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 24 May 2016 – Morning
Time: 1 hour 30 minutes

Paper Reference
8PH0/01

You may need a 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.
- 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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P 4 9 8 4 5 A 0 1 2 8

PEARSON

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 The winner of a 400 m race must have the greatest

☒ **A** acceleration.

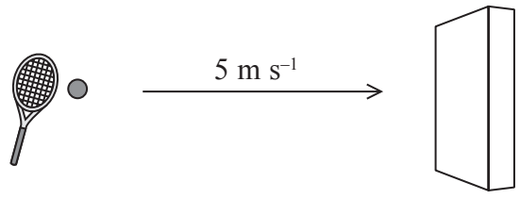
☒ **B** average speed.

☒ **C** instantaneous speed.

☒ **D** maximum speed.

(Total for Question 1 = 1 mark)

2 A tennis ball of mass 0.06 kg moves towards a wall at a velocity of 5 m s^{-1} as shown.



The tennis ball hits the wall perpendicularly and rebounds at the same speed.

What is the change in momentum of the ball?

☒ **A** 0.60 kg m s^{-1}

☒ **B** 0.30 kg m s^{-1}

☒ **C** −0.30 kg m s^{-1}

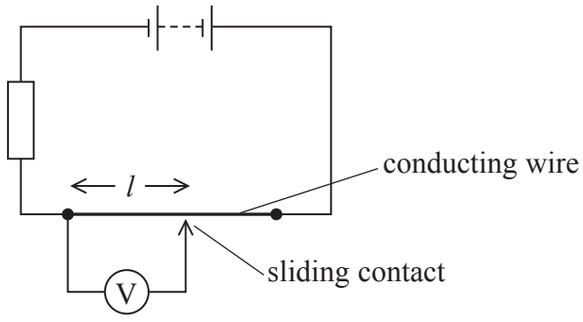
☒ **D** −0.60 kg m s^{-1}

(Total for Question 2 = 1 mark)

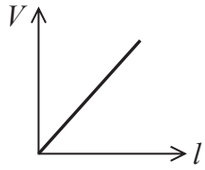
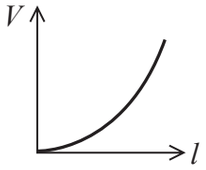
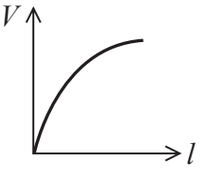
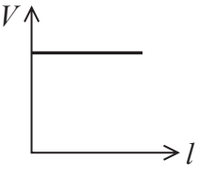
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3 A student set up the circuit below and moved a sliding contact along a uniform conducting wire.
The student recorded the potential difference V across each length of wire l under test.



Which graph correctly shows how V varies with l?

			
☒ **A**	☐ **B**	☐ **C**	☐ **D**

(Total for Question 3 = 1 mark)

4 Which of the following correctly defines electromotive force?

- ☐ **A** Force per unit charge to move a charge across a component.
- ☐ **B** Force per unit charge to move a charge around a circuit.
- ☐ **C** Work done per unit charge to move a charge across a component.
- ☒ **D** Work done per unit charge to move a charge around a circuit.

(Total for Question 4 = 1 mark)

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5 Which of the following is the unit for tension expressed in SI base units?

☒ **A** N

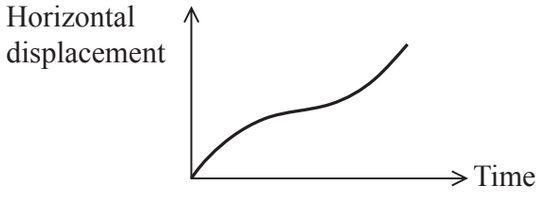
☒ **B** N s

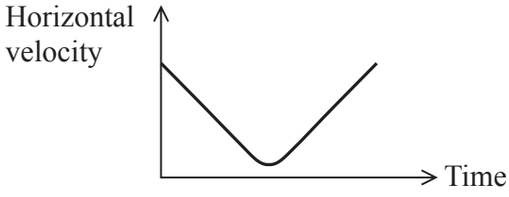
☒ **C** kg m s^{-1}

☒ **D** kg m s^{-2}

(Total for Question 5 = 1 mark)

6 The graphs shown represent the displacement-time and velocity-time graphs for the horizontal component of the motion of a ball.





