Please check the examination details below before entering your candidate information

Candidate surname	Other names
StemUp Model Solution	

Pearson Edexcel Level 3 GCE

Centre Number	Candidate Number

Tuesday 12 May 2020

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

Physics

Advanced Subsidiary
Paper 1: Core Physics 1

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 Section 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 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.
- 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. Write your answers in the spaces provided.

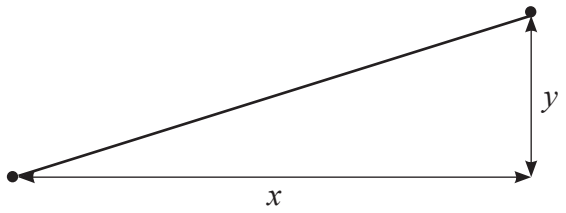
All multiple choice questions must be answered with a cross ☒ in the box for the correct answer from A to D. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 A student wanted to measure the thickness of a single sheet of aluminium foil.
Which of the following instruments would be the most appropriate to make this measurement?

- ☒ **A** measuring tape
- ☒ **B** micrometer screw gauge
- ☒ **C** ruler
- ☒ **D** vernier calipers

(Total for Question 1 = 1 mark)

2 An object of mass m is moved from the bottom to the top of a slope. The vertical height of the slope is y.
The horizontal distance between the bottom and top of the slope is x.



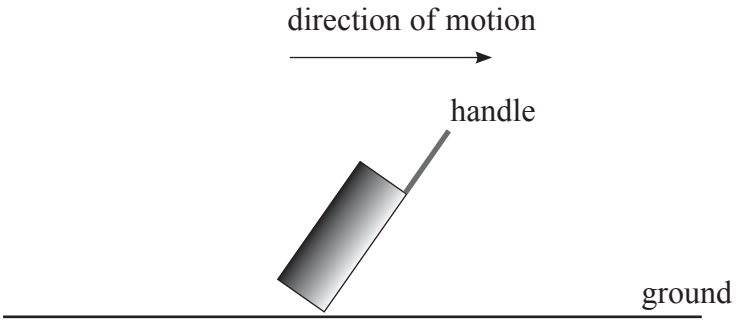
Which of the following gives the gain of gravitational potential energy of the object as it moves from the bottom to the top of the slope?

- ☒ **A** mgx
- ☒ **B** mgy
- ☒ **C** $mg(x + y)$
- ☒ **D** $mg\sqrt{(x^2 + y^2)}$

(Total for Question 2 = 1 mark)

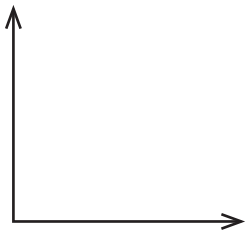
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3 A suitcase is being dragged along the ground by the handle in the direction shown.

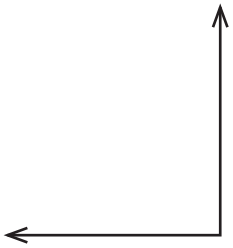


Which of the following shows the direction of the horizontal and vertical components of force acting on the ground due to the suitcase?

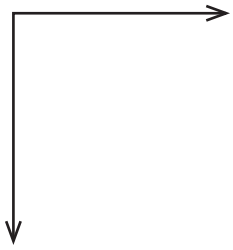
☒ **A**



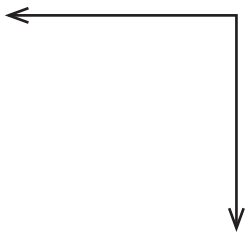
☒ **B**



☒ **C**



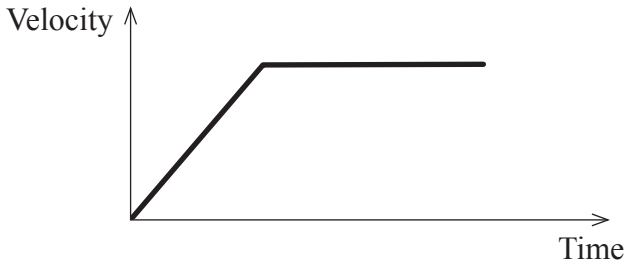
☒ **D**



(Total for Question 3 = 1 mark)

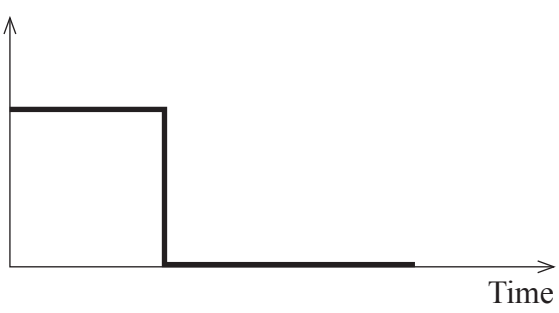
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4 The graph shows how the velocity varies with time for an object.

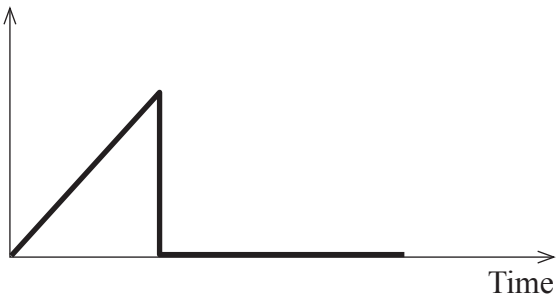


Which of the following graphs shows how the displacement varies with time for this object?

