Write your name here

Surname	Other names

Pearson Edexcel
Level 3 GCE

Centre Number | Candidate Number

Physics

Advanced
Paper 1: Advanced Physics I

Thursday 15 June 2017 – Morning
Time: 1 hour 45 minutes

Paper Reference
9PH0/01

You do not need any other materials.

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.
- Answer the questions in the spaces provided – *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- You may use a scientific calculator.
- In questions marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically showing how the points that you make are related or follow on from each other where appropriate.

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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P 4 8 0 9 7 R R A 0 1 2 8

Pearson

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 volt can be defined as a

☒ **A** coulomb per joule.

☒ **B** coulomb per second.

☒ **C** joule per coulomb.

☒ **D** joule per second.

(Total for Question 1 = 1 mark)

2 A trolley, mass 0.50 kg, has a speed of 2.0 m s^{-1}. A second trolley, mass 1.0 kg, has a speed of 2.0 m s^{-1}. The two trolleys are travelling in opposite directions and collide.

Which of the following could be a correct value of total momentum, in kg m s^{-1}, after the collision?

☒ **A** 0

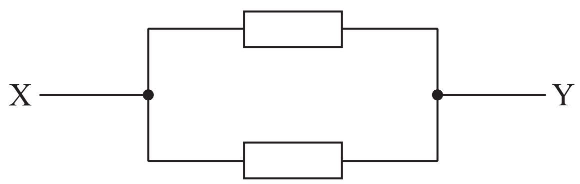
☒ **B** 1.0

☒ **C** 2.0

☒ **D** 3.0

(Total for Question 2 = 1 mark)

3 The two resistors shown each have resistance R.



Which expression gives the correct resistance between point X and point Y?

☒ **A** $\frac{R}{2}$

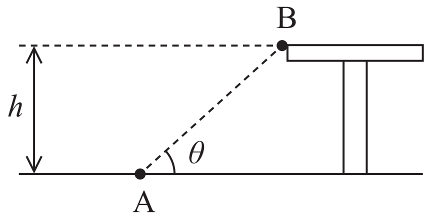
☒ **B** R

☒ **C** $2R$

☒ **D** R^2

(Total for Question 3 = 1 mark)

4 An object of mass m is moved from point A on the ground, to point B on a bench of height h as shown in the diagram.



Which of the following is a correct expression for the work done on the object?

☒ **A** $\dfrac{mgh}{\sin\theta}$

☒ **B** $\dfrac{mgh}{\cos\theta}$

☒ **C** mgh

☒ **D** $mgh\sin\theta$

(Total for Question 4 = 1 mark)

5 A capacitor of capacitance C is charged to a potential difference V by a power supply. The energy stored on the charged capacitor is W.

What would be the energy stored if the potential difference were $2V$?

☒ **A** $\dfrac{W}{4}$

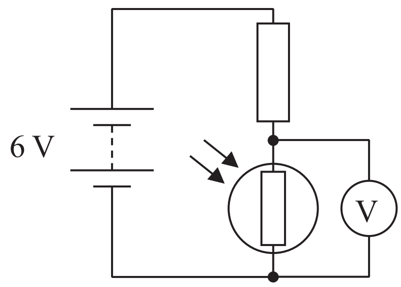
☒ **B** $\dfrac{W}{2}$

☒ **C** $2W$

☒ **D** $4W$

(Total for Question 5 = 1 mark)

6 A light-dependent resistor (LDR) and resistor are connected in series with a 6 V battery as shown. A voltmeter measures the potential difference across the LDR.



In daylight the voltmeter reads 3.0 V.

Which reading is most likely if the circuit is now in total darkness?

☒ **A** a little above 0 V

☒ **B** a little below 3 V

☒ **C** a little above 3 V

☒ **D** a little below 6 V

(Total for Question 6 = 1 mark)

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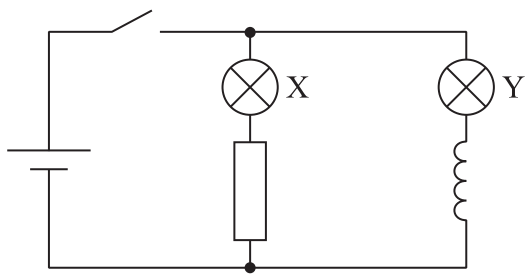
7 A circuit is set up as shown in the diagram. Lamps X and Y are identical. The coil has a soft iron core. The resistor and the coil have the same resistance.



