Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | | | | | |

Candidate Number | | | | |

Pearson Edexcel International Advanced Level

Thursday 29 May 2025

Afternoon (Time: 1 hour 45 minutes)

Paper reference **WPH14/01**

Physics

International Advanced Level
UNIT 4: Further Mechanics, Fields and Particles

You must have:
Scientific calculator, ruler

Total Marks

Instructions:

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*
- **Show all your working out** in calculations and **include units** where appropriate.

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.*
- In the question marked with an **asterisk (*)**, marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.
- The list of data, formulae and relationships is printed at the end of this booklet.

Advice:

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P 7 8 7 5 6 A 0 1 3 6

Pearson

SECTION A

Answer ALL questions.

For questions 1–10, in Section A, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

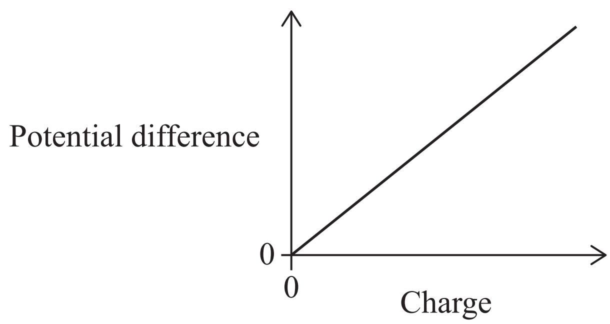
1: An isotope of astatine has the symbol $^{213}_{85}\text{At}$.

Which row of the table shows the number of protons and the number of neutrons in a nucleus of this isotope?

	Protons	Neutrons
☒ **A**	213	85
☒ **B**	85	128
☒ **C**	213	128
☒ **D**	85	213

(Total for Question 1 = 1 mark)

2: A capacitor is charging. A graph of potential difference against charge is shown.



Which of the following gives the capacitance of the capacitor?

☒ **A** The area between the line and the potential difference axis

☒ **B** The area between the line and the charge axis

☒ **C** The gradient of the line

☒ **D** The inverse of the gradient of the line

(Total for Question 2 = 1 mark)

3: A proton is in a vacuum. At a distance r from the proton, the electric field strength due to the proton is $0.77\,\mathrm{N\,C^{-1}}$.

Which of the following gives the distance r, in m?

☒ **A** $\sqrt{\dfrac{1.6\times10^{-19}}{4\pi\times8.85\times10^{-12}\times0.77}}$

☒ **B** $\sqrt{\dfrac{(1.6\times10^{-19})^2}{4\pi\times8.85\times10^{-12}\times0.77}}$

☒ **C** $\dfrac{1.6\times10^{-19}}{4\pi\times8.85\times10^{-12}\times0.77}$

☒ **D** $\dfrac{(1.6\times10^{-19})^2}{4\pi\times8.85\times10^{-12}\times0.77}$

(Total for Question 3 = 1 mark)

4: In the upper atmosphere, high-energy cosmic rays collide with molecules of air to produce muons. The average speed of these muons is v.

The average lifetime of these muons is greater than the average lifetime of stationary muons.

Which of the following gives the reason for this increase in average lifetime?

☒ **A** $v > c$

☒ **B** $v = c$

☒ **C** $v \approx c$

☒ **D** $v \ll c$

(Total for Question 4 = 1 mark)

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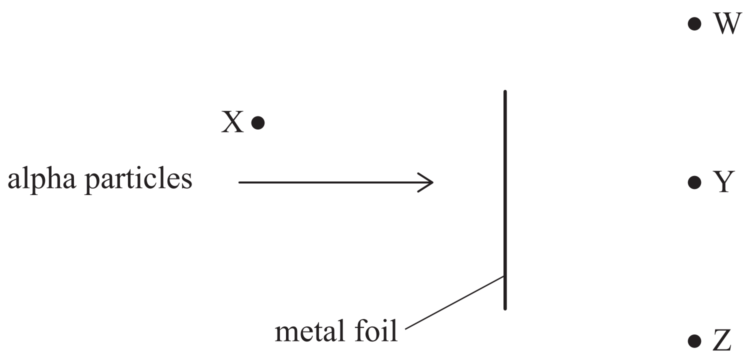
5: In large-angle alpha scattering experiments, alpha particles were directed at a thin metal foil. The alpha particles were then detected at four positions, W, X, Y and Z, as shown.



Where were most of the alpha particles detected?

- ☒ **A** position W
- ☒ **B** position X
- ☒ **C** position Y
- ☒ **D** position Z

(Total for Question 5 = 1 mark)

6: In an electron gun, a current heats a metal filament to release electrons.

Which of the following is the name of this process?

- ☒ **A** beta decay
- ☒ **B** ionisation
- ☒ **C** photoelectric effect
- ☒ **D** thermionic emission

(Total for Question 6 = 1 mark)

7: An electron and a positron collide and annihilate, producing two photons.

Which of the following is the energy, in joules, of one of these photons?