Which of the following situations could produce this motion of the ball?

☒ **A** Rolling down one ramp and then rolling up a second ramp.

☒ **B** Rolling down a ramp then along the floor.

☒ **C** Rolling up one ramp and down a second ramp.

☒ **D** Rolling up a ramp and rolling back down the same ramp.

(Total for Question 6 = 1 mark)

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7 A pilot wishes to fly due east. A wind is blowing in a northerly direction.

The direction of north is as shown.



Which of the following correctly shows the direction the plane should point?



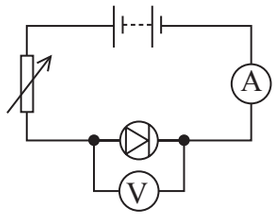
☒ **A** ☒ **B** ☒ **C** ☒ **D**

(Total for Question 7 = 1 mark)

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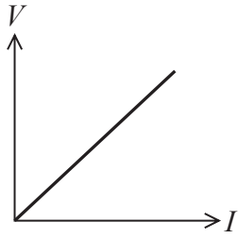
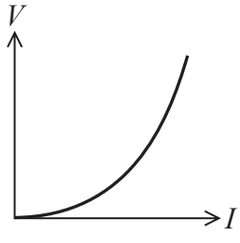
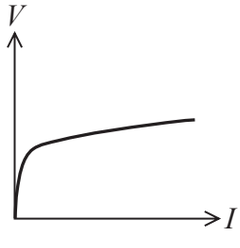
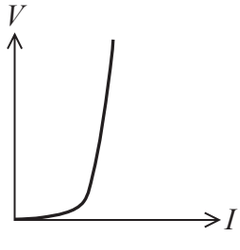
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8 A student carried out an experiment to investigate the current-potential difference characteristics of a diode using the circuit below.



He plotted the graph of potential difference V on the y-axis against the corresponding current I on the x-axis.

Which graph would be obtained by the student?

☒ **A**	
☒ **B**	
☒ **C**	
☒ **D**	

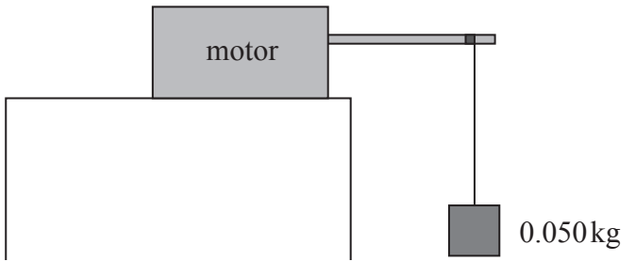
(Total for Question 8 = 1 mark)

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9 A motor lifts a block of mass 0.050 kg at a constant velocity of 0.40 m s^{-1}.

The current in the motor is 85 mA and the potential difference across it is 3.0 V.



Calculate the efficiency of the motor.

(3)

Input power P = VI = 3.0 V × 85 × 10^{-3} A = 0.255 W

Useful output power = mgh/t = mgv = 0.050 kg × 9.81 N kg^{-1} × 0.40 m s^{-1} = 0.196 W

efficiency = useful power output ÷ total power input = 0.196 W ÷ 0.255 W = 0.77

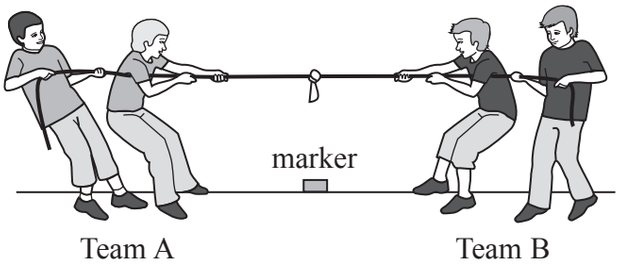
Efficiency of the motor = *0.77 (77%)*

(Total for Question 9 = 3 marks)