The switch is closed and lamp X lights instantly.

Which statement best describes lamp Y after the switch is closed?

☒ **A** Lights after a delay with a final brightness less than X

☒ **B** Lights after a delay with a final brightness the same as X

☒ **C** Lights instantly with less brightness than X

☒ **D** Lights instantly with the same brightness as X

(Total for Question 7 = 1 mark)

8 The alpha particle scattering experiment led to a number of observations and conclusions.

Which row in the table gives a correct observation and corresponding conclusion from the alpha particle scattering experiment?

	Observation	Conclusion
☒ **A**	Most alpha particles come straight back.	The nucleus is charged.
☒ **B**	Most alpha particles come straight back.	The atom is mainly empty space.
☒ **C**	Most alpha particles go straight through.	The atom is mainly empty space.
☒ **D**	Most alpha particles go straight through.	The nucleus is charged.

(Total for Question 8 = 1 mark)

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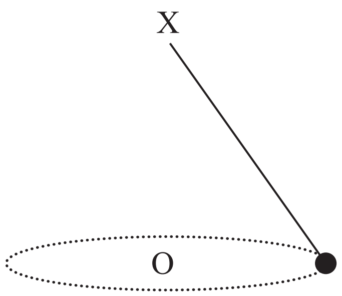
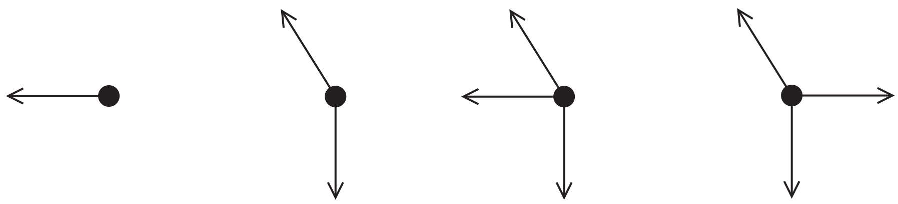
9 A mass is attached to a light thread which is fixed at X. The mass is moving at constant speed in a horizontal circle, centre O.



Which of the following is a correct free-body force diagram for this mass?



A **B** **C** **D**

☒ **A**

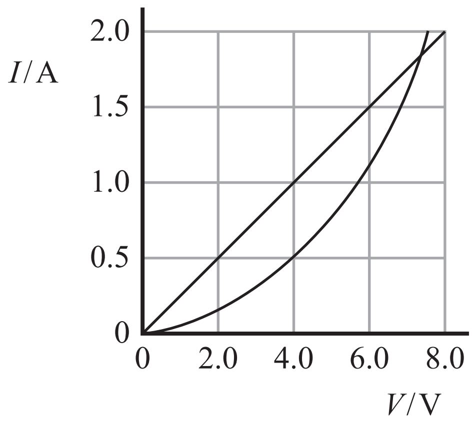
☒ **B**

☒ **C**

☒ **D**

(Total for Question 9 = 1 mark)

10 The current-potential difference graphs for a resistor and a thermistor are shown.



The resistor and thermistor are connected in series to a 6 V battery.

What is the current, in amps, in the resistor?

☒ **A** 0.5

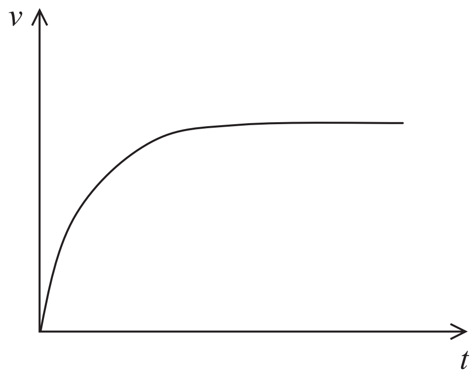
☒ **B** 1.0

☒ **C** 1.5

☒ **D** 2.0

(Total for Question 10 = 1 mark)

11 A sports class is studying cycling. They produce a video of a cyclist on a horizontal lawn. The cyclist starts from rest.
They produce a sketch graph of the velocity v of the cyclist against time t.



(a) Explain the shape of this graph and include a consideration of force as part of your answer.
(3)

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(b) A student makes the following statement.

The work done by the cyclist is converted into the kinetic energy of the cyclist and bicycle.