- ☒ **A** $9.11 \times 10^{-31} \times (3 \times 10^{8})^{2}$
- ☒ **B** $9.11 \times 10^{-31} \times 3 \times 10^{8}$
- ☒ **C** $2 \times 9.11 \times 10^{-31} \times (3 \times 10^{8})^{2}$
- ☒ **D** $2 \times 9.11 \times 10^{-31} \times 3 \times 10^{8}$

(Total for Question 7 = 1 mark)

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8: In high-energy collisions, electrons are used to investigate the structure of nucleons.

Which of the following is the reason why the electrons need a very high energy?

- ☒ **A** So that new particles are created.
- ☒ **B** So that collisions between electrons and nucleons are elastic.
- ☒ **C** So that the electrons have a large wavelength.
- ☒ **D** So that a quark is knocked out of the nucleon.

(Total for Question 8 = 1 mark)

9: In a nuclear fission reaction, a nucleus splits into a nucleus S, a nucleus T and several neutrons.

S and T have the same kinetic energy. T has twice the mass of S.

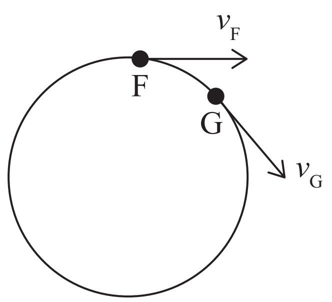
Which of the following is the ratio $\frac{\text{momentum of T}}{\text{momentum of S}}$?

- ☒ **A** $\frac{1}{2}$
- ☒ **B** $\frac{1}{\sqrt{2}}$
- ☒ **C** $\sqrt{2}$
- ☒ **D** 2

(Total for Question 9 = 1 mark)

10: A model aeroplane is moving at a constant speed, in a horizontal circle.

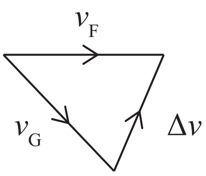
F and G are two positions of the model aeroplane. The velocity at F is v_F and the velocity at G is v_G, as shown.



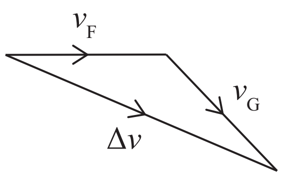
As the model aeroplane moves from F to G, the change in velocity is Δv.

Which of the following is a correct vector diagram for this situation?

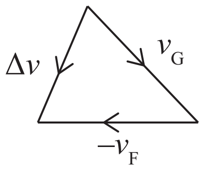
☒ **A**



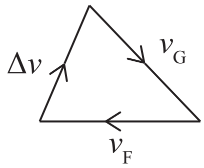
☒ **B**



☒ **C**



☒ **D**



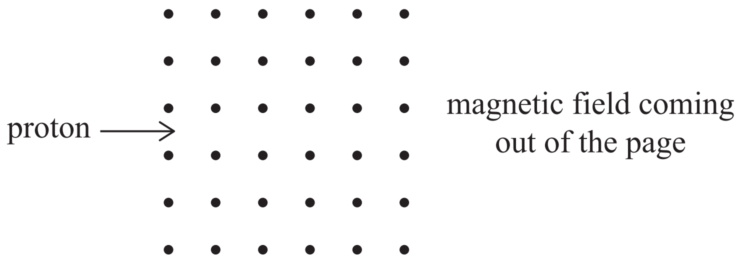
(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11: A proton enters a magnetic field, as shown.



(a) The proton experiences a force of 6.5×10^{-13} N due to the magnetic field.

Calculate the speed of the proton.

magnetic flux density = 0.52 T

(2)

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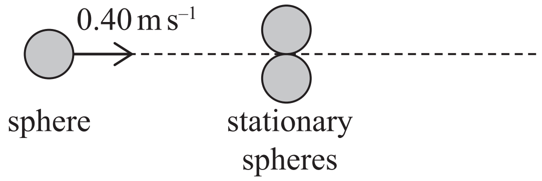
Speed = ...

(b) Draw, on the diagram above, the path of the proton in the magnetic field.

(2)

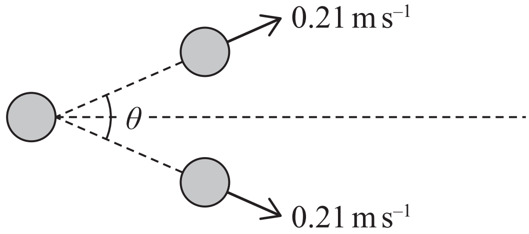
(Total for Question 11 = 4 marks)

12: A student investigated collisions, using three spheres. The student rolled a sphere of mass 35 g into two stationary spheres, each of mass 37 g, as shown.



During the collision, the rolling sphere was brought to rest and the two stationary spheres began to move apart at an angle θ, as shown below.

Not to scale



Determine the angle θ.

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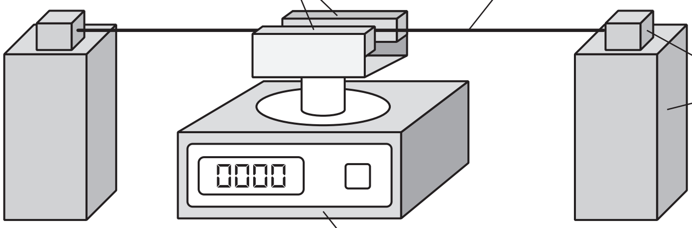
θ = ...