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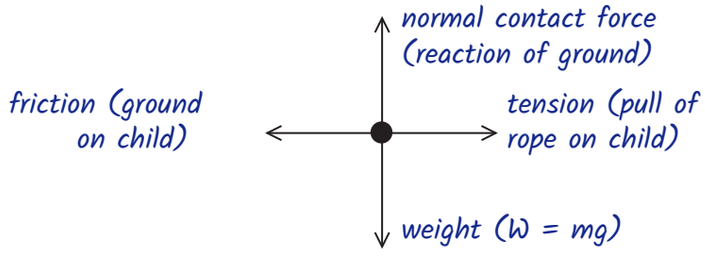
10 In a game of tug-of-war two teams of children pull on opposite ends of a rope. The team that pulls the other team over a marker wins the game.



(a) Initially Team A and Team B are stationary.

Add labels to the free-body force diagram for the child at the end of the rope for Team A at this instant.

(3)



*(b) Team B wins by pulling Team A over the marker.

By considering the forces on the children and on the rope explain, in terms of Newton's laws, the process by which Team A loses the game.

(6)

The rope is under tension. Team A pulls on the rope, so by Newton's third law the rope exerts an equal and opposite force (tension) on Team A, towards Team B.

The frictional force between the ground and Team B is larger than that for Team A, so Team B can apply a greater force on the rope than Team A.

The tension (force of the rope on Team A) becomes greater than the maximum frictional force between Team A and the ground, so the forces on Team A are unbalanced: there is a resultant force on Team A towards Team B (to the right).

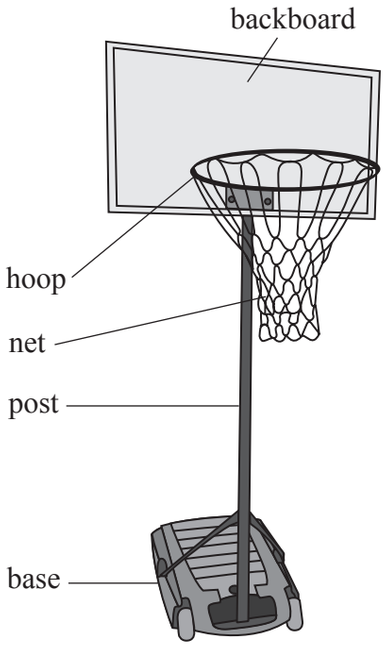
By Newton's first and second laws ($\Sigma F = ma$), Team A accelerates to the right, so Team A is pulled over the marker and loses.

(Total for Question 10 = 9 marks)

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11 A portable basketball set has a base and a post arrangement. The post arrangement consists of a post, backboard, hoop and net. The base can be filled with water to increase stability.



(a) The base has a capacity of 85.0 litres.

Show that the maximum weight of the base is about 870 N.

mass of 1.00 litre of water = 1.00 kg
mass of base when empty = 3.50 kg

(2)