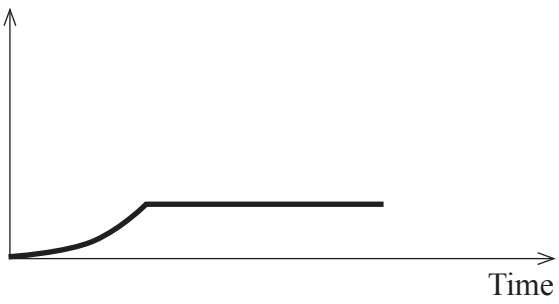
☒ **A**



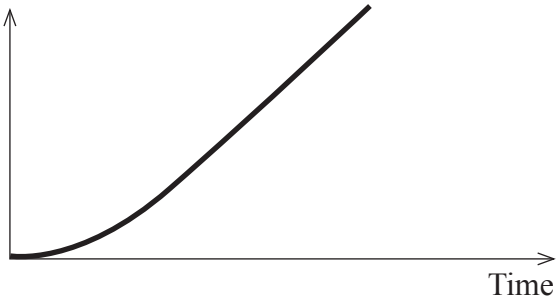
☒ **B**



☒ **C**



☒ **D**



(Total for Question 4 = 1 mark)

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5 Which of the following is a vector quantity?

- ☒ **A** kinetic energy
- ☒ **B** momentum
- ☒ **C** time
- ☒ **D** work done

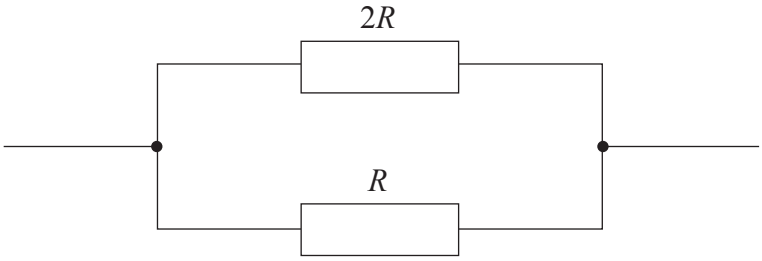
(Total for Question 5 = 1 mark)

6 Which of the following gives the S.I. base units equivalent to the volt?

- ☒ **A** $J\,C^{-1}$
- ☒ **B** $J\,A^{-1}\,s^{-1}$
- ☒ **C** $kg\,m^2\,s^{-2}\,C^{-1}$
- ☒ **D** $kg\,m^2\,s^{-3}A^{-1}$

(Total for Question 6 = 1 mark)

7 Part of an electric circuit consists of two resistors. One resistor has a resistance $2R$ and the other resistor has a resistance R as shown.



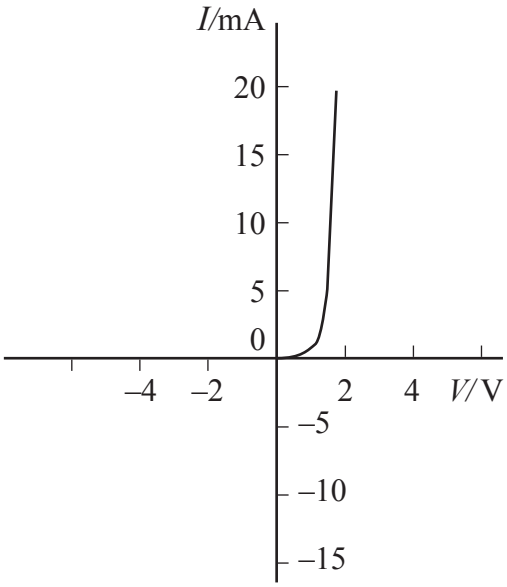
Which of the following is the equivalent resistance of this combination?

- ☒ **A** $\frac{R}{3}$
- ☒ **B** $\frac{2R}{3}$
- ☒ **C** $\frac{3R}{2}$
- ☒ **D** $3R$

(Total for Question 7 = 1 mark)

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8 The graph shows the variation of current I with potential difference V for a diode.



Which of the following statements is correct?

- ☒ **A** The diode has zero resistance when connected in the forward direction.
- ☒ **B** The diode has zero resistance when connected in the reverse direction.
- ☒ **C** The diode starts to conduct when the potential difference is about 0.7 V.
- ☒ **D** The diode stops conducting when the potential difference is about –0.7 V.

(Total for Question 8 = 1 mark)

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9 A vehicle that skids can leave a mark on the road surface. This skid mark can be used to calculate the velocity of the vehicle at the start of the skid.

At a test track a car of mass 1500 kg was collided into the back of a stationary car of mass 1200 kg. The two cars skidded along the road together, leaving skid marks of length 7.5 m. The cars decelerated at 5.6 m s^{-2} to a stop at the end of the skid.

(a) Show that the velocity of the two cars at the start of the skid was about 9 m s^{-1}.

(3)

$v^2 = u^2 + 2as$, with $v = 0$ at the end of the skid and $a = -5.6$ m s^{-2}

$0 = u^2 + 2 \times (-5.6 \text{ m s}^{-2}) \times 7.5$ m

$u^2 = 84$ m^2 s^{-2}, so $u = 9.2$ m s^{-1} (about 9 m s^{-1})

(b) Calculate the velocity with which the car of mass 1500 kg collided with the stationary car.