(Total for Question 12 = 3 marks)

13: A student placed two magnets on a top pan balance. The student clamped a metal wire horizontally in the uniform magnetic field between the magnets, as shown.



The student connected the ends of the metal wire to a battery, an ammeter and a switch.

When the switch was closed, the reading on the ammeter was 3.1 A. The reading on the balance increased by 0.45 g.

The length of the metal wire in the magnetic field was 40 mm.

Calculate the magnetic flux density in the region between the magnets.

Magnetic flux density = ...

(Total for Question 13 = 3 marks)

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14: The omega minus baryon (Ω^-) was discovered in 1964 when a negative kaon meson (K^-) was observed to collide with a stationary proton.

The Ω^- was produced in the following reaction.

$$K^- + p \rightarrow \Omega^- + K^+ + K^0$$

(a) (i) State the quark structure of a meson.

(1)

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(ii) Explain how the law of conservation of baryon number and the law of conservation of charge are obeyed in this reaction.

(2)

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(b) Before its discovery, the mass of the Ω^- was predicted to be 2.9714×10^{-27} kg.

The most recent accepted value for the mass of the Ω^- is $1672\,\text{MeV/c}^2$.

Calculate the percentage difference between these two masses.

(3)

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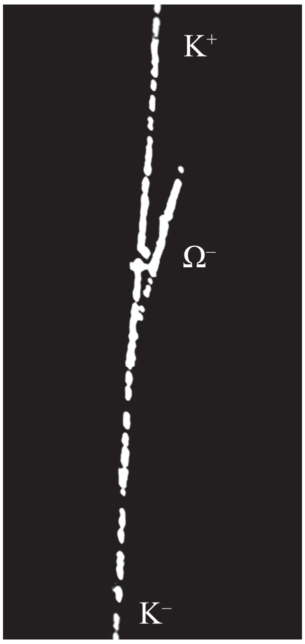
Percentage difference = ...

(c) The photograph shows tracks produced by particles in a particle detector when a K^- collided with a stationary proton. The tracks produced by the K^+ and Ω^- are labelled.



(Source: © Science History Images / Alamy Stock Photo)

Explain how evidence from the photograph shows that a K^0 was also formed.

(3)

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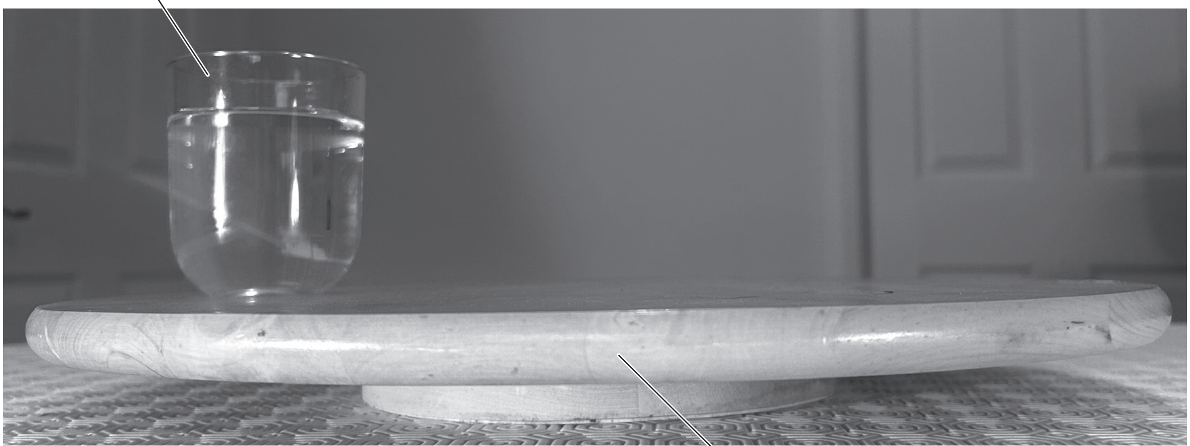
(Total for Question 14 = 9 marks)

15: A turntable is a circular board that rotates around a vertical axis. Dining turntables can be used on large tables, as shown.

The turntable is used to move the glass of water to different positions.
The photograph below shows the side view of the glass of water on the turntable.



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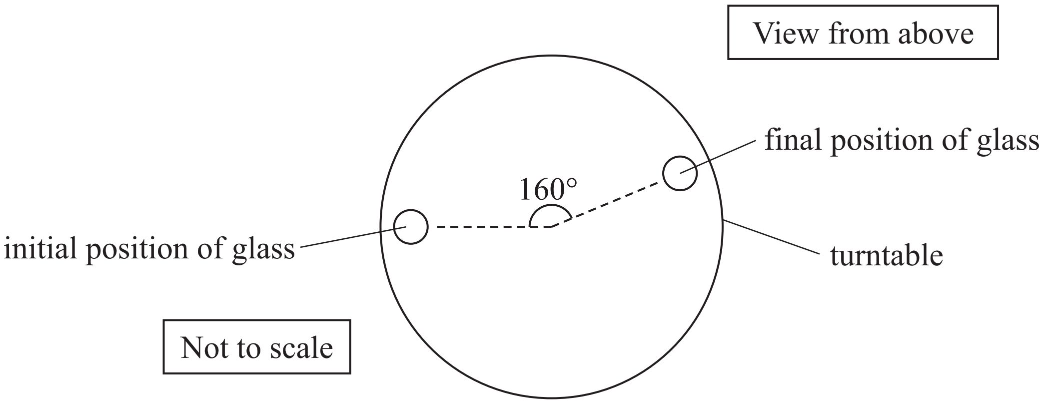
(a) The turntable is rotated through 160°, as shown.