Criticise this statement.
(3)

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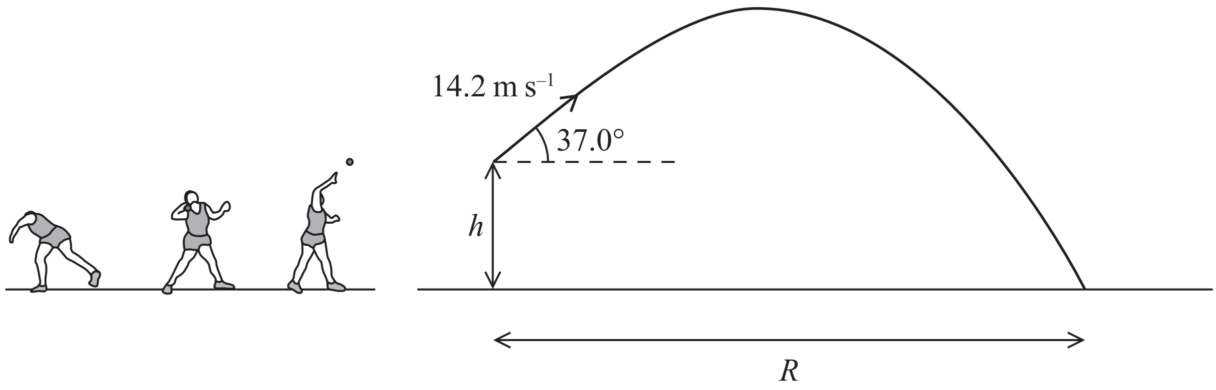
(Total for Question 11 = 6 marks)

12 The shot put is an Olympic field event. The distance for the women's world record shot put is in excess of twenty two metres.

The shot is a metal ball, which is thrown from a standing position so that it lands on the ground a horizontal distance R away from the thrower.



A shot is thrown from a height h above the ground with an initial velocity of 14.2 m s^{-1} at an angle of 37.0° to the horizontal. The time it takes for the shot to reach the ground is 1.98 s.

(a) Show that the vertical component of the initial velocity is about 8.6 m s^{-1}.

(2)

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(b) Calculate the height h above the ground from which the shot was thrown.

(3)

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h = ...

(c) Calculate the horizontal distance R for this throw.

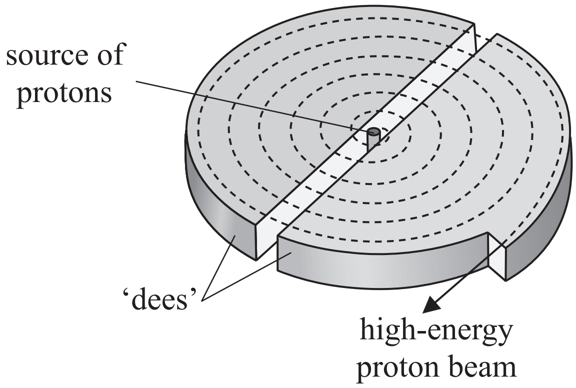
(3)

R = ...

(Total for Question 12 = 8 marks)

13 Proton beam therapy is being introduced in the UK as a new cancer treatment.

A beam of protons is accelerated by a cyclotron to an energy of 23 MeV and is then focused onto a tumour.

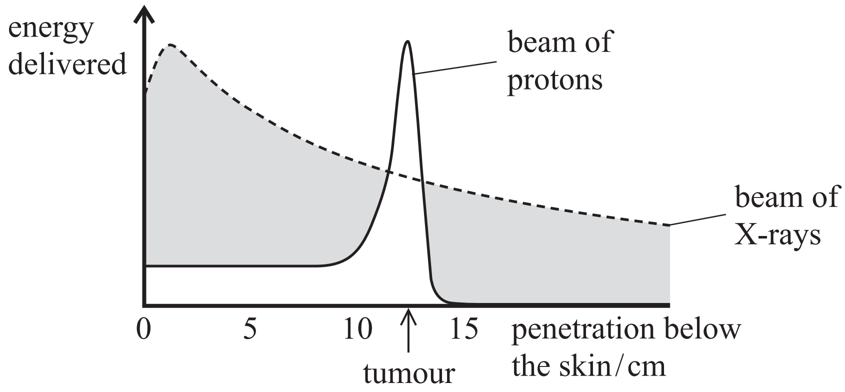


*(a) Explain how the cyclotron produces the high-energy proton beam.