(3)

Momentum is conserved in the collision: total momentum before = total momentum after ($p = mv$)

momentum after = (1500 + 1200) kg × 9.2 m s^{-1} = 2700 × 9.2 = 24 840 kg m s^{-1}

momentum before = 1500 kg × v + 0 (stationary car)

1500 v = 24 840, so v = 16.6 m s^{-1}

Velocity = 17 m s^{-1}

(c) In practice, the velocity of the car is not exactly the same as that calculated in (b).

Explain why.

(2)

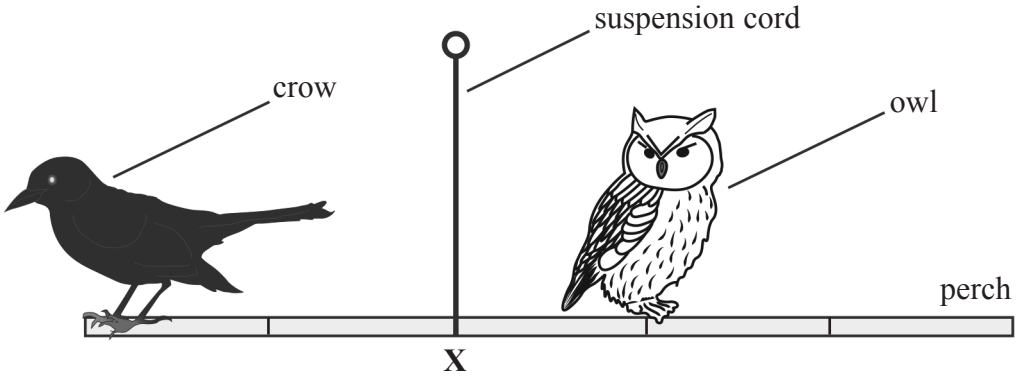
Momentum is not conserved exactly during the collision because an external force acts on the cars:

friction from the road acts on the tyres (as the cars collide and start to skid).

(Total for Question 9 = 8 marks)

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10 In a 'balancing birds' puzzle, model owls and crows are each placed in one of six equally spaced positions marked on a perch. The perch has negligible mass, and is suspended from another of the six marked positions. With the birds placed, and the perch suspended, as shown, the puzzle is in equilibrium.



(a) State what is meant by 'in equilibrium'.

(2)

The resultant force on it is zero (sum of the forces in any direction is zero) and the resultant moment about any point is zero (clockwise moments = anticlockwise moments).

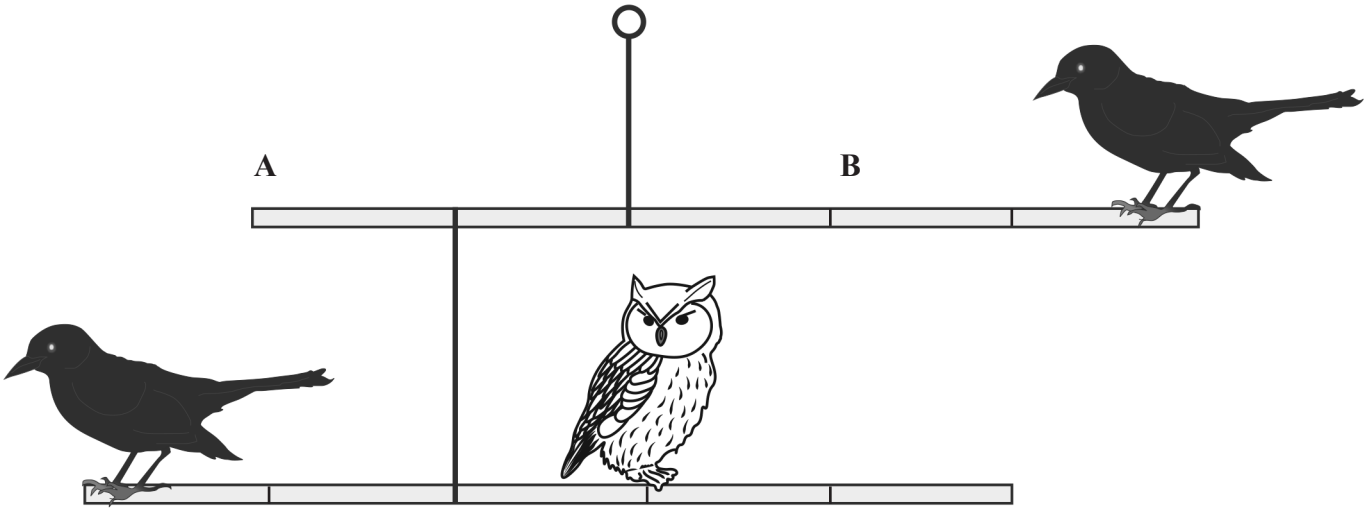
(b) (i) The owl has a mass $2M$ and the crow has a mass M. Show that the perch will balance when suspended as shown from position X.

(1)

About X: anticlockwise moment = Mg × 2 = 2Mg; clockwise moment = 2Mg × 1 = 2Mg (distances in positions), equal so it balances.

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(ii) The perch is then attached to a second perch and suspended as shown. Two more birds, not shown, are placed at A and B, and the whole arrangement is in equilibrium. Each crow has the same mass M. The mass of an owl is $2M$.



Explain, with the aid of a calculation, which type of bird sits at A and which type of bird sits at B to ensure the whole arrangement is in equilibrium.

(3)

Take moments about the suspension cord of the upper perch (distances in positions):

lower perch and its birds (total 3M) act 1 position to the left; the crow on the upper perch is 3 positions to the right.

anticlockwise = clockwise: $3M \times 1 + m_A \times 2 = M \times 3 + m_B \times 1$, so $m_B = 2m_A$

So the bird at B has twice the mass of the bird at A: a crow (M) sits at A and an owl (2M) sits at B.