(i) The time taken for the turntable to be rotated through 160° is 2.2 s.

Show that the average angular velocity of the glass is about 1.3 rad s^{-1}.

(3)

(ii) The glass can be placed at different positions on the turntable.

Explain why the angular velocity of the glass is the same but its velocity varies, depending on the position of the glass on the turntable.

(2)

(b) (i) The maximum frictional force between the glass of water and the turntable is equal to $\frac{mg}{30}$, where m is the mass of the glass of water.

Someone says that if they place the glass less than 5 cm from the edge of the turntable then the glass will slide when the turntable rotates.

Deduce whether they are correct.

angular velocity = 1.3 rad s^{-1}
diameter of turntable = 50.0 cm

(4)

(ii) Two identical glasses are placed at the same distance from the edge of the turntable. One of the glasses is filled with water and the other is empty.

Explain whether either of these glasses would be more likely to slide as the turntable is rotated.

(2)

(Total for Question 15 = 11 marks)

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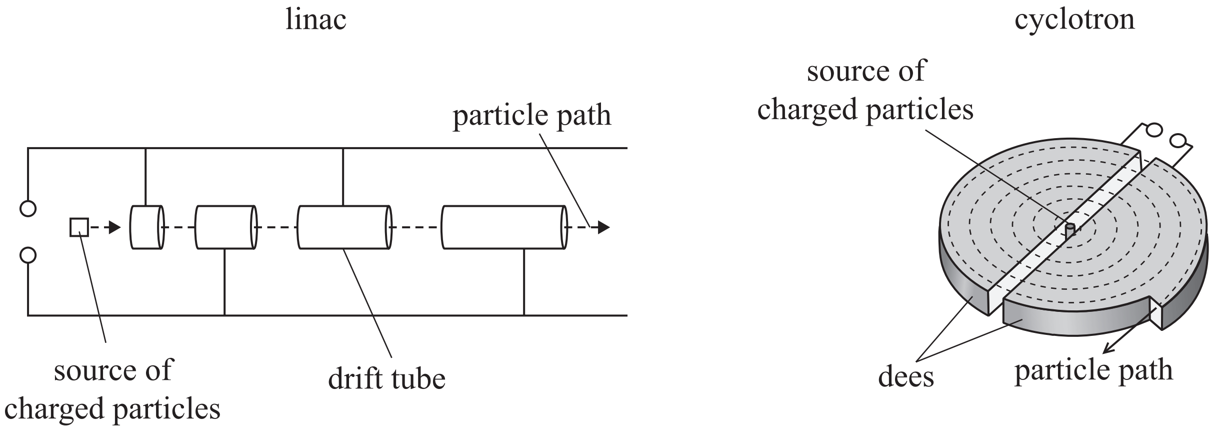
16: The simplified diagrams show a linac and a cyclotron. Both machines are used to accelerate charged particles.



*(a) Explain how these machines use a potential difference to accelerate charged particles.

(6)

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(b) A scientist plans to use each type of particle accelerator to accelerate protons from rest.

(i) In the linac, a potential difference of 0.40 MV is applied to the tubes. The protons pass through 4 gaps.

Show that the speed of the protons is about $2 \times 10^7\,\mathrm{m\,s^{-1}}$ as they leave the 4th gap.

(4)

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(ii) In the cyclotron, the protons leave the dees when the radius of their path is 29 cm.

Deduce whether the speed of the protons as they leave the cyclotron is the same as the speed of the protons as they leave the 4th gap in the linac.

magnetic flux density = 0.55 T

(3)

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(Total for Question 16 = 13 marks)

