Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Physics

Advanced
Unit 4: Physics on the Move

Monday 20 January 2014 – Afternoon
Time: 1 hour 35 minutes

Paper Reference
WPH04/01

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 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.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

Advice

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

Turn over ▶

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P 4 3 1 1 4 A 0 1 2 4

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 Electric field strength can have the units of

☒ **A** N m

☒ **B** N C^{-1}

☒ **C** V m

☒ **D** V C^{-1}

(Total for Question 1 = 1 mark)

2 The angular speed of the Earth about its axis is

☒ **A** 7.3×10^{-5} rad s^{-1}

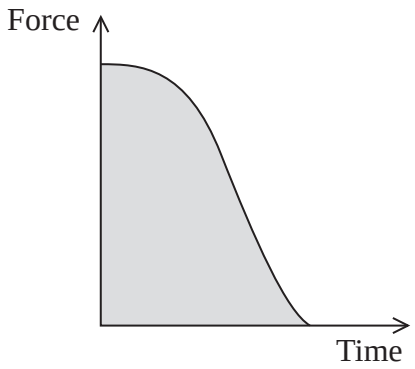
☒ **B** 4.2×10^{-3} rad s^{-1}

☒ **C** 4.4×10^{-3} rad s^{-1}

☒ **D** 5.4×10^{5} rad s^{-1}

(Total for Question 2 = 1 mark)

3 The graph shows how the force on a stone being fired from a catapult varies with time.



Which quantity is represented by the shaded area?

☒ **A** the acceleration of the stone

☒ **B** the work done on the stone

☒ **C** the change in momentum of the stone

☒ **D** the displacement of the stone

(Total for Question 3 = 1 mark)

---

4 Two small charged objects, a distance *d* apart, exert an attractive force *F* on each other.
The charge on each object is doubled and the distance increased to 2*d*.
The force of attraction would be

☒ **A** *F*/4

☒ **B** *F*/2

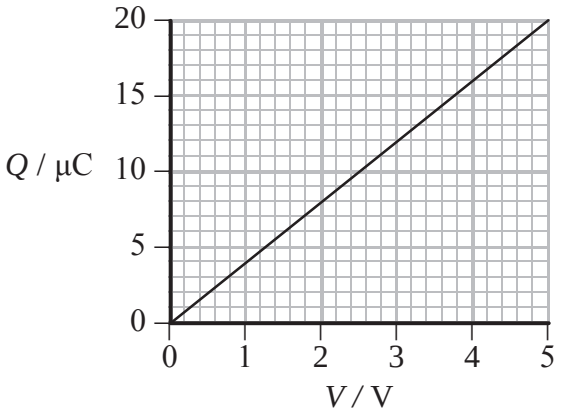
☒ **C** *F*

☒ **D** 2*F*

(Total for Question 4 = 1 mark)

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5 The graph shows how the charge Q stored on a capacitor varies with the potential difference p.d. V across it.