(Total for Question 10 = 6 marks)

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11 A student modelled the behaviour of a circuit containing a cell of emf 1.5 V with internal resistance 3.0 Ω, using a spreadsheet. In this model the cell is connected across a resistor. The student used the model to investigate how the power P dissipated by the resistor varies with its resistance R.

	A	B	C
1	R / Ω	Current / A	P / W
2	0.5	0.43	0.09
3	1.0	0.38	0.14
4	1.5	0.33	0.17
5	2.0	0.30	0.18
6	2.5	0.27	0.19
7	3.0	0.25	0.19
8	3.5	0.23	0.19
9	4.0	0.21	0.18
10	4.5	0.20	0.18

(a) Show how the value in B2 is calculated.

(1)

B2 = $I = \varepsilon / (R + r) = 1.5 / (0.5 + 3.0) = 0.43$ A, i.e. =1.5/(A2+3.0)

(b) Show how the value in C5 is calculated.

(1)

C5 = $P = I^2R = 0.30^2 \times 2.0 = 0.18$ W, i.e. =B5^2*A5

(c) The student concluded that the power dissipated by the resistor is a maximum when R is between 2.5 Ω and 3.5 Ω.

Explain how this spreadsheet could be improved so that this maximum can be located more precisely.

(2)

Use smaller increments of resistance (e.g. steps of 0.1 Ω) in column A, around the area of the peak, i.e. between R = 2.5 Ω and 3.5 Ω, and give P to more significant figures.

(Total for Question 11 = 4 marks)

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12 A student wants to investigate how the resistance R of a negative temperature coefficient thermistor varies with its temperature T.

(a) Write a set of instructions that the student could follow and include one safety precaution.

(6)

1. Connect the thermistor to an ohmmeter (multimeter on the resistance setting) to measure its resistance R.

2. Immerse the thermistor in a beaker of water (water bath), starting with ice and water at about 0 °C.

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

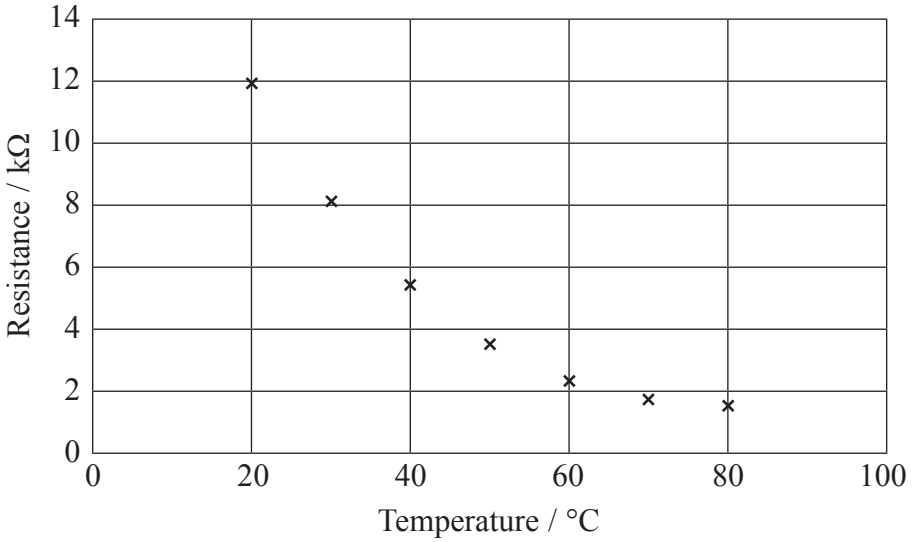
4. Heat the water and at fixed intervals (e.g. every 5 °C up to 100 °C) stir the water, allow time for the thermistor to reach the water temperature, then record T and R.

5. Read the thermometer at eye level to avoid parallax error.

6. Safety: clamp the thermometer and leads in a retort stand so the beaker is stable, stand it on a heatproof mat and wear safety glasses in case of splashes of hot water.

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(b) The following graph was plotted from the results of another student's experiment for the same topic.



Give two modifications to the experimental procedure that could improve these results.

(2)

Take readings at smaller intervals, e.g. every 5 °C, especially at 25 °C and 35 °C where R is changing most.

Widen the range: add ice to go down to 0 °C and heat to 100 °C (boiling water).

Repeat and average R.

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(c) Explain, in terms of particle behaviour, why the resistance of the thermistor decreases as temperature increases.

(4)

As the temperature increases, more energy is transferred to the lattice ions / atoms, which vibrate more.

Some of this energy releases more electrons, so more charge carriers are available (the number per unit volume n increases).

Since I = nAvq, the current increases for the same p.d. (the increase in n outweighs the extra collisions with the lattice).

As R = V / I, a larger current for the same p.d. means the resistance decreases.

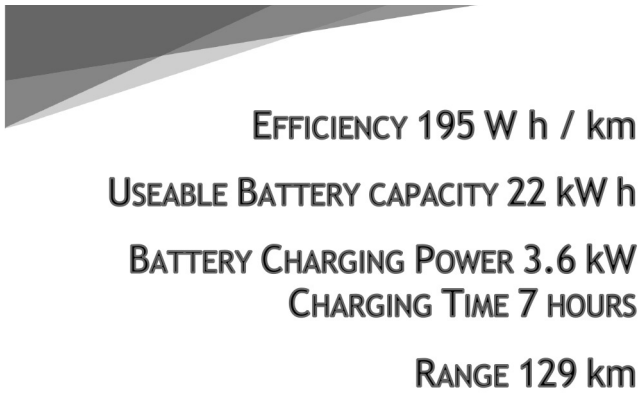
(Total for Question 12 = 12 marks)

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13 A website advertises an electric car with the following information.