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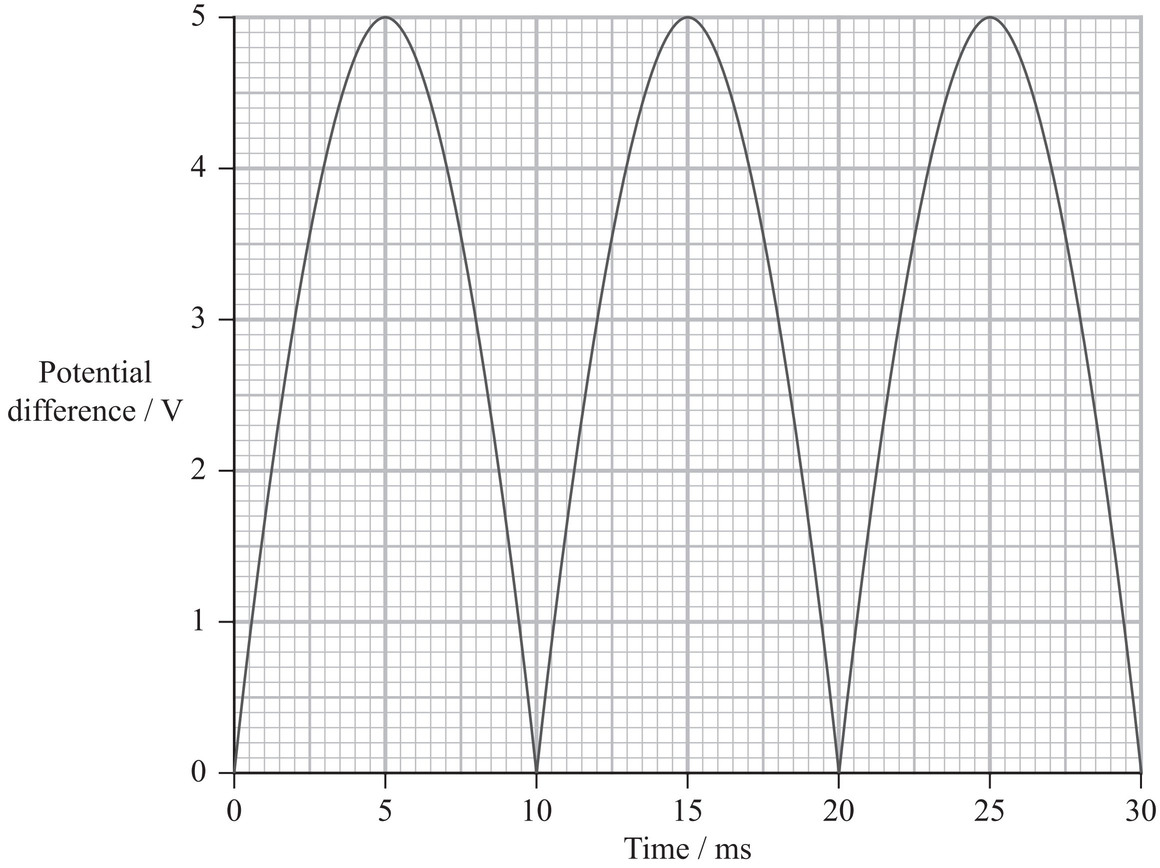
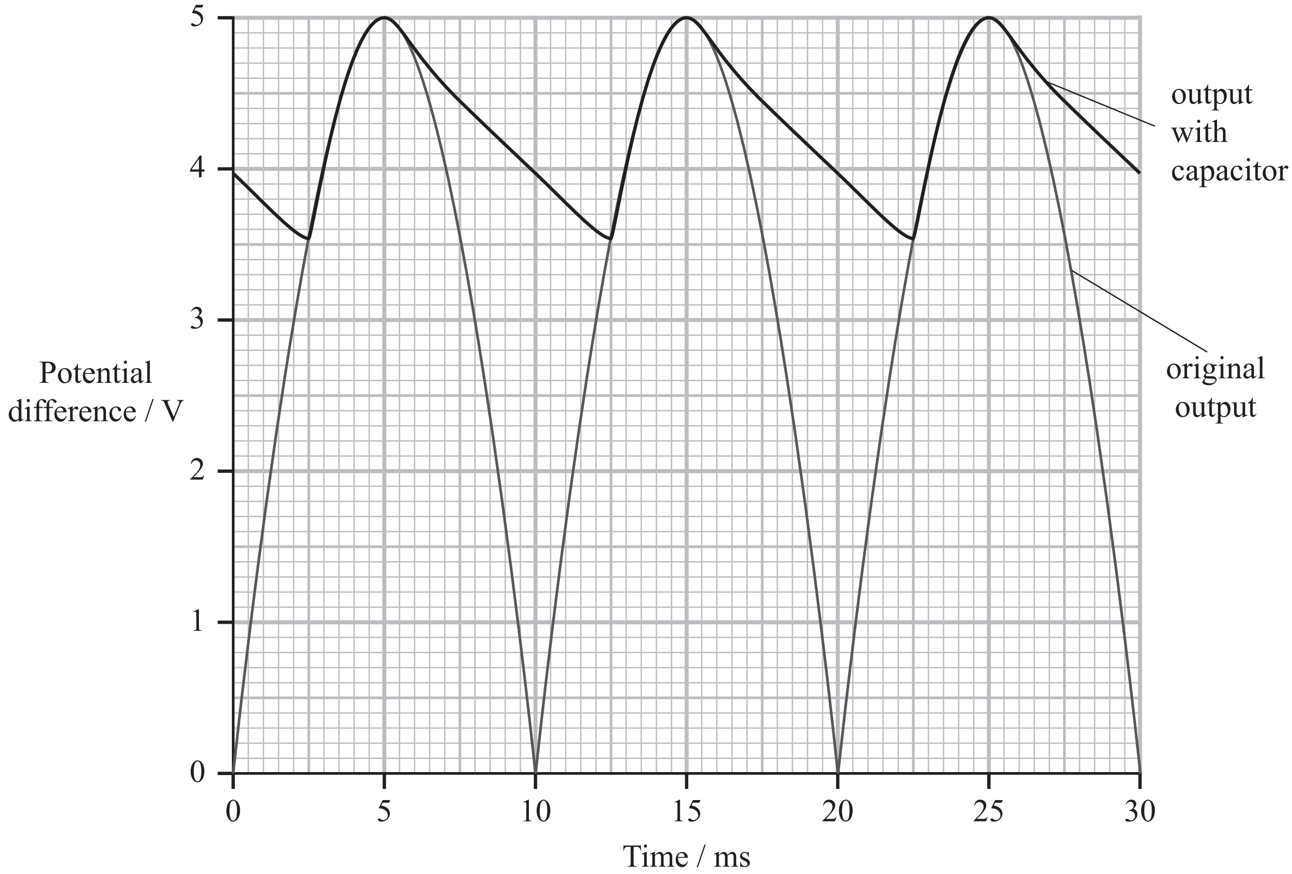
17: The output of a power supply varies, as shown.