mass of water = 85.0 litres × 1.00 kg = 85.0 kg

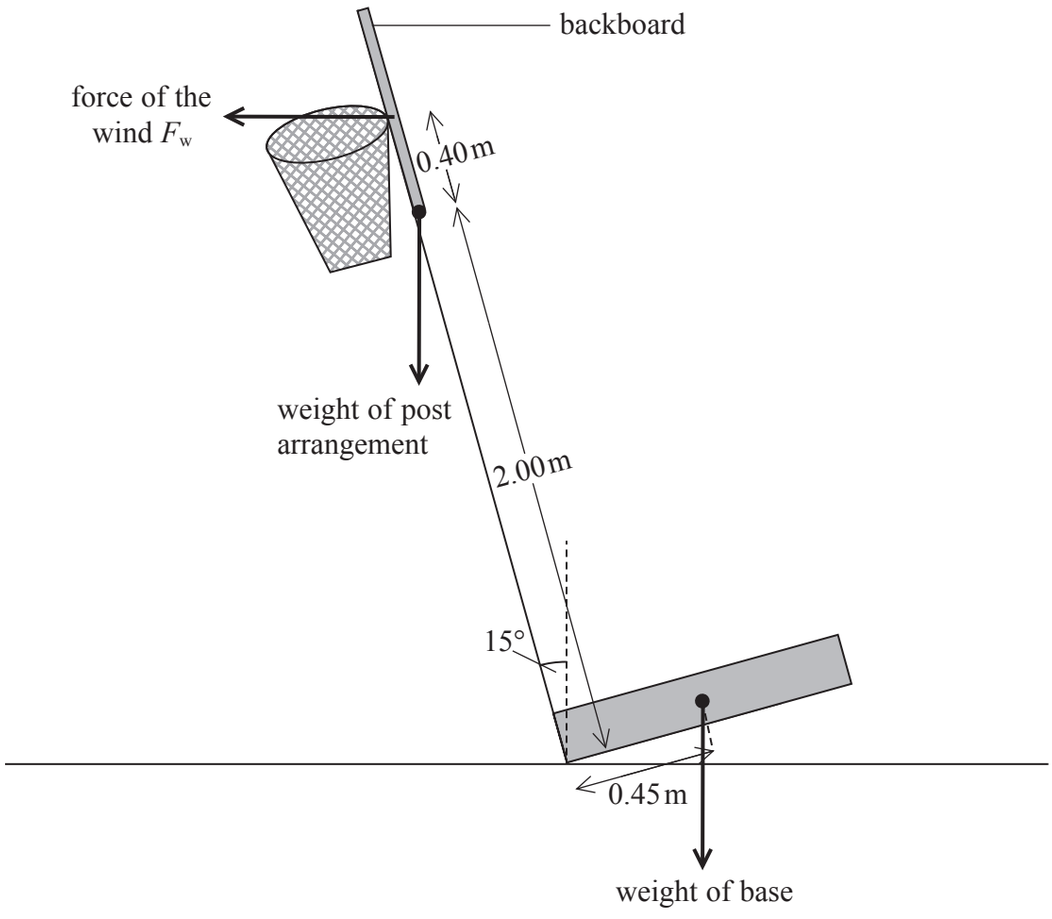
total mass = 85.0 kg + 3.50 kg = 88.5 kg

$W = mg = 88.5 \text{ kg} \times 9.81 \text{ N kg}^{-1} = 868 \text{ N (about 870 N)}$

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(b) Due to the large area of the backboard, the basketball set may topple over when the wind blows.



Calculate the minimum force of the wind F_w that will cause the basketball set to be blown over when it is at the angle shown. Ignore the effect of the wind on the base.

weight of post arrangement = 27.0 N

(5)

Take moments about the pivot (the edge of the base in contact with the ground). On the point of toppling:

moment of base weight = moment of post arrangement weight + moment of wind

$868\ N \times 0.45\ m \times \cos 15° = (27.0\ N \times 2.00\ m \times \cos 75°) + (F_w \times 2.40\ m \times \cos 15°)$

$377.3\ N\ m = 13.98\ N\ m + 2.318\ F_w$

$F_w = 363.3\ N\ m \div 2.318\ m = 157\ N$

Minimum force of the wind F_w ~~=~~ 157 N

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(c) The base is filled with sand instead of water. The density of sand is greater than the density of water.

State and justify what would happen to the value of F_w calculated in part (b).

(3)

F_w would increase.

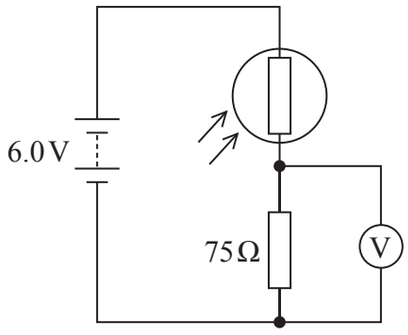
The sand has a greater density, so the base has a greater mass and so a greater (heavier) weight.

This increases the moment of the weight of the base about the pivot (the clockwise moment), so a larger wind force is needed to tip it over.

(Total for Question 11 = 10 marks)

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12 A student set up a circuit containing a light dependent resistor (LDR) in series with a fixed resistor as shown.



(a) As the student moved a lamp towards the circuit she observed the potential difference (p.d.) changing across the fixed resistor.

With reference to the electrons in the LDR explain this observation.