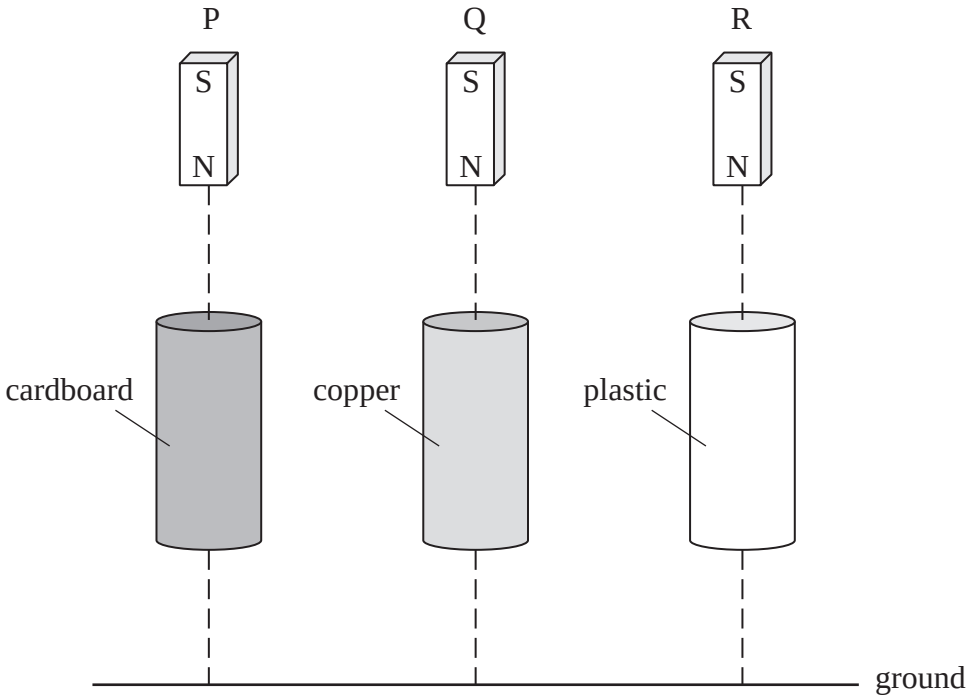


The values of the capacitance of the capacitor and the energy stored when the p.d. is 5 V are

		Capacitance / μF	Energy / μJ
☒	**A**	4	100
☒	**B**	4	50
☒	**C**	20	100
☒	**D**	20	50

(Total for Question 5 = 1 mark)

6 The diagram shows three bar magnets P, Q and R, being dropped simultaneously to fall through tubes of different materials.



The order in which the magnets reach the ground is

☒ **A** P and Q simultaneously followed by R.

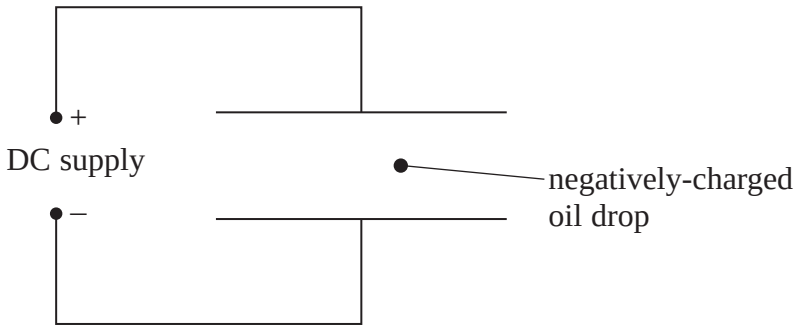
☒ **B** P and R simultaneously followed by Q.

☒ **C** Q first then P and R simultaneously.

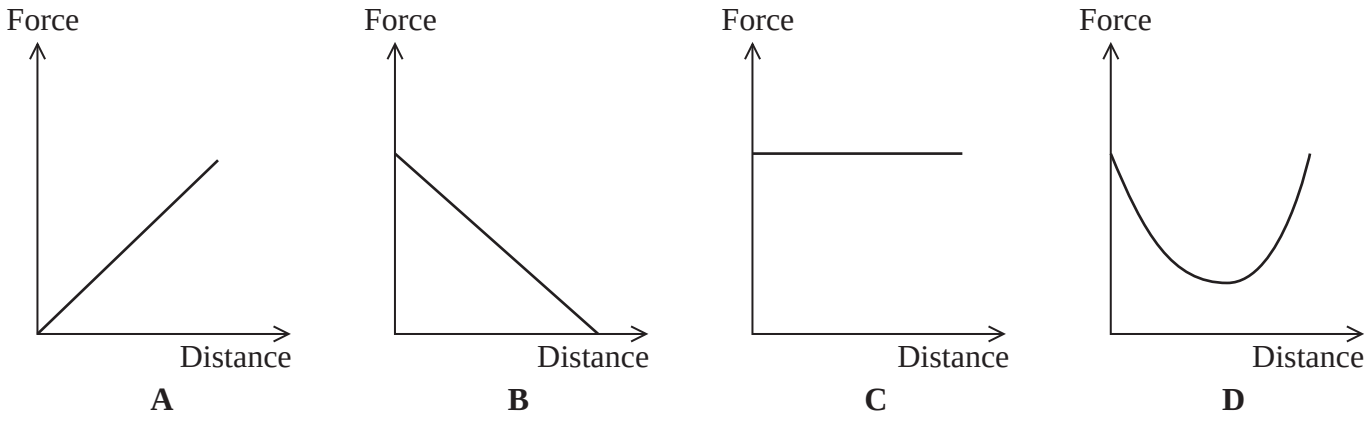
☒ **D** all three arrive simultaneously.