(a) State why the 'efficiency' given on the website cannot be a value of efficiency as defined in physics.

(1)

Efficiency should be a ratio of energies (or powers), so it has no units; 195 W h / km has units.

(b) Explain why the kilowatt-hour (kW h) is a unit of energy.

(2)

P = E / t, so energy E = power × time.

The kilowatt is a unit of power and the hour is a unit of time, so kW × h is a unit of energy (1 kW h = 3.6 × 10^6 J).

(c) Calculate the efficiency of the battery.

(3)

efficiency = useful energy output / total energy input

energy input = power × time = 3.6 kW × 7 h = 25.2 kW h

efficiency = 22 kW h / 25.2 kW h = 0.873

Efficiency = *0.87*

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(d) A comparable petrol car has a petrol consumption of 21 km / litre.

Show that the electric car is cheaper to run.

cost of 1 litre of petrol = £1.20

cost of 1 kW h of electricity = 13 p

(2)

Electric: energy per km = 0.195 kW h, cost = 0.195 × 13 p = 2.54 p per km

(or charging cost = 25.2 kW h × 13 p = £3.28 for 129 km)

Petrol: cost per km = 120 p / 21 km = 5.71 p per km

2.54 p < 5.71 p, so the electric car is cheaper to run.

(e) Give one environmental advantage of an electric car.

(1)

No exhaust gases when driven, so less carbon dioxide emission (fewer greenhouse gases).

(f) The website provides the following additional information.

Maximum Engine Power 80 kW
Maximum Performance 0 to 28 ms^{-1} in 11.5 s
Mass of Car 1500 kg

Deduce whether the power of the engine is capable of producing this performance.

(3)

$E_k = \frac{1}{2}mv^2 = \frac{1}{2} \times 1500\ kg \times (28\ m\ s^{-1})^2 = 5.88 \times 10^5\ J$

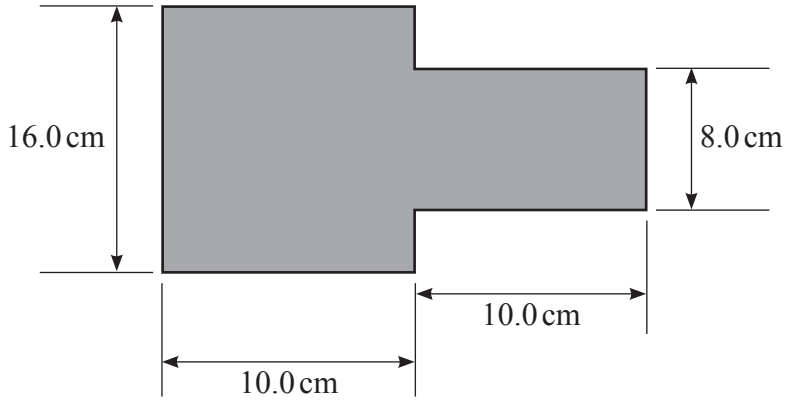
$P = E / t = 5.88 \times 10^5\ J / 11.5\ s = 5.11 \times 10^4\ W = 51\ kW$

51 kW is less than the maximum engine power of 80 kW, so the engine is capable of producing this performance.

(Total for Question 13 = 12 marks)

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14 Carbon paper is an electrically conducting paper. A student cut a sheet of this paper into the shape shown, to carry out an investigation.

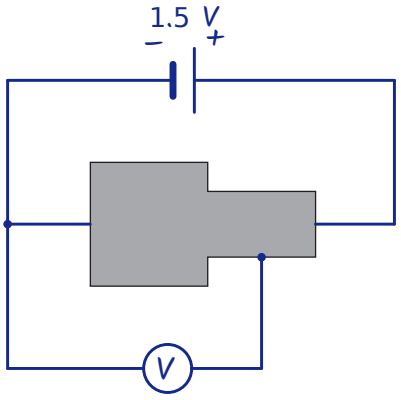


The student followed the procedure below to set up a potential divider circuit:

- connect the 16 cm and 8 cm wide ends to a 1.5 V cell
- connect the 16 cm wide end to the negative (0 V) terminal of the cell
- connect a voltmeter so that it measures the potential at a point 15 cm from the 16 cm wide end.

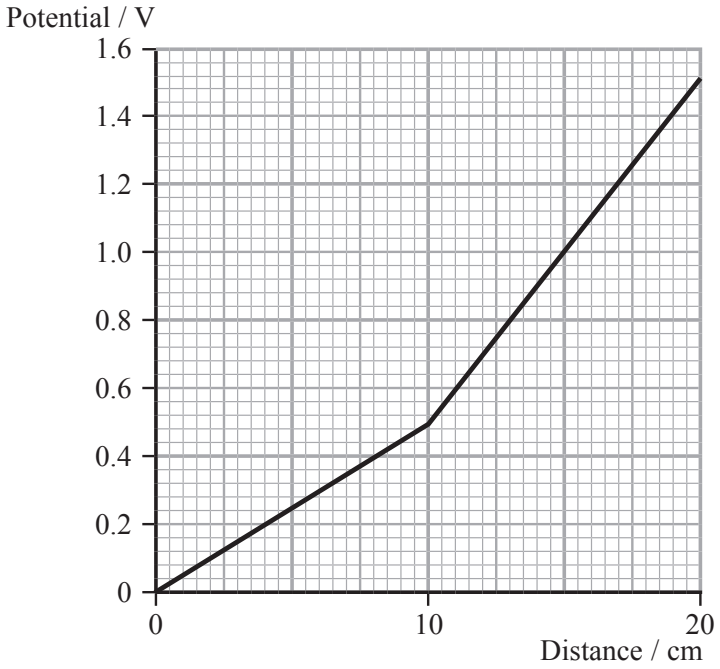
(a) Add a circuit diagram to the diagram below to show how the carbon paper is connected.