(5)

When light falls on the LDR, the electrons gain energy from the light (photons) and are released, becoming conduction electrons.

As the lamp is moved towards the LDR, the intensity of the light falling on the LDR increases.

This increases the number of conduction electrons (the charge carrier density) in the LDR.

So the resistance of the LDR decreases.

The LDR therefore takes a smaller share of the 6.0 V supply; the p.d. across the LDR decreases and the p.d. across the fixed resistor (the voltmeter reading) increases.

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(b) When the lamp was at a distance of 10 cm from the LDR, the reading on the voltmeter was 2.4 V.

Calculate the resistance of the LDR at this distance.

(3)

p.d. across LDR = 6.0 V − 2.4 V = 3.6 V

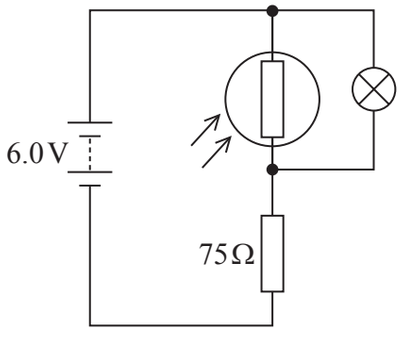
I = V/R = 2.4 V ÷ 75 Ω = 0.032 A

R = V/I = 3.6 V ÷ 0.032 A = 112.5 Ω

Resistance of the LDR = 110 Ω

(c) The student wants to modify the circuit so that a light bulb lights up when the room goes dark.

She modifies the circuit as shown below. When working normally the resistance of the light bulb is 3 Ω and the p.d. across it is 3 V.



Explain, without further calculation, whether this circuit would work as intended.

(3)

The bulb (3Ω) is in parallel with the LDR, so their combined resistance is less than 3Ω, even in the dark.

This combined resistance is always much less than the 75 Ω fixed resistor, which takes most of the 6.0 V.

So the p.d. across the bulb is always much less than 3 V and the bulb will not light in the dark: the circuit would not work as intended.

(Total for Question 12 = 11 marks)

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13 Road trains are used in Australia to transport freight across large, flat areas of the country. They consist of a minimum of three trailers connected to a cab unit to pull them along.



(a) The braking distance of a road train travelling at 15 m s^{-1} is 70 m.

Assuming that the same braking force is applied at all speeds, show that the braking distance of a road train when travelling at 25 m s^{-1} is about 190 m.

(3)

Braking force constant, so the deceleration is constant.

$v^2 = u^2 + 2as$: $0 = (15\ m\ s^{-1})^2 + 2 \times a \times 70\ m$, so $a = -1.61\ m\ s^{-2}$

$0 = (25\ m\ s^{-1})^2 + 2 \times (-1.61\ m\ s^{-2}) \times s$

$s = 625 \div 3.21 = 194\ m$ (about 190 m)

(b) A car accelerates uniformly at 3.7 m s^{-2} as it passes a stationary road train.

The initial speed of the car is 30 m s^{-1} and it reaches the speed limit of 130 km h^{-1} as it passes the front of the cab.

Calculate the length of the road train.

(3)

$v = 130\ km\ h^{-1} = 130\ 000\ m \div 3600\ s = 36.1\ m\ s^{-1}$

$v^2 = u^2 + 2as$: $(36.1\ m\ s^{-1})^2 = (30\ m\ s^{-1})^2 + 2 \times 3.7\ m\ s^{-2} \times s$

$s = (1304 - 900) \div 7.4 = 54.6\ m$

Length of the road train = 55 m

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(c) One region of Australia decided to trial the removal of the speed limit on some roads.

The following statements were made in an online forum discussing this issue.

> Comment
>
> *"If a car was going faster, it would have better fuel economy. A lot of modern cars have engines that are more efficent at 200 km h^{-1} than at 100 km h^{-1}."*
>
> Reply
>
> *"You confuse efficiency with fuel consumption. You cannot get better fuel economy at higher speeds."*

Justify the statement in the reply.

(3)

As the speed increases, the drag (air resistance) increases greatly.
So more fuel is used per kilometre to maintain a higher constant speed: the fuel economy reduces at higher speeds.
The efficiency of the engine may increase with speed, but the fuel economy still decreases; efficiency is a ratio of energies, which cannot be compared with fuel consumption.