(6)

(b) Conventional treatment may use X-rays to deliver energy to a tumour.

The graph shows the variation of energy delivered with penetration below the skin for a beam of protons and a beam of X-rays.



Deduce why the beam of protons could be a more effective treatment for tumours than a beam of X-rays.

(2)

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(c) Developing new cancer treatments is expensive.

Give two possible reasons why money should be provided for the development of this new cancer treatment.

(2)

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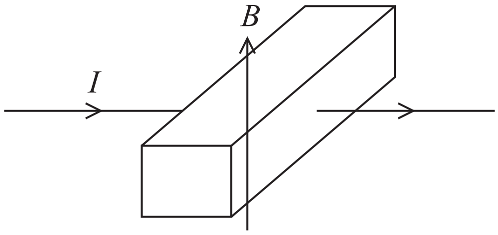
(Total for Question 13 = 10 marks)

14 Some liquids conduct electricity. This property can be used to pump these liquids through pipes.

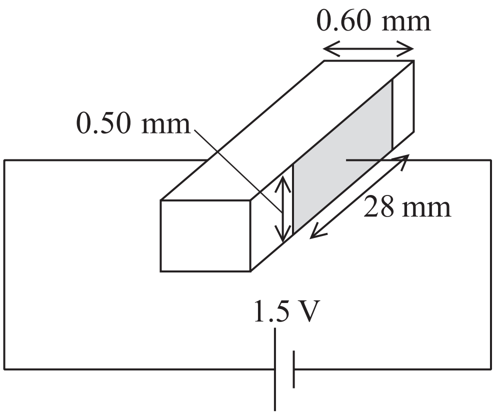
A short section of a rectangular pipe containing a liquid is shown in the diagram. The pipe is placed in a magnetic field of flux density B and a current I is passed through the liquid as shown.



(a) Add an arrow to the diagram above to show the direction in which the liquid will move.
(1)

(b) A practical demonstration of this principle used two rectangular electrodes, opposite each other on either side of the pipe, a distance of 0.60 mm apart. The dimensions of the electrodes are shown in the diagram.

The electrodes were connected to a 1.5 V cell. Salt water was pumped using a magnetic field of magnetic flux density 0.40 T.



(i) Show that the current through the salt water is about 20 mA.

resistivity of salt water = 1.6 Ω m
(4)

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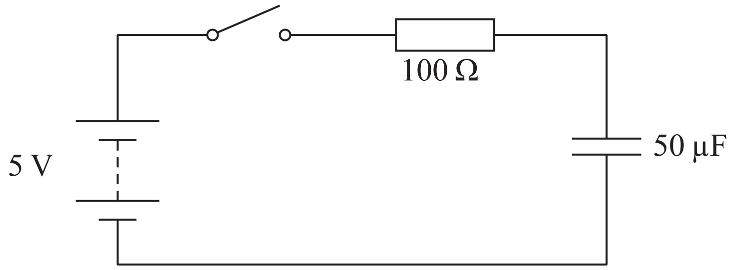
(ii) Hence calculate the force on the salt water.

(2)

Force = ...

(Total for Question 14 = 7 marks)

15 A circuit consists of a battery of e.m.f. 5 V and negligible internal resistance, a switch, a 100 Ω resistor and an uncharged 50 μF capacitor.



(a) Describe what happens to the potential difference across the resistor and the potential difference across the capacitor after the switch is closed.

(4)