(Total for Question 6 = 1 mark)

7 An electric field is set up between two parallel plates. A negatively-charged oil drop between the plates will experience an electrostatic force.



Select the graph that shows how this force varies with distance from the bottom plate.



☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 7 = 1 mark)

8 What is the acceleration of a proton in an electric field of strength 4.0×10^4 V m^{-1}?

☒ **A** 2.4×10^{31} m s^{-2}

☒ **B** 3.8×10^{12} m s^{-2}

☒ **C** 7.0×10^{15} m s^{-2}

☒ **D** 6.4×10^{-15} m s^{-2}

(Total for Question 8 = 1 mark)

9 A radioactive isotope of carbon is $^{14}_{6}C$.

Select the row in the table that correctly identifies a neutral atom of this isotope.

		Neutrons	Protons	Electrons
☒	**A**	8	6	8
☒	**B**	6	8	6
☒	**C**	6	8	8
☒	**D**	8	6	6

(Total for Question 9 = 1 mark)

10 The rest mass of a kaon is 494 MeV/c^2.
This mass in kg is

☒ **A** 3.4×10^{10}

☒ **B** 2.6×10^{-19}

☒ **C** 8.8×10^{-28}

☒ **D** 8.8×10^{-34}

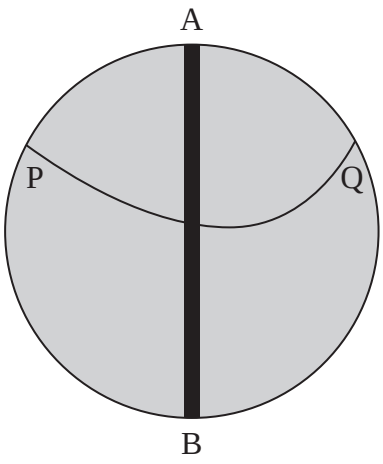
(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

***11** The diagram shows the track of a charged particle in a magnetic field. The field is at right angles to the plane of the paper and its direction is out of the plane of the paper. AB is a thin sheet of lead that the particle passes through.

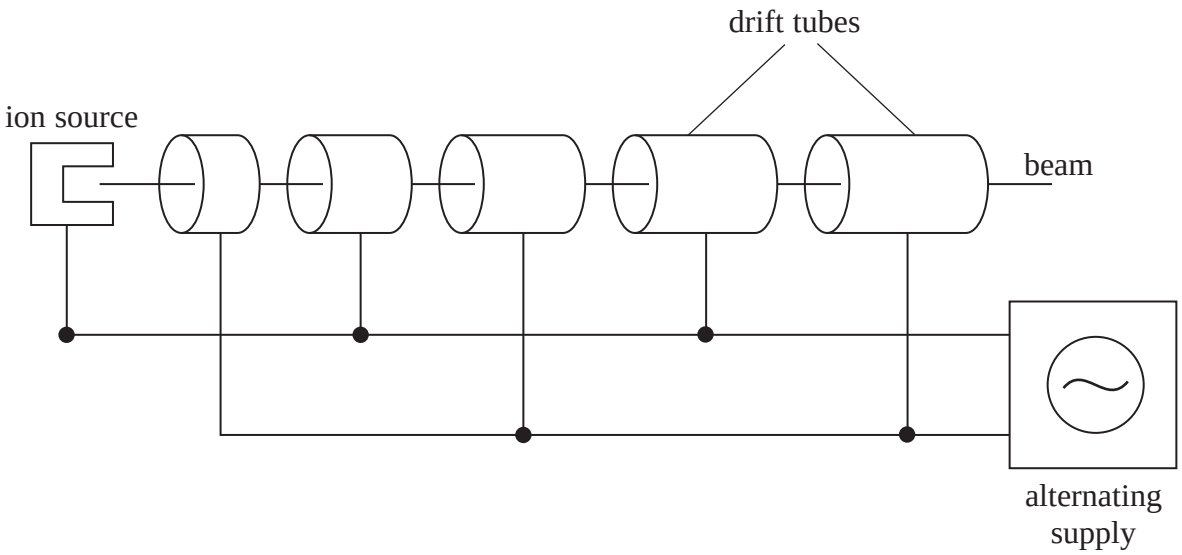


Work out the direction of movement of the particle and the sign of the charge of the particle. Explain clearly how you reached your conclusions.