(2)



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*(b) The following graph was plotted from an investigation in which the potential was measured at various distances from the 16.0 cm wide end of the shape.



Explain the shape of this graph. **(6)**

The paper behaves as two resistors in series: the wide section (10 cm long, 16 cm wide) and the narrow section (10 cm long, 8 cm wide).

Using $R = \rho l / A$, the two sections have the same length and thickness but the wide section has twice the cross-sectional area, so its resistance is half that of the narrow section.

The current is the same throughout the length of the paper, so by $V = IR$ the p.d. across each section is proportional to its resistance: the 1.5 V is divided into 0.5 V across the wide section and 1.0 V across the narrow section.

Within each section R is proportional to l, so the potential increases linearly with distance, giving straight lines; the narrow section has twice the gradient, so the graph becomes steeper at 10 cm.

At 0 cm both voltmeter terminals are at the 0 V end so it reads 0 V; at 20 cm it is across the whole length and reads the p.d. of the cell, 1.5 V.

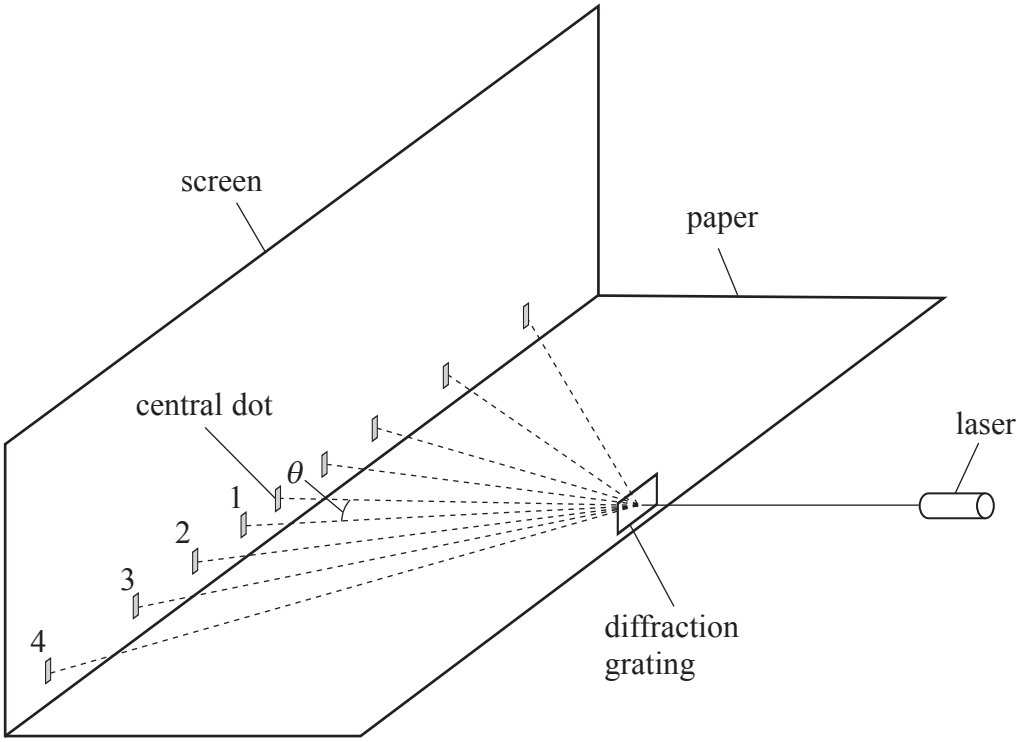
(Total for Question 14 = 8 marks)

TOTAL FOR SECTION A = 58 MARKS

SECTION B

Answer ALL questions.

15 The arrangement shown was used to determine the wavelength of light emitted by a laser.



A laser light beam was shone at a diffraction grating. A series of dots of light was produced on a screen. The angles θ between the light ray to the central dot and the light rays to the dots labelled 1 to 4 were measured with a protractor.

n	θ / °	$\sin\theta$
1	12	0.21
2	23	0.39
3	34	0.56
4	51	0.78

(a) Describe how the angle θ could be determined without using a protractor.