A capacitor can be connected to the power supply to modify this output.

As the output increases, the capacitor charges. The capacitor modifies the output and produces the variation shown by the bold line on the graph below.



(a) State the potential difference across the capacitor at the end of a period of discharge.

(1)

Potential difference = ...

(b) The capacitor discharges through a resistor labelled with a value of $6.8\,k\Omega$ and a tolerance of $\pm$ 5%.

The capacitor has a capacitance of $3.3\,\mu F$.

(i) Deduce whether the output with the capacitor shown on the graph is consistent with a resistor tolerance of $\pm$ 5%.

(5)

(ii) Calculate the change in the energy stored in the capacitor during the discharging process.

(3)

Change in the energy stored = ...

(iii) The resistor is replaced by a bulb with a much lower resistance than 6.8 kΩ.

Explain why the output is now very similar to the original output of the power supply.

(3)

(Total for Question 17 = 12 marks)

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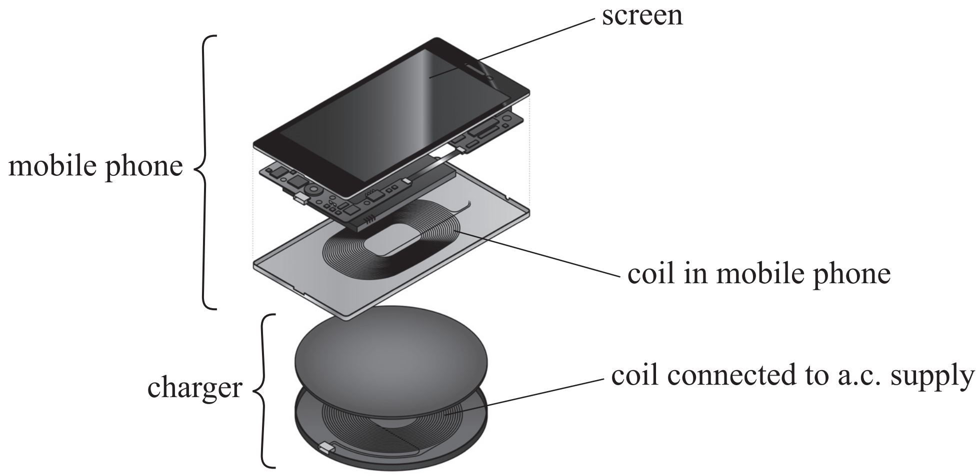
18: Some mobile phones can be charged using a 'wireless' charger. To charge the mobile phone, the charger is connected to a power supply. The mobile phone is placed near to the charger, as shown.

(Source: © Lee Charlie/Shutterstock)

There is an alternating current (a.c.) in a coil in the charger. There is a second coil of wire in the mobile phone. A diagram of the charger and mobile phone is shown below.



(Source: © Zern Liew/Shutterstock)

(a) Explain how the mobile phone charges when placed near to the charger.

(4)

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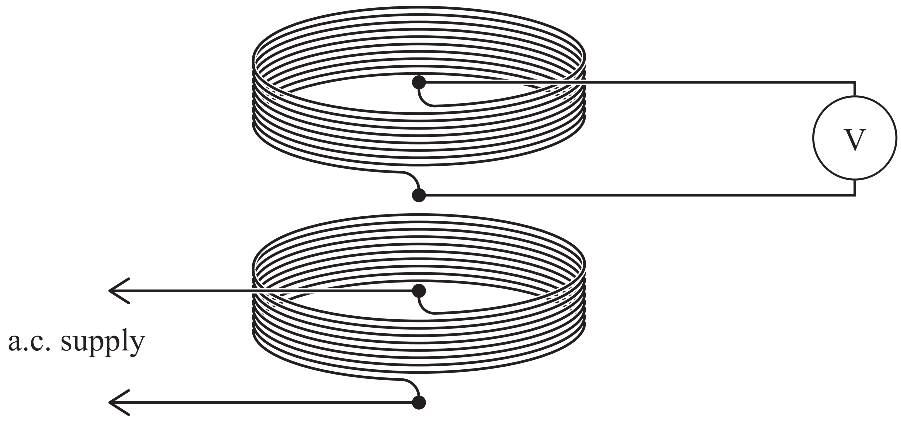
(b) A teacher demonstrated a simplified version of the charger to her class. She used two identical coils. She attached one coil to an a.c. supply and the other coil to a digital voltmeter.