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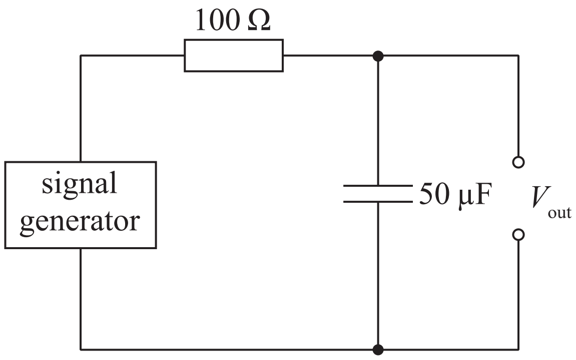
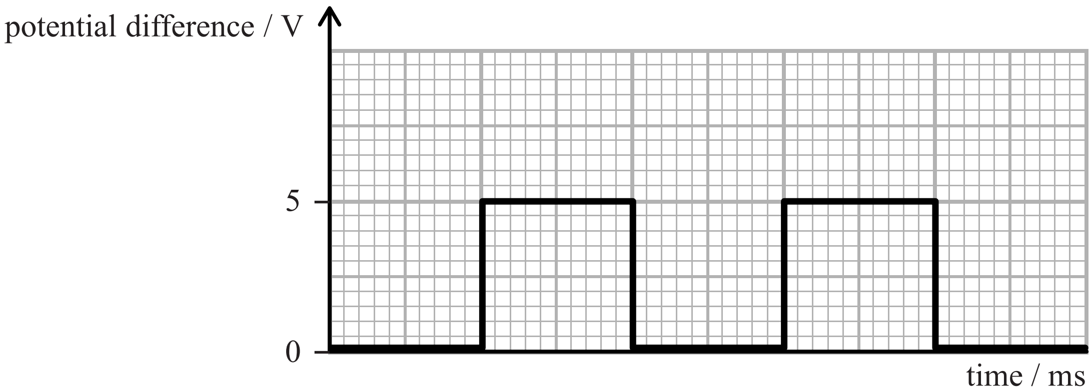
(b) The battery and switch are replaced by a signal generator providing a square wave output of peak potential difference 5 V. The signal generator has negligible internal resistance.



The graph shows the square wave output of the signal generator. The frequency of the square wave is 20 Hz.



On the graph add values to the time axis and sketch a graph of the potential difference, V_{out}, across the capacitor for two cycles of the square wave. Assume the capacitor is initially uncharged.

(5)

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(Total for Question 15 = 9 marks)

16 The neutral lambda Λ^0 particle is a baryon of mass 1116 MeV/c^2 and contains one strange quark.

(a) The table shows quarks and their relative charge.

Quark	Charge / *e*
u	+2/3
d	–1/3
s	–1/3

State, with justification, the quark content of a Λ^0 particle.

(2)

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(b) Calculate the mass of the Λ^0 particle in kg.

(3)

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Mass of Λ^0 particle = ... kg

(c) A student suggests five ways a Λ^0 particle might decay. These are

$$\Lambda^0 \rightarrow p + \pi^-$$
$$\Lambda^0 \rightarrow e^+ + e^-$$
$$\Lambda^0 \rightarrow n + \pi^0$$
$$\Lambda^0 \rightarrow n$$
$$\Lambda^0 \rightarrow p + \pi^0$$

Deduce which of these decay processes are **not** possible.

(6)

(d) Lambda particles were first detected in experiments which made use of cosmic rays entering the atmosphere. Cosmic rays are mainly high-energy protons which have a mass less than that of a lambda particle.

Explain why a cosmic ray could lead to the creation of a lambda particle.

(2)

(e) The Λ^0 particle cannot be directly observed in particle experiments, however some of the decay products can.

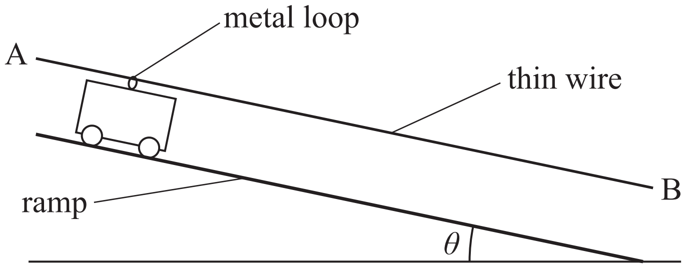
Explain why the Λ^0 particle cannot be directly observed but information about it can be obtained by studying its decay particles.

(3)

(Total for Question 16 = 16 marks)

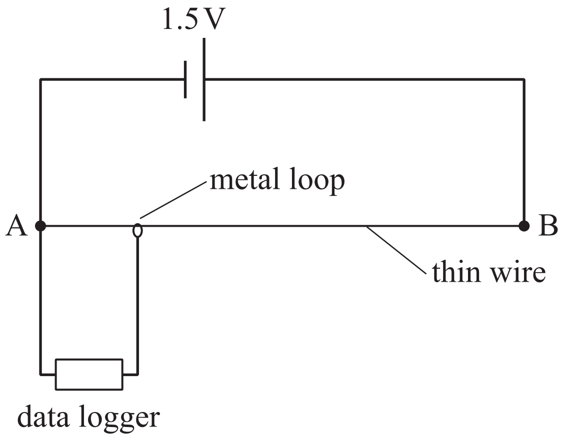
17 A student investigates the motion of a friction-free trolley down a ramp. On the top of the trolley there is a metal loop which makes contact with a length of thin resistance wire, AB, fixed above the ramp. The resistance wire has a uniform diameter.

