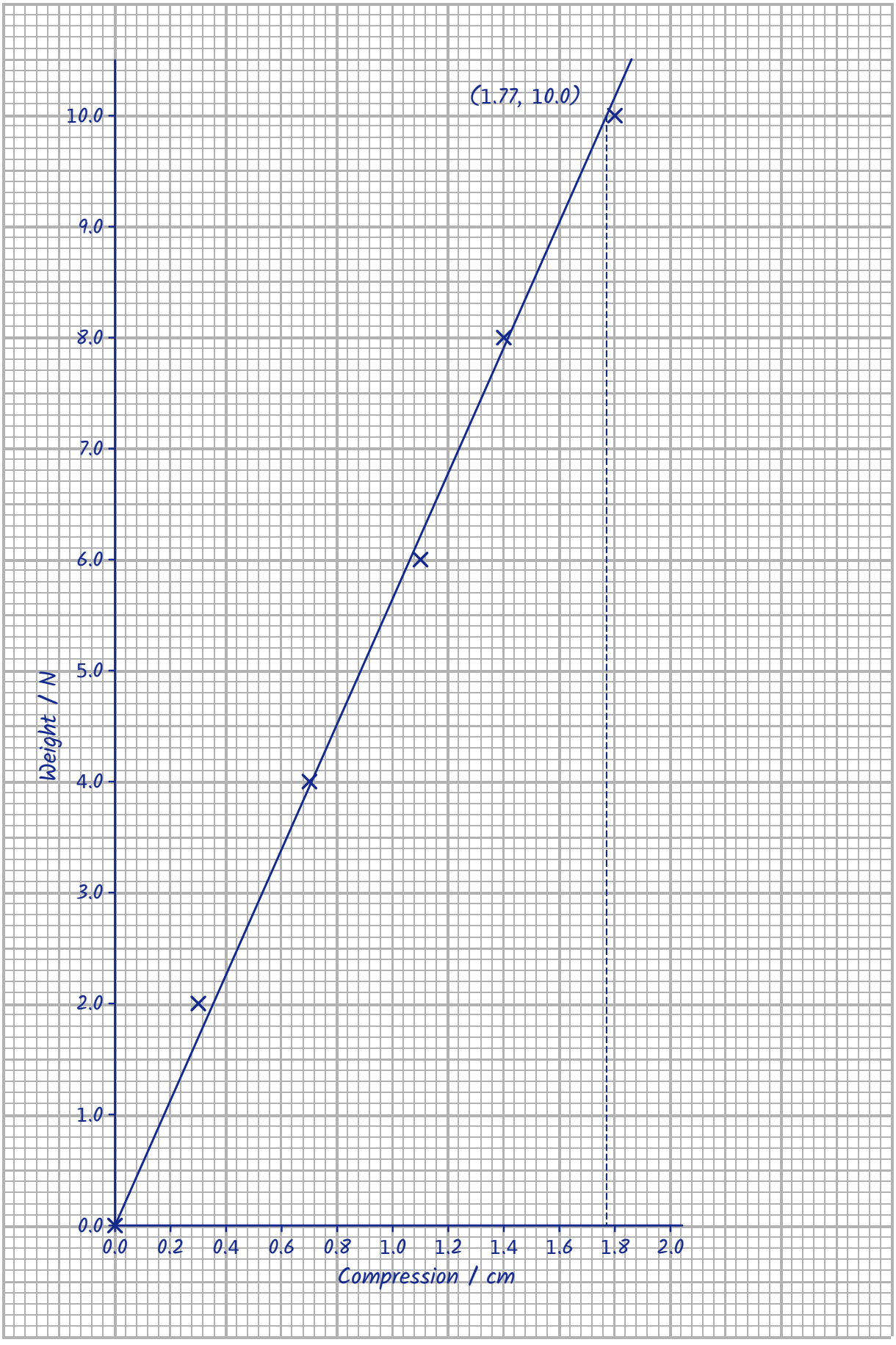
The recorded results are shown in the table.

Weight / N	Position of plunger / cm	Compression / cm
0.00	37.3	0.0
2.00	37.0	0.3
4.00	36.6	0.7
6.00	36.2	1.1
8.00	35.9	1.4
10.00	35.5	1.8

(i) Use the results to plot a graph of weight against compression. You may use the additional column for your processed data.

(5)

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(ii) The student concluded that the spring obeys Hooke's law with a spring constant of about 600 $N\,m^{-1}$.

Determine whether the student's conclusion is justified.

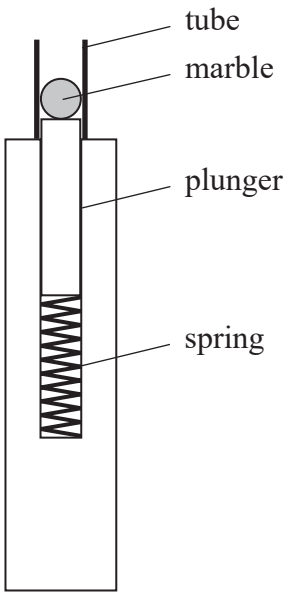
(4)

The best fit line is a straight line through the origin, so the compression is directly proportional to the force (weight) and the spring obeys Hooke's law.

Gradient of best fit line: $k = \Delta F/\Delta x = 10.0\ N \div 0.0177\ m = 565\ N\ m^{-1}$

$565\ N\ m^{-1} = 600\ N\ m^{-1}$ to 1 significant figure, so the student's conclusion is justified.

(b) Another trolley was adapted by placing a tube around the plunger so that it could be used to launch marbles. A marble was placed in the tube while the plunger was depressed. When the plunger was released it launched the marble.



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Determine the maximum possible launch velocity of the marble when the spring is compressed by 5.4 cm.

spring constant = 610 N m^{-1}

mass of marble = 4.1 g

mass of plunger = 35.4 g

(4)

$\Delta F = k\Delta x = 610\ N\ m^{-1} \times 0.054\ m = 32.9\ N$

$\Delta E_{el} = \frac{1}{2}F\Delta x = \frac{1}{2} \times 32.9\ N \times 0.054\ m = 0.889\ J$

All elastic energy becomes kinetic energy of marble and plunger:

$0.889\ J = \frac{1}{2} \times (0.0041 + 0.0354)\ kg \times v^2$

$v^2 = 45.0\ m^2\ s^{-2}$ $v = 6.7\ m\ s^{-1}$

Maximum launch velocity = $6.7\ m\ s^{-1}$

(c) The launch velocity was measured using a light gate and data logger. This produced a smaller value for the launch velocity than that calculated in (b).

Give a reason why this method produced a smaller value for the launch velocity.

(1)

Work is done against friction between the marble and the tube (and the plunger), so less energy becomes kinetic energy of the marble.

(Total for Question 16 = 14 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

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

$I = nqvA$

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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

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

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

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

de Broglie wavelength

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

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