The magnetic flux density produced by the coil connected to the a.c. supply has a maximum value of 18 mT.

(i) Calculate the maximum magnetic flux linkage for the coil connected to the a.c. supply.

diameter of coils = 4.0 cm
number of turns in each coil = 50

(4)

Maximum magnetic flux linkage = ...

(ii) The maximum potential difference across the coil connected to the digital voltmeter is less than the maximum potential difference of the a.c. supply.

Suggest why.

(1)

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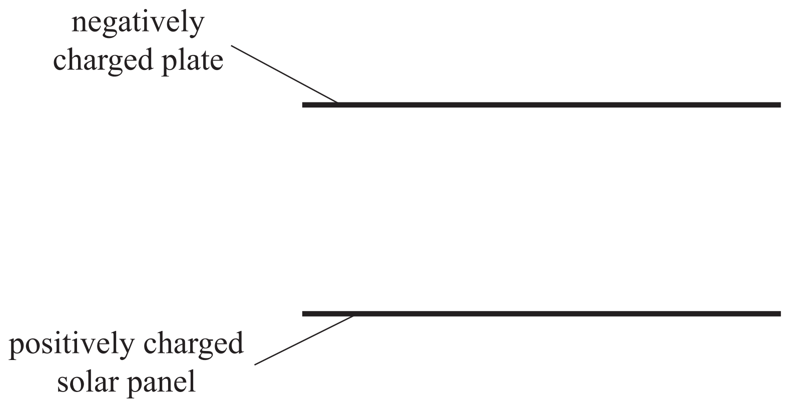
(Total for Question 18 = 9 marks)

19: In desert areas of California, solar panels use sunlight to generate electrical power. If sand collects on the solar panels, their efficiency is reduced.

To remove sand, a positive electric charge is given to the sand particles and a negatively charged plate is moved across the panel.

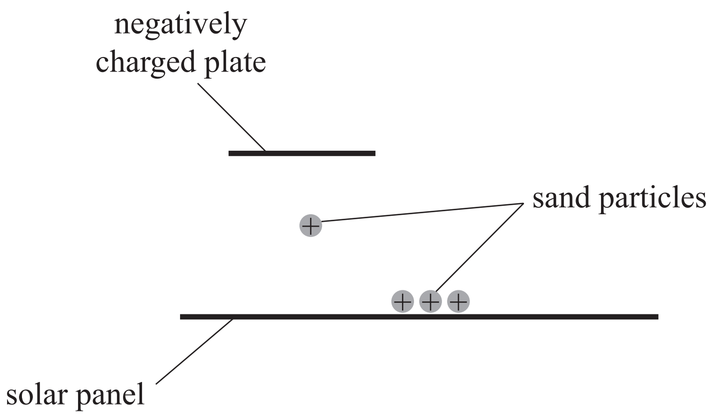
(a) The diagram shows a negatively charged plate above a positively charged solar panel.



Add to the diagram to show the electric field lines between the plate and the solar panel.

(2)

(b) A positive electric charge is given to the sand particles when the solar panel is charged.
When the negatively charged plate is moved across the solar panel, the sand particles move off the panel, as shown below.



(i) Explain why a sand particle moves as shown.

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(ii) Show that the electric field strength between the negatively charged plate and the solar panel is about $8.1 \times 10^5\,\mathrm{V\,m^{-1}}$.

distance between plate and solar panel = 1.50 cm
potential difference between plate and solar panel = 12.2 kV

(2)

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(iii) The maximum positive charge that can be given to the sand particles when the solar panel is charged is $4.0 \times 10^{-12}\,\mathrm{C}$.

The table below shows the diameters of some sand particles.

Diameter of sand particle / μm	310	590	720	970

Only some of these particles could be lifted from the solar panel when using an electric field strength of $8.1 \times 10^5\,\mathrm{V\,m^{-1}}$.

Deduce the largest diameter of sand particles given in this table that could be lifted from the solar panel.

density of sand = $2600\,\mathrm{kg\,m^{-3}}$

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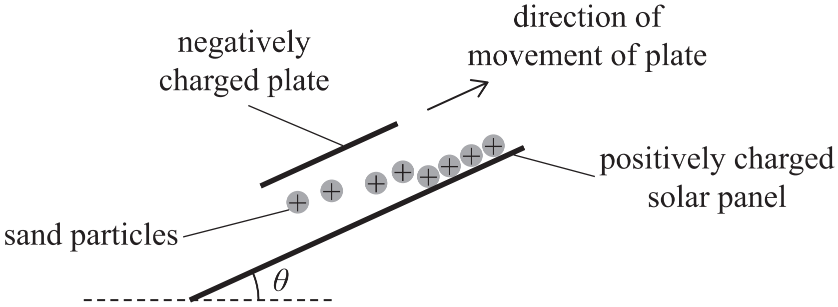
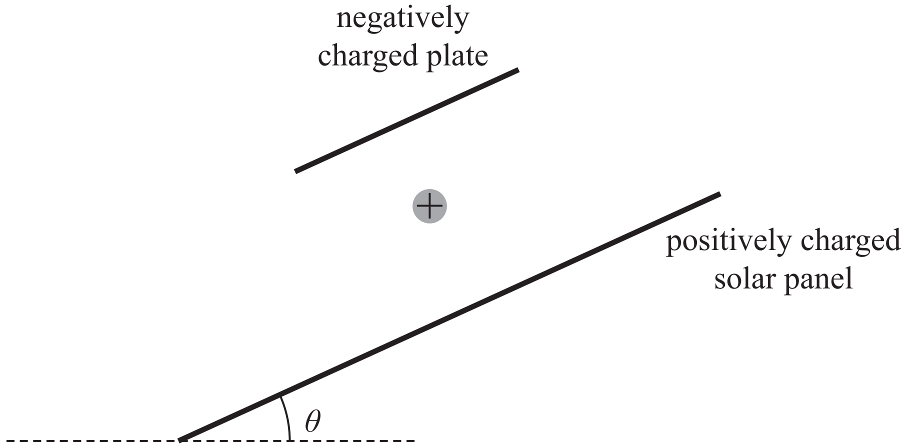
(c) The solar panels are usually inclined at an angle θ to the horizontal. The plate moves parallel to the solar panel, as shown.