(Total for Question 13 = 9 marks)

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14 A mobile phone is powered by a lithium-ion battery. The information shown is taken from the battery.

3.82 V
6.91 W h

(a) (i) The watt-hour (W h) is an alternative unit for energy.

Show that the maximum energy that can be stored by the battery is about 25 kJ.
1 W h = 3600 J

(1)

$E = 6.91\ W\ h \times 3600\ J = 24\ 900\ J$ (about 25 kJ)

(ii) Calculate the maximum charge that the battery can provide.

(2)

$V = W/Q$ so $Q = W/V$

$Q = 24\ 876\ J \div 3.82\ V = 6512\ C$

Maximum charge = 6510 C

(iii) The mobile phone 'runs out of charge'.

Calculate the minimum time taken, in hours, for the battery to fully recharge.

charging current = 0.90 A

(3)

$t = Q/I = 6512\ C \div 0.90\ A = 7236\ s$

$t = 7236\ s \div 3600\ s\ h^{-1} = 2.01\ h$

Minimum time = 2.0 hours

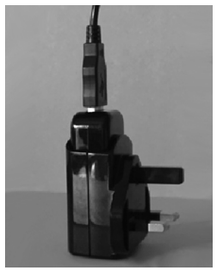
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(b) The mobile phone in part (a), when purchased, was supplied with a charging plug marked 1 A, 5 V. The mobile phone owner lost the original charging plug and replaced it with a charging plug marked 0.5 A, 5 V.



original charging plug
1A, 5 V



replacement charging plug
0.5A, 5 V

By evaluating the information given, discuss the suitability of using the replacement charging plug for this mobile phone. Include references to possible benefits, disadvantages and risks associated with using the replacement charging plug.

(4)

The replacement plug still has to supply the same charge (6510 C) to fully charge the battery.

The replacement plug supplies a lower current (0.5 A), so it takes more time to charge: $t = Q/I$ = 6510 C ÷ 0.5 A = 13 000 s (3.6 h) compared with 6510 C ÷ 1 A = 6510 s (1.8 h) for the original plug. (If the phone only draws 0.90 A, charging takes about twice as long.)

Benefit: the replacement plug uses a lower current, which reduces the heating effect (I^2R) in the plug, cable and battery.

Risk: the voltage is the same (5 V), but the phone may try to draw a current of 1 A (or 0.90 A), more than the 0.5 A rating, which may overheat and damage the replacement charging plug.

(Total for Question 14 = 10 marks)

TOTAL FOR SECTION A = 60 MARKS

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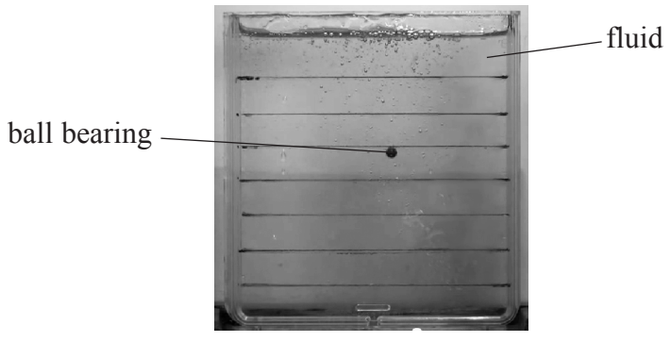
SECTION B

Answer ALL questions.

15 A student carried out an experiment to identify a fluid from its viscosity at room temperature.

A ball bearing of diameter d was released at the top of a container containing the fluid. The motion of the ball bearing was recorded using a video camera and hence the terminal velocity v of the ball bearing was determined.

This was repeated for ball bearings of increasing diameter with the fluid at a constant temperature.



(a) To determine the viscosity η, the student used the equation $v = \dfrac{d^2 g(\rho_b - \rho_f)}{18\eta}$

where ρ_b = density of the material of the ball bearing
ρ_f = density of the fluid.

Explain why a graph of v on the y-axis and d^2 on the x-axis should be a straight line through the origin.