(4)

(Total for Question 11 = 4 marks)

*12 The diagram shows the basic structure of a linac.

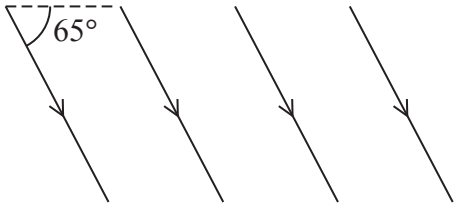


Explain how the linac produces a beam of high speed particles, making reference to the alternating supply and the lengths of the tubes.

(4)

(Total for Question 12 = 4 marks)

13 The diagram shows the direction of the Earth's magnetic field over a region of the Earth where the magnetic flux density is 4.4×10^{-5} T. The magnetic field in a vertical plane, acts at 65° to the horizontal.



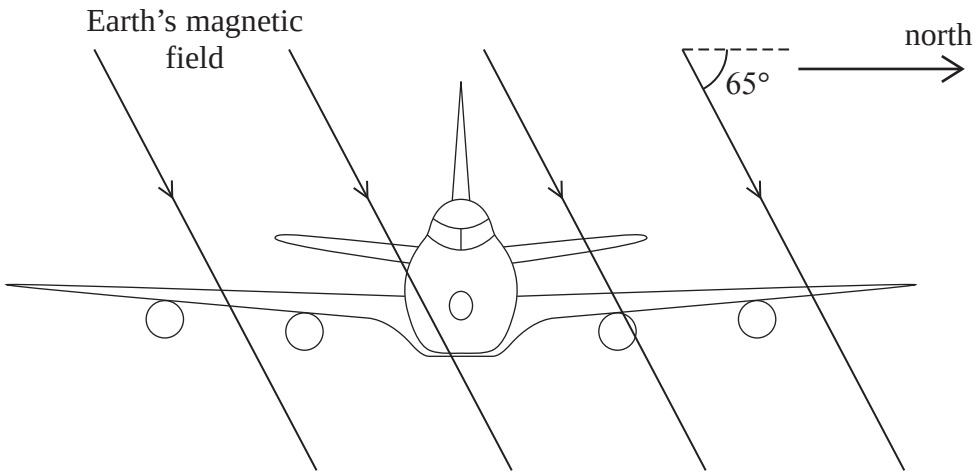
(a) Calculate the magnitude of the vertical component of the Earth's magnetic flux density in this region.

(1)

.....

Magnitude of vertical component = ...

(b) An aeroplane's wings and fuselage are made of metal which contains conduction electrons that are free to move. The aeroplane flies west to east from North America to Europe. At the beginning of the flight the wing tips become charged.



(i) Assuming that the wings act as a continuous conductor, explain why the wing tips become charged.

(2)

(ii) Identify which wing tip will become positive. Mark this on the diagram with an ×.

(1)

(iii) Once the aeroplane has reached a constant speed there is no further build up of charge.

Explain why.

(2)

(iv) The shape of the Earth's magnetic field is as though there were a bar magnet at the centre of the Earth, aligned approximately on the North-South axis.

If the plane flies west to east, but above the equator, the wing tips do not become charged.

Explain why.

(2)

(Total for Question 13 = 8 marks)

14 The Gravitron is a theme park ride consisting of a circular chamber which rotates about a central, vertical axis.



External view of Graviton

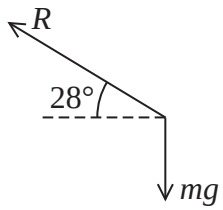


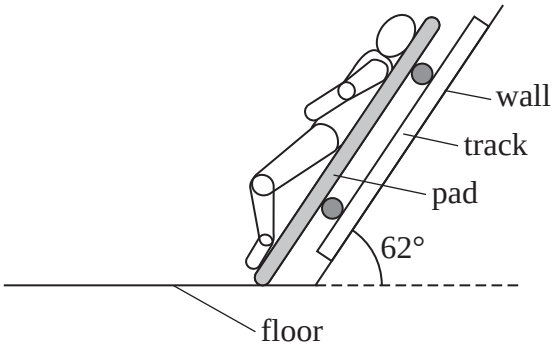
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Internal view of Graviton

The passengers lie back on pads which line the interior of the chamber. These are all inclined at 62° to the horizontal. Each pad is mounted on a small track on the Gravitron wall. As the Gravitron rotates faster and faster, a speed is reached where each pad rises up its track so that the passengers lose contact with the floor of the chamber.