(i) Add to the diagram below to show the forces acting on a charged sand particle.

(2)



(ii) Explain how inclining the solar panel at an angle θ would improve the removal of sand particles from the solar panel.

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(Total for Question 19 = 16 marks)

TOTAL FOR SECTION B = 80 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's law constant	$k = 1/4\pi\varepsilon_0$	
	$= 8.99 \times 10^{9}\ \text{N m}^2\ \text{C}^{-2}$	
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	$u = 1.66 \times 10^{-27}\ \text{kg}$	

Unit 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

$$\Sigma F = ma$$

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

$$W = mg$$

Momentum

$$p = mv$$

Moment of force

$$\text{moment} = Fx$$

Work and energy

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

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

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

Power

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

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

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Efficiency

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

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

Materials

Density $\rho = \dfrac{m}{V}$

Stokes' law $F = 6\pi\eta rv$

Hooke's law $\Delta F = k\Delta x$

Elastic strain energy $\Delta E_{\text{el}} = \dfrac{1}{2}F\Delta x$

Young modulus $E = \dfrac{\sigma}{\varepsilon}$ where

Stress $\sigma = \dfrac{F}{A}$

Strain $\varepsilon = \dfrac{\Delta x}{x}$

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Unit 2

Waves

Wave speed	$v = f\lambda$
Speed of a transverse wave on a string	$v = \sqrt{\dfrac{T}{\mu}}$
Intensity of radiation	$I = \dfrac{P}{A}$
Refractive index	$n_1 \sin\theta_1 = n_2 \sin\theta_2$
	$n = \dfrac{c}{v}$
Critical angle	$\sin C = \dfrac{1}{n}$
Diffraction grating	$n\lambda = d\sin\theta$

Electricity

Potential difference	$V = \dfrac{W}{Q}$
Resistance	$R = \dfrac{V}{I}$
Electrical power, energy	$P = VI$
	$P = I^2R$
	$P = \dfrac{V^2}{R}$
	$W = VIt$
Resistivity	$R = \dfrac{\rho l}{A}$
Current	$I = \dfrac{\Delta Q}{\Delta t}$
	$I = nqvA$
Resistors in series	$R = R_1 + R_2 + R_3$
Resistors in parallel	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

Particle nature of light

Photon model	$E = hf$
Einstein's photoelectric equation	$hf = \phi + \frac{1}{2}mv^2_{max}$
de Broglie wavelength	$\lambda = \dfrac{h}{p}$

Unit 4

Further mechanics

Impulse	$F\Delta t = \Delta p$
Kinetic energy of a non-relativistic particle	$E_k = \dfrac{p^2}{2m}$
Motion in a circle	$v = \omega r$
	$T = \dfrac{2\pi}{\omega}$
	$a = \dfrac{v^2}{r}$
	$a = r\omega^2$
Centripetal force	$F = ma = \dfrac{mv^2}{r}$
	$F = mr\omega^2$

Electric and magnetic fields

Electric field	$E = \dfrac{F}{Q}$
Coulomb's law	$F = \dfrac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$
	$E = \dfrac{Q}{4\pi\varepsilon_0 r^2}$
	$E = \dfrac{V}{d}$
Electrical potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
Capacitance	$C = \dfrac{Q}{V}$
Energy stored in capacitor	$W = \dfrac{1}{2}QV$
	$W = \dfrac{1}{2}CV^2$
	$W = \dfrac{1}{2}\dfrac{Q^2}{C}$
Capacitor discharge	$Q = Q_0 e^{-t/RC}$

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Resistor-capacitor discharge $I = I_0 e^{-t/RC}$

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

$\ln Q = \ln Q_0 - \frac{t}{RC}$

$\ln I = \ln I_0 - \frac{t}{RC}$

$\ln V = \ln V_0 - \frac{t}{RC}$

In a magnetic field $F = Bqv \sin \theta$

$F = BIl \sin \theta$

Faraday's and Lenz's laws $\mathscr{E} = \frac{-d(N\phi)}{dt}$

Nuclear and particle physics

In a magnetic field $r = \frac{p}{BQ}$

Mass-energy $\Delta E = c^2 \Delta m$

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