(3)

Compare with $y = mx + c$: $v = [g(\rho_b - \rho_f) \div 18\eta] \times d^2 + 0$

g, ρ_b, ρ_f and η are all constants, so the gradient $m = g(\rho_b - \rho_f) \div 18\eta$ is constant and $v \propto d^2$.

$c = 0$ (when $d^2 = 0$, $v = 0$), so the graph is a straight line through the origin.

(b) The student obtained the following data.

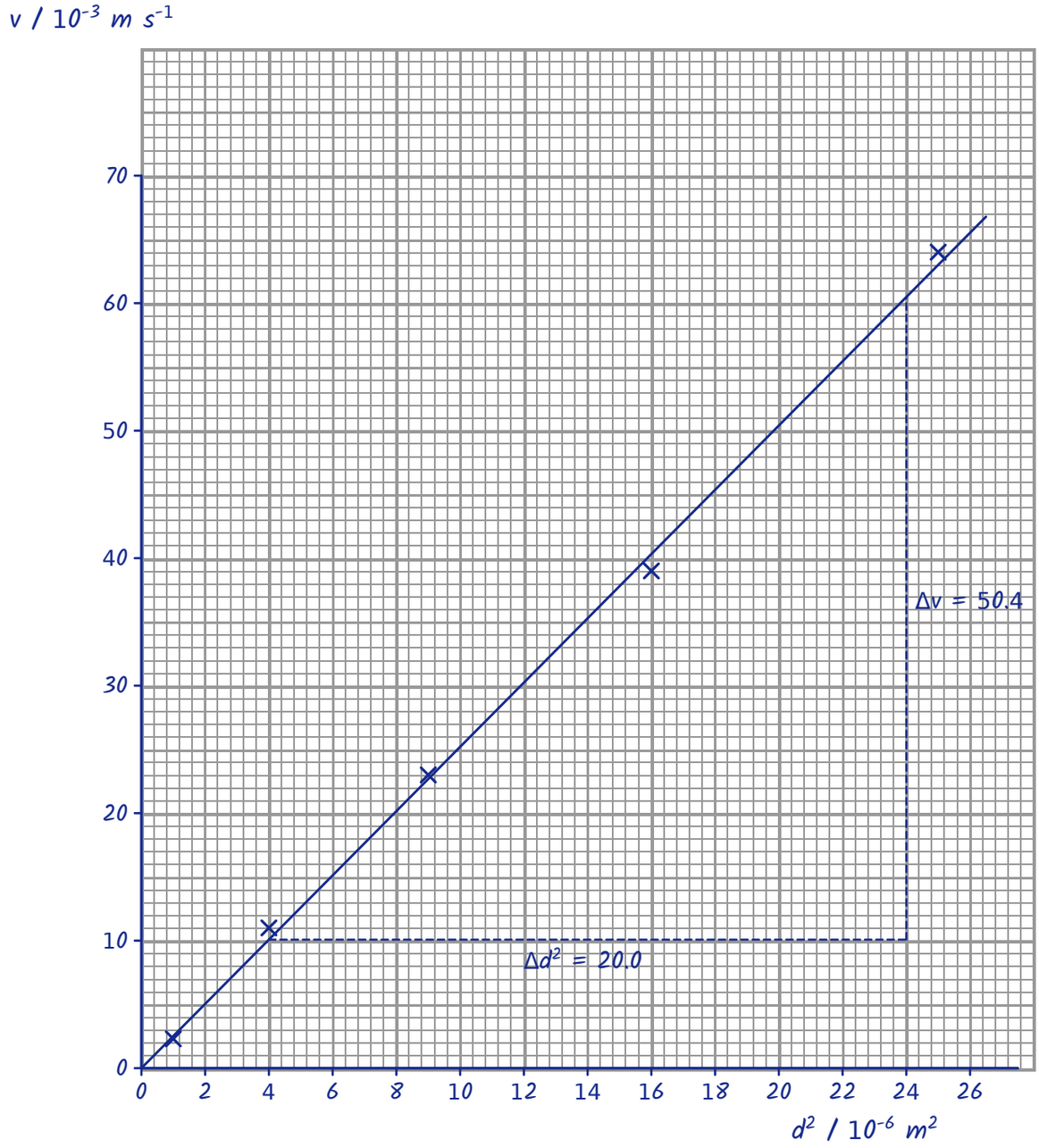
d / 10^{-3} m	d^2 / 10^{-6} m^2	v / 10^{-3} m s^{-1}
1.0	1.0	2.3
2.0	4.0	11
3.0	9.0	23
4.0	16.0	39
5.0	25.0	64

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Plot the graph of v against d^2.