The trolley accelerates down the ramp and the metal loop stays in contact with the wire along the full length of the ramp.



The student uses a protractor to measure the angle θ between the ramp and the horizontal and records a value of 4° with an uncertainty of ±1°.

(a) The two ends of the wire are connected to a 1.5 V cell. A data logger, set to measure potential difference, is connected to the metal loop and to the negative terminal of the cell.



Explain how the potential difference recorded by the data logger will vary as the loop moves along the length of the wire AB.

(3)

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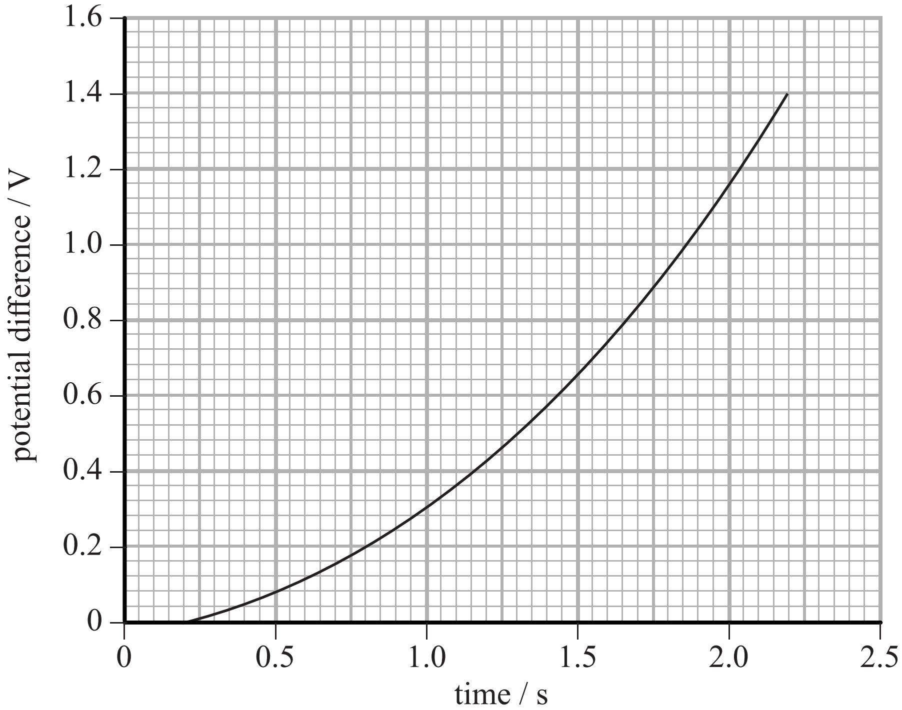
(b) The graph shows the data obtained from the data logger.



Determine the velocity of the trolley at 1.5 s.

1.5 V represents a distance of 2.00 m.

(4)

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Velocity = ...

(c) The student calculated the velocity of the trolley at 2.0 s to be 1.5 m s^{-1}.

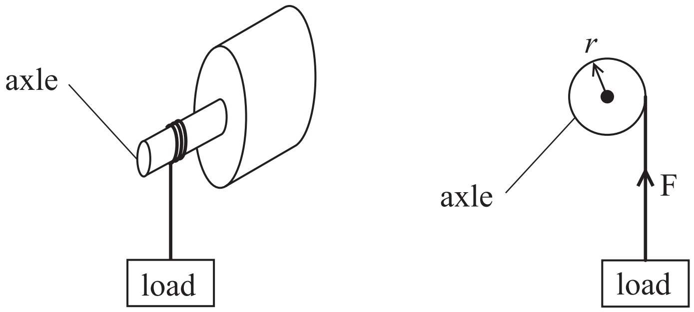
By considering the acceleration of the trolley, determine whether the student's measurement of θ was within the uncertainty quoted.

(4)

(Total for Question 17 = 11 marks)

18 Motors usually have a rotating component which can do work W.

(a) A motor lifts a load in a time t. The axle of the motor has a radius r and exerts a force F.