(2)

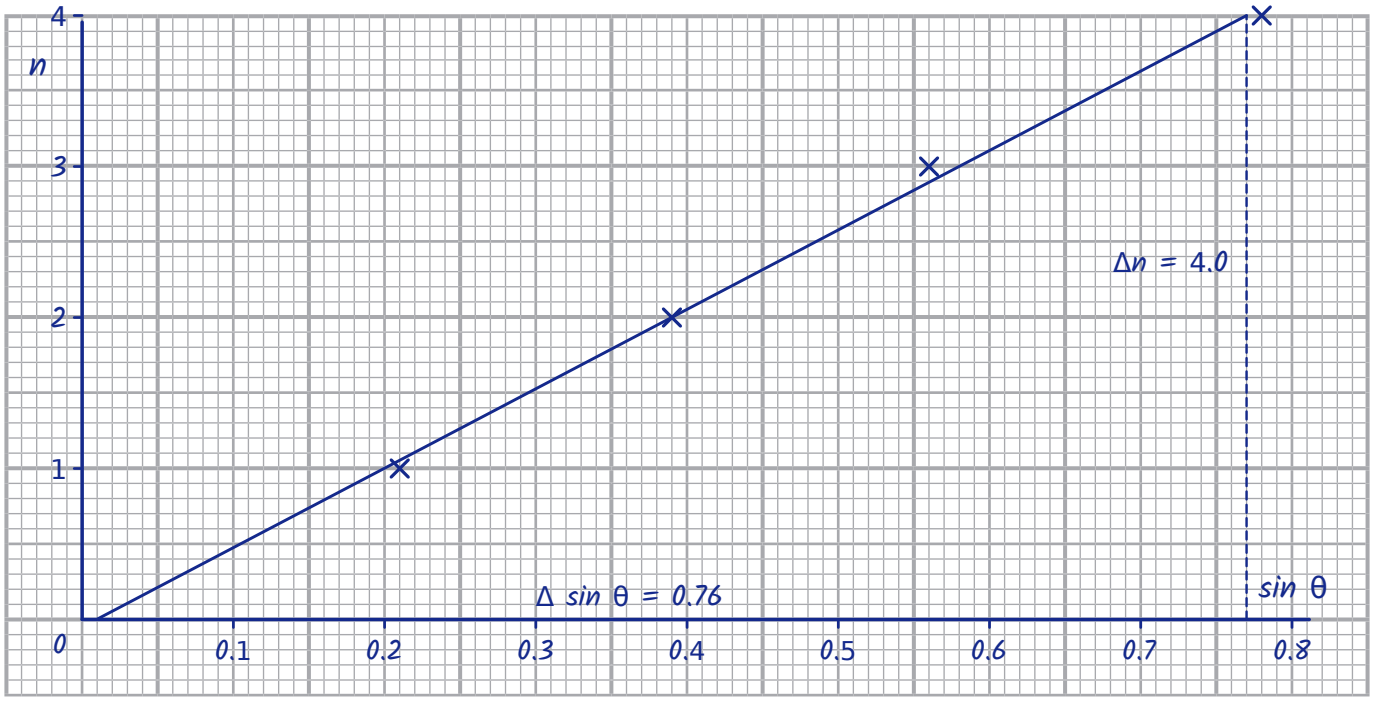
Measure the perpendicular distance l from the grating to the screen and the distance x on the screen from the central dot to each dot, using a metre rule.

Then calculate θ using tan θ = x / l.

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(b) Plot a graph of n against $\sin\theta$ on the grid below.

(4)



(c) The diffraction grating has 300 lines mm^{-1}.

Determine the wavelength of the laser light.

(4)

gradient = Δn / Δ sin θ = 4.0 / 0.76 = 5.26

nλ = d sin θ so n = (d / λ) sin θ, hence gradient = d / λ

$d = 1 \times 10^{-3}$ m / 300 = 3.33×10^{-6} m

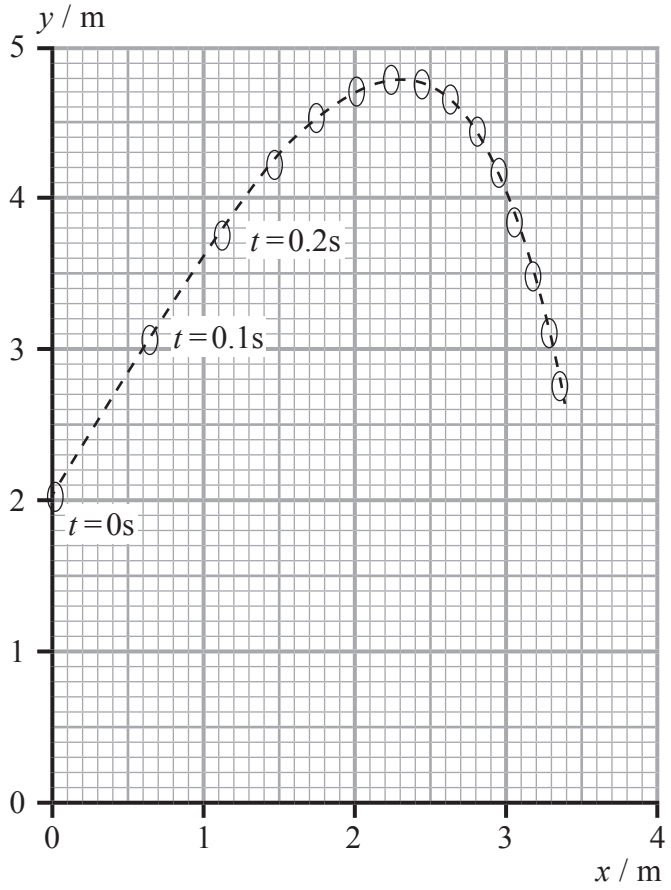
λ = d / gradient = 3.33×10^{-6} m / 5.26 = 6.3×10^{-7} m