The diagram is a free-body force diagram of a passenger as the pad rises up the track. R is the normal reaction force acting on the passenger and mg is the weight of the passenger. You can assume that no other forces act on the passenger.





(a) (i) Show that when m is 80 kg the reaction force R is about 1700 N.

(2)

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.....

(ii) Calculate the centripetal acceleration of the passenger.

(2)

Centripetal acceleration = ...

(iii) Calculate the speed of the passenger at the moment that the pad starts to rise up the track. The distance from the passenger's centre of mass to the centre of the Gravitron is 5.0 m.

(2)

Speed = ...

(b) The Gravitron is limited to a maximum rate of rotation of 24 revolutions per minute. Calculate the linear speed of the passenger at this rate of rotation.

(2)

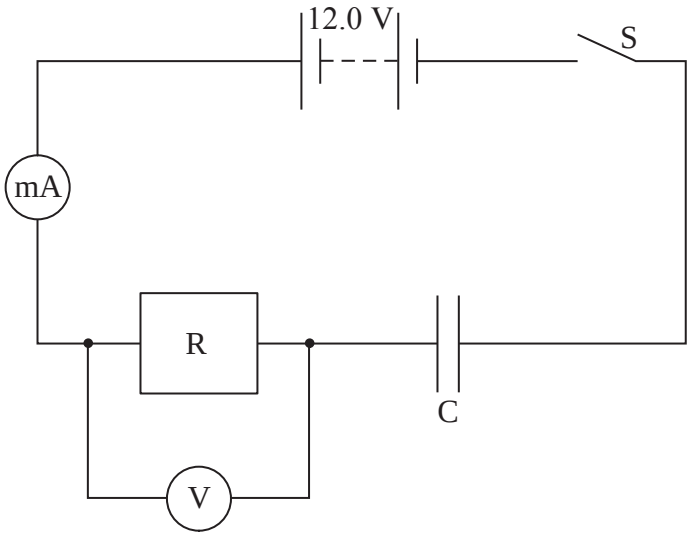
Linear speed = ...

(c) An advert for the ride states that 'children feel more comfortable on the ride than adults'.
Suggest why children might feel more comfortable on this ride.

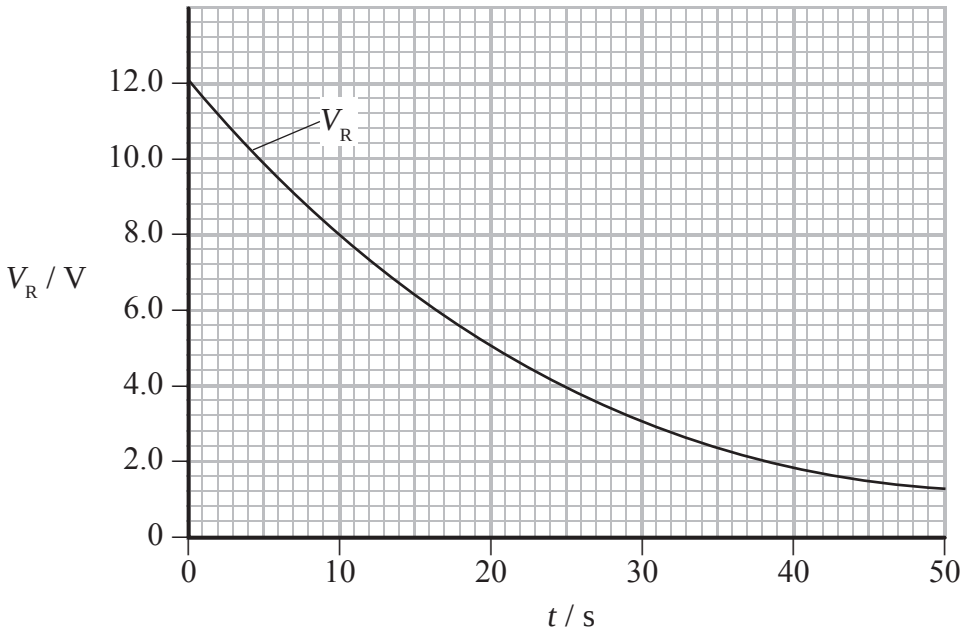
(2)

(Total for Question 14 = 10 marks)

15 A capacitor circuit is set up as shown in the diagram.



The capacitor is initially uncharged and the switch is closed at time $t = 0$. The graph shows how the potential difference V_R across the resistor varies with time t.