The power produced by a motor can be calculated by using the following word equation.

Power = moment of the force exerted by the rotating axle × angular velocity

Derive this equation, starting with power $P = \frac{W}{t}$.

(4)

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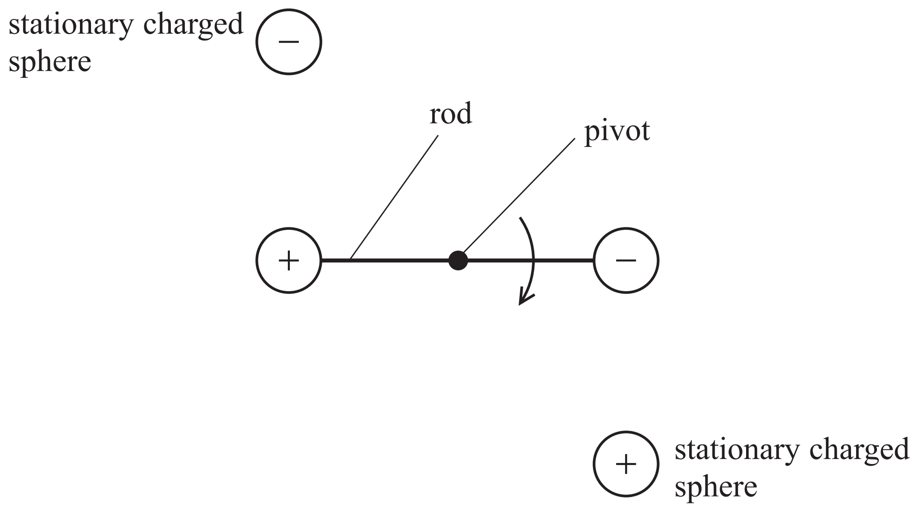
(b) An electrostatic motor was first demonstrated by Benjamin Franklin in 1750.

The diagram shows a simplified version of part of this motor.

This consists of a rod, with an oppositely charged sphere at either end, which rotates around a fixed pivot. Two stationary charged spheres apply a force on the spheres at either end of the rod.

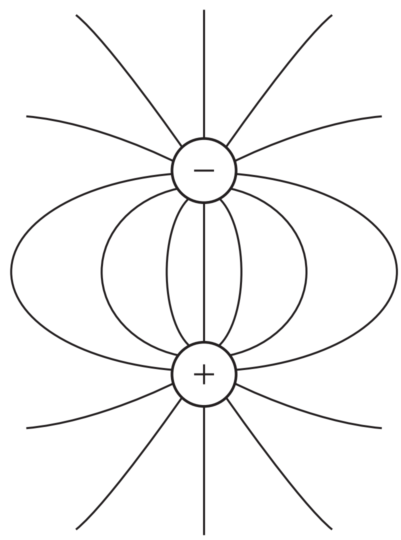


(i) In the diagram below, electric field lines have been drawn around one pair of these spheres.

Add to the diagram to show

- the directions of the field lines
- the lines of equipotential.

(3)



(ii) The distance between the centres of each charged sphere in this pair is 5.0 cm.

Show that the force between this pair of charged spheres is about 0.04 N.

charge on each sphere = 0.10 μC

(2)

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(c) The table shows the typical power and the corresponding angular velocity required for three different appliances.

	Power / W	Angular velocity / rad s^{-1}
Electric car	2.0×10^4	300
Vacuum cleaner	1.4×10^3	1000
Small pond pump	0.5	200

Deduce which of these appliances, in principle, could use the electrostatic motor in (b).

You should use the word equation in (a) and assume that the length of the rod in the electrostatic motor is 8.0 cm.

Assume that the electrostatic motor would deliver a constant force throughout one complete rotation.