(4)



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(c) The table shows the viscosity of some different fluids.

Fluid	Viscosity at room temperature / Pa s
castor oil	1.0
glycerol	1.2
corn syrup	1.4
honey	1.9

Use the graph to deduce which fluid the student used.

density of ball bearing = 8000 kg m^{-3}
density of fluid = 1260 kg m^{-3}

(4)

gradient = $\Delta v/\Delta d^2$ = 50.4 × 10^{-3} m s^{-1} ÷ 20.0 × 10^{-6} m^2 = 2520 m^{-1} s^{-1}

gradient = $g(\rho_b - \rho_f) \div 18\eta$, so $\eta = g(\rho_b - \rho_f) \div (18 \times \text{gradient})$

η = 9.81 × (8000 − 1260) ÷ (18 × 2520)

η = 1.46 Pa s

This is closest to 1.4 Pa s, so the fluid is corn syrup.

(Total for Question 15 = 11 marks)

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16 In 2010, Andre Geim and Konstantin Novoselov were awarded the Nobel Prize in Physics for producing, identifying and studying graphene.

Graphene is a form of carbon which exists only as a single atomic layer of graphite. It has a breaking stress of 130 GPa compared to 0.5 GPa for steel. Some scientists claim that graphene is the strongest material ever measured.

(a) Explain why graphene, despite its greater strength, is unlikely to replace steel in many applications.

(2)

Graphene is only one atom thick, so its cross-sectional area is far smaller than that of a sample of steel, and most applications need a thickness much greater than one atom (if many layers are used the bonds between the layers are weak).

So although graphene has a greater breaking stress, it will break at a much lower force ($F = \sigma A$) than a steel component.

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(b) Graphite used in pencils consists of many layers of carbon. It can be assumed that a pencil deposits approximately 100 layers of carbon atoms when drawn across a piece of paper.

A student carried out an experiment to determine the resistivity of the graphite in a pencil.

A line of length 0.200 m and width 0.50 mm was drawn on a piece of paper.
An ohmmeter was then used to measure the resistance of the graphite line.



Calculate the resistivity of graphite.

resistance = $1.029 \times 10^{6}\ \Omega$
diameter of carbon atom = 1.4×10^{-10} m

(4)

depth of graphite = $100 \times 1.4 \times 10^{-10}\ m = 1.4 \times 10^{-8}\ m$

A = depth × width = $1.4 \times 10^{-8}\ m \times 0.50 \times 10^{-3}\ m = 7.0 \times 10^{-12}\ m^2$

$R = \rho l/A$ so $\rho = RA/l$

$\rho = (1.029 \times 10^{6}\ \Omega \times 7.0 \times 10^{-12}\ m^2) \div 0.200\ m = 3.6 \times 10^{-5}\ \Omega\ m$

Resistivity of graphite = $3.6 \times 10^{-5}\ \Omega\ m$

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(c) Photocells traditionally use silicon to generate electricity using visible light. Research demonstrates that unlike silicon, graphene is able to respond at all wavelengths and releases multiple electrons as it absorbs one photon.

Deduce why it would be an advantage to use graphene in photocells to generate electricity.

(3)

Silicon only releases a photoelectron for a limited range of frequencies (wavelengths) and releases only one electron per incident photon.

Graphene responds to all wavelengths and releases several electrons per photon, so it gives a greater current for the same illumination.

So graphene photocells are more efficient, and could be smaller, thinner and cheaper for the same power output.

(Total for Question 16 = 9 marks)

TOTAL FOR SECTION B = 20 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

$\Delta W = F\Delta s$

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

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

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

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

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

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

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

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

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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