(a) (i) Explain the shape of the graph.

(2)

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(ii) On the same axes draw a graph to show how the potential difference V_C across the capacitor varies with time.

(2)

(b) The time constant for this circuit is 25 s.

(i) Describe how you could have determined the value of the time constant from the graph.

(2)

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(ii) The initial current is 0.25 mA.
Calculate the resistance R of the resistor and the capacitance C of the capacitor.

(4)

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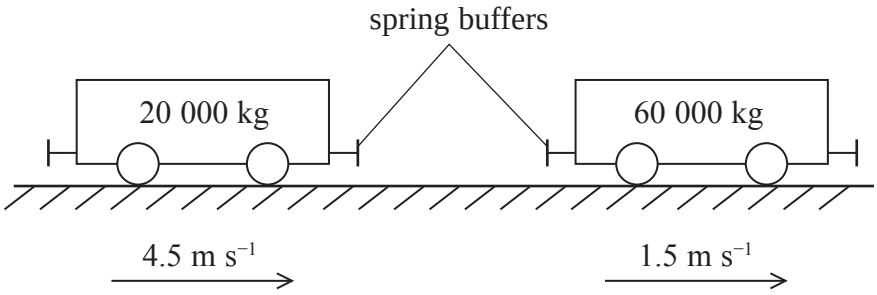
.....

R = ...

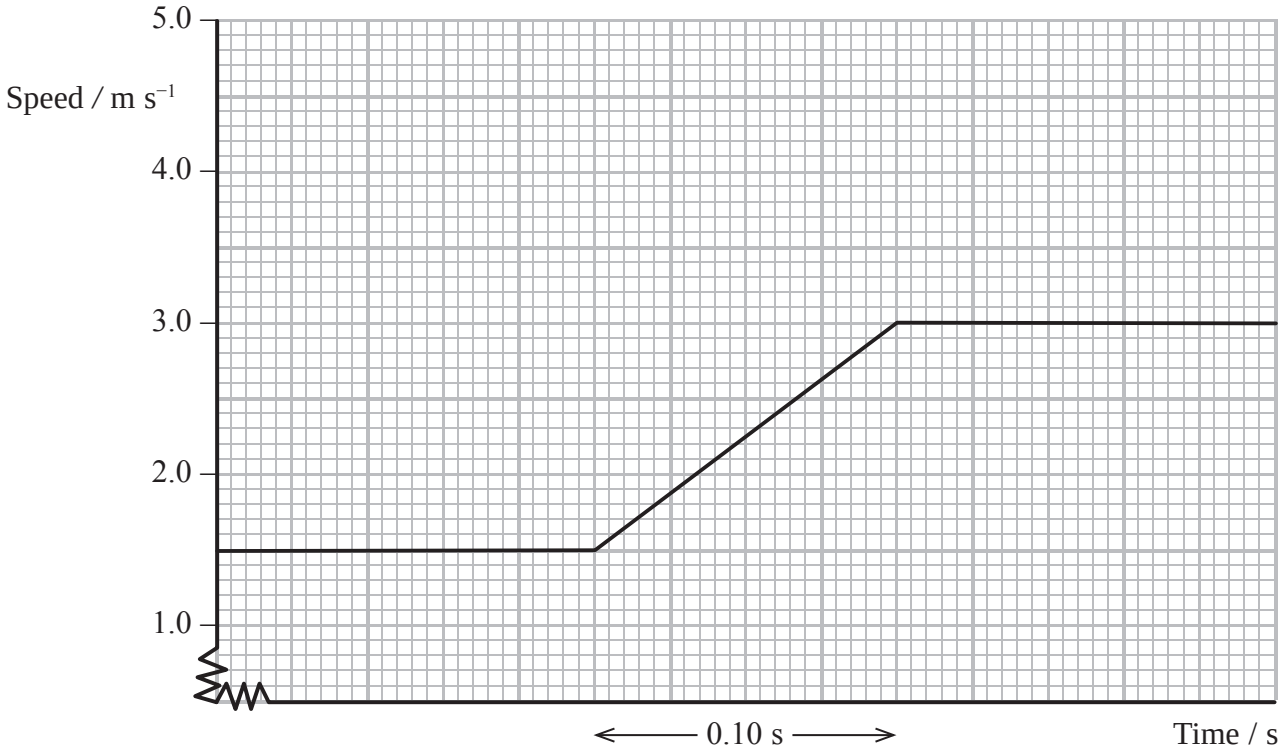
C = ...