(4)

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(Total for Question 18 = 13 marks)

TOTAL FOR PAPER = 90 MARKS

List of data, formulae and relationships

Acceleration of free fall	$g = 9.81\ \text{m s}^{-2}$	(close to Earth's surface)
Boltzmann constant	$k = 1.38 \times 10^{-23}\ \text{J K}^{-1}$	
Coulomb law constant	$k = \dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\ \text{N m}^2\ \text{C}^{-2}$	
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 constant	$G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$	
Gravitational field strength	$g = 9.81\ \text{N kg}^{-1}$	(close to Earth's surface)
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{F m}^{-1}$	
Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$	
Proton mass	$m_p = 1.67 \times 10^{-27}\ \text{kg}$	
Speed of light in a vacuum	$c = 3.00 \times 10^{8}\ \text{m s}^{-1}$	
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$	
Unified atomic mass unit	$u = 1.66 \times 10^{-27}\ \text{kg}$	

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

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

$$I = nqvA$$

Materials

Density

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

Stokes' law

$$F = 6\pi\eta rv$$

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

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

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

$$hf = \phi + \frac{1}{2}mv^2_{\text{max}}$$

de Broglie wavelength

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

Further mechanics

Impulse

$$F\Delta t = \Delta p$$

Kinetic energy of a non-relativistic particle

$$E_\text{k} = \frac{p^2}{2m}$$

Motion in a circle

$$v = \omega r$$

$$T = \frac{2\pi}{\omega}$$

$$F = ma = \frac{mv^2}{r}$$

$$a = \frac{v^2}{r}$$

$$a = r\omega^2$$

Centripetal force

$$F = \frac{mv^2}{r}$$

$$F = mr\omega^2$$

Fields

Coulomb's law

$$F = k\frac{Q_1Q_2}{r^2}$$

$$\text{where } k = \frac{1}{4\pi\varepsilon_0}$$

Electric field strength

$$E = \frac{F}{Q}$$

$$E = k\frac{Q}{r^2}$$

$$E = \frac{V}{d}$$

Electric potential

$$V = k\frac{Q}{r}$$

Capacitance

$$C = \frac{Q}{V}$$

Energy stored in a capacitor

$$W = \frac{1}{2}QV$$

Capacitor discharge

$$Q = Q_0 \text{e}^{-t/RC}$$

Resistor – capacitor discharge

$$I = I_0 \text{e}^{-t/RC}$$

$$V = V_0 \text{e}^{-t/RC}$$

In a magnetic field

$$F = BIl \sin \theta$$

$$F = Bqv \sin \theta$$

Faraday's and Lenz's laws

$$\varepsilon = \frac{-\text{d}(N\phi)}{\text{d}t}$$

Root-mean-square values

$$V_\text{rms} = \frac{V_0}{\sqrt{2}}$$

$$I_\text{rms} = \frac{I_0}{\sqrt{2}}$$

Nuclear and particle physics

In a magnetic field

$$r = \frac{p}{BQ}$$

Thermodynamics

Heating

$$\Delta E = mc\Delta\theta$$

$$\Delta E = L\Delta m$$

Molecular kinetic theory

$$\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$$

$$pV = \frac{1}{3}Nm\langle c^2\rangle$$

Ideal gas equation

$$pV = NkT$$

Stefan-Boltzmann law

$$L = \sigma AT^4$$

$$L = \sigma 4\pi r^2T^4$$

Wien's law

$$\lambda_{max}T = 2.898 \times 10^{-3}\ \mathrm{m\ K}$$

Space

Intensity

$$I = \frac{L}{4\pi d^2}$$

Redshift of electromagnetic radiation

$$z = \frac{\Delta\lambda}{\lambda} \approx \frac{\Delta f}{f} \approx \frac{v}{c}$$

Cosmological expansion

$$v = H_0 d$$

Nuclear radiation

Mass-energy

$$\Delta E = c^2\Delta m$$

Radioactive decay

$$A = \lambda N$$

$$\frac{dN}{dt} = -\lambda N$$

$$\lambda = \frac{\ln 2}{t_{½}}$$

$$N = N_0\, e^{-\lambda t}$$

$$A = A_0\, e^{-\lambda t}$$

Gravitational fields

Gravitational force

$$F = \frac{Gm_1m_2}{r^2}$$

Gravitational field strength

$$g = \frac{Gm}{r^2}$$

Gravitational potential

$$V_{grav} = \frac{-Gm}{r}$$

Oscillations

Simple harmonic motion

$$F = -kx$$

$$a = -\omega^2 x$$

$$x = A\cos\omega t$$

$$v = -A\omega\sin\omega t$$

$$a = -A\omega^2\cos\omega t$$

$$T = \frac{1}{f} = \frac{2\pi}{\omega}$$

$$\omega = 2\pi f$$

Simple harmonic oscillator

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$T = 2\pi\sqrt{\frac{l}{g}}$$

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