Wavelength = 6.3×10^{-7} m

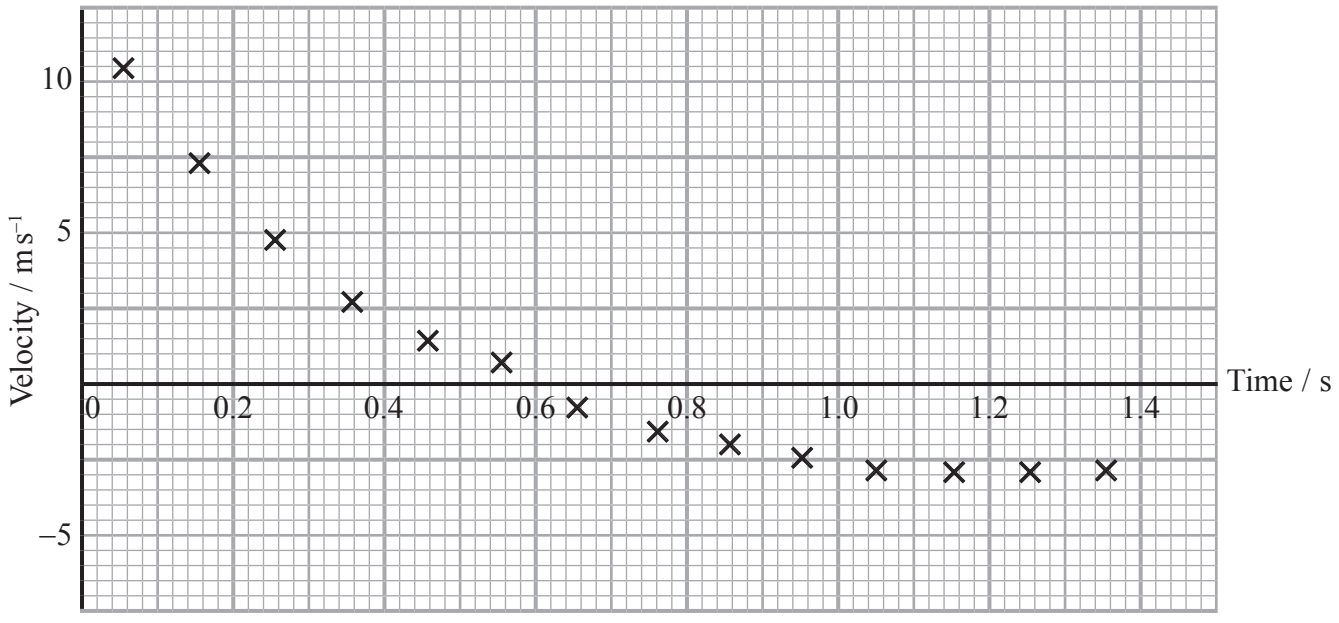
(Total for Question 15 = 10 marks)

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16 In a game of badminton, a shuttlecock is hit by a racket. The graph shows how the vertical displacement (y) and horizontal displacement (x) of the shuttlecock vary from the moment it leaves the racket. The positions are recorded every 0.10 s.



(a) The graph below shows how the velocity of the shuttlecock in the vertical direction varies with time.



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(i) Explain how the velocities have been calculated from the successive vertical positions of the shuttlecock.

(2)

Calculate the difference between successive vertical positions read from the y against x graph (Δy in each 0.10 s),

then velocity = Δy / 0.10 s, e.g. v = (3.0 − 2.0) m / 0.10 s = 10 m s^{-1}.

(ii) State why these velocities have been plotted at the mid-range of the time interval.

(1)

Each value is the average velocity over the 0.10 s interval, which is the velocity at the middle of the interval.

(iii) State, with a reason, two pieces of evidence from the graphs that show that the shuttlecock does **not** follow the motion of a projectile moving freely under gravity.

(3)

The horizontal distances between successive points decrease, but for a free projectile the horizontal component of velocity should be constant.

The path is not symmetrical about the highest point (not parabolic).

The velocity-time graph is not a straight line (its gradient is not constant), but the vertical acceleration should equal g.

(iv) Show, using the velocity-time graph, that the maximum height gained by the shuttlecock is about 3 m.

(3)

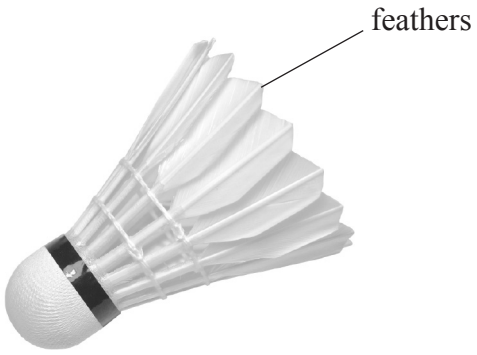
Maximum height gained = area under the velocity-time graph from t = 0 to when v = 0.

Area of approximate triangle = ½ × 0.50 s × 11.5 m s^{-1}

= 2.88 m, which is about 3 m.

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(b) The photograph shows a shuttlecock.



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The shuttlecock always moves through the air with the 'feathers' trailing behind.

Explain how the feathers affect the motion of the shuttlecock along its path.

(3)

The feathers increase the surface area and cause turbulent air flow behind the shuttlecock.

This results in a high drag force (air resistance) acting against its motion, so it stays pointing along its path with the feathers behind.

The horizontal velocity decreases quickly and the vertical acceleration is no longer g, so the path is not parabolic and it falls steeply at the end.

(Total for Question 16 = 12 marks)

TOTAL FOR SECTION B = 22 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

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

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

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

de Broglie wavelength

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

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