(Total for Question 15 = 10 marks)

16 A railway truck of mass 20 000 kg is moving at a speed of 4.5 m s^{-1}. It catches up and collides with a loaded truck of total mass 60 000 kg which is moving in the same direction at 1.5 m s^{-1}.



The graph shows the speed of the heavier truck before, during and after the collision.



(a) (i) By means of a calculation, show that the speed of the lighter truck after the collision will be zero.

(2)

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.....

(ii) Add a second line to the graph to show the speed of the lighter truck before, during and after the collision.

(1)

(iii) Calculate the force that each truck exerts on the other truck.

(2)

Force = ...

(b) The collision between the railway trucks is elastic.

(i) State what is meant by an elastic collision.

(1)

(ii) Show that the total kinetic energy halfway through the collision is less than the total kinetic energy after the collision.

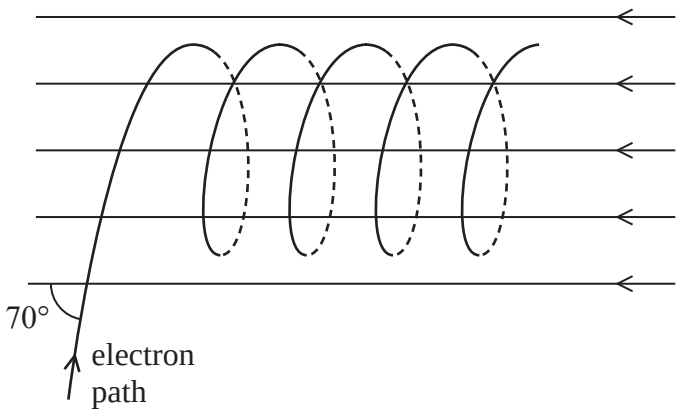
(3)

(iii) Suggest a reason for this.

(1)

(Total for Question 16 = 10 marks)

17 An electron travelling at 8.0×10^6 m s^{-1} enters a uniform magnetic field, at an angle of 70° to the field. The electron moves in a helical path as shown in the diagram.



(a) (i) Calculate the component of the electron's initial velocity that is perpendicular to the magnetic field.

(1)

.....

Perpendicular component = ...

(ii) Calculate the component of the electron's initial velocity that is parallel to the magnetic field.

(1)

.....

Parallel component = ...

(iii) Explain why the electron moves in the helical path.

(2)

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(b) (i) Show that the radius of the loop of the helical path is about 3×10^{-3} m.

magnetic flux density of the field = 0.015 T

(3)

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.....

(ii) Calculate the time taken for the electron to complete one loop.

(2)

.....

.....

Time for one loop = ...

(iii) Calculate the distance between two adjacent loops in the helical path.

(2)

.....

.....

Distance = ...

(c) Describe how the path would be different if the electron entered the magnetic field at an angle less than 70°.

(2)

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(Total for Question 17 = 13 marks)

18 (a) In 1962, the existence of a particle with strangeness −3 was predicted. Two years later it was identified in an experiment involving the interaction of a proton and a K^- meson which has a strangeness of −1. The new particle was given the name omega, Ω.

The interaction, which conserves strangeness, was

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

(i) Deduce with reasons the charge on the Ω and whether it is a baryon or a meson.

(2)

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(ii) Using the information given in the table below deduce the quark composition of each of the particles involved.

(4)

Type of quark	**Charge/*e***	**Strangeness**
u	+2/3	0
d	−1/3	0
s	−1/3	−1

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(b) In another experiment, involving a head-on collision between two protons, the following interaction was observed.

$$p + p \rightarrow p + 7\pi^+ + 7\pi^- + K^+ + \Lambda$$

mass of p = 938 MeV/c^2

mass of π^+ and π^- = 140 MeV/c^2

mass of K^+ = 494 MeV/c^2

mass of Λ = 1115 MeV/c^2

(i) Calculate the minimum kinetic energy of each proton, in MeV, for this interaction to occur.

(3)

Minimum kinetic energy = ...

(ii) This interaction would **not** have taken place if one of the protons had been stationary and the other had twice the calculated value of kinetic energy.

Explain why.

(2)

(Total for Question 18 = 11 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

List of data, formulae and relationships

Acceleration of free fall	$g = 9.81$ m s^{-2}	(close to Earth's surface)
Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}	
Coulomb's law constant	$k = 1/4\pi\varepsilon_0$ $= 8.99 \times 10^9$ N m^2 C^{-2}	
Electron charge	$e = -1.60 \times 10^{-19}$ C	
Electron mass	$m_e = 9.11 \times 10^{-31}$ kg	
Electronvolt	1 eV $= 1.60 \times 10^{-19}$ J	
Gravitational constant	$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}	
Gravitational field strength	$g = 9.81$ N kg^{-1}	(close to Earth's surface)
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}	
Planck constant	$h = 6.63 \times 10^{-34}$ J s	
Proton mass	$m_p = 1.67 \times 10^{-27}$ kg	
Speed of light in a vacuum	$c = 3.00 \times 10^8$ m s^{-1}	
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8}$ W m^{-2} K^{-4}	
Unified atomic mass unit	$u = 1.66 \times 10^{-27}$ kg	

Unit 1

Mechanics

Kinematic equations of motion

$v = u + at$
$s = ut + \frac{1}{2}at^2$
$v^2 = u^2 + 2as$

Forces

$\Sigma F = ma$
$g = F/m$
$W = mg$

Work and energy

$\Delta W = F\Delta s$
$E_k = \frac{1}{2}mv^2$
$\Delta E_{grav} = mg\Delta h$

Materials

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

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

Density: $\rho = m/V$

Pressure: $p = F/A$

Young modulus: $E = \sigma/\varepsilon$ where
Stress $\sigma = F/A$
Strain $\varepsilon = \Delta x/x$

Elastic strain energy: $E_{el} = \frac{1}{2}F\Delta x$

Unit 2

Waves

Wave speed	$v = f\lambda$
Refractive index	${}_1\mu_2 = \sin i / \sin r = v_1/v_2$

Electricity

Potential difference	$V = W/Q$
Resistance	$R = V/I$
Electrical power, energy and efficiency	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$ $\%\ \text{efficiency} = \dfrac{\text{useful energy output}}{\text{total energy input}} \times 100$ $\%\ \text{efficiency} = \dfrac{\text{useful power output}}{\text{total power input}} \times 100$
Resistivity	$R = \rho l/A$
Current	$I = \Delta Q/\Delta t$ $I = nqvA$
Resistors in series	$R = R_1 + R_2 + R_3$
Resistors in parallel	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

Quantum physics

Photon model	$E = hf$
Einstein's photoelectric equation	$hf = \phi + \frac{1}{2}mv^2_{max}$

Unit 4

Mechanics

Momentum	$p = mv$
Kinetic energy of a non-relativistic particle	$E_k = p^2/2m$
Motion in a circle	$v = \omega r$ $T = 2\pi/\omega$ $F = ma = mv^2/r$ $a = v^2/r$ $a = r\omega^2$

Fields

Coulomb's law	$F = kQ_1Q_2/r^2$ where $k = 1/4\pi\varepsilon_0$
Electric field	$E = F/Q$ $E = kQ/r^2$ $E = V/d$
Capacitance	$C = Q/V$
Energy stored in capacitor	$W = \frac{1}{2}QV$
Capacitor discharge	$Q = Q_0e^{-t/RC}$
In a magnetic field	$F = BIl \sin\theta$ $F = Bqv \sin\theta$ $r = p/BQ$
Faraday's and Lenz's Laws	$\varepsilon = -d(N\phi)/dt$

Particle physics

Mass-energy	$\Delta E = c^2 \Delta m$
de Broglie wavelength	$\lambda = h/p$