Edexcel Physics Unit 4

Past Paper Pack

2010-2013

Write your name here

Surname	Other names

Centre Number | Candidate Number

Edexcel GCE

Physics

Advanced

Unit 4: Physics on the Move

Thursday 28 January 2010 – Afternoon
Time: 1 hour 35 minutes

Paper Reference
6PH04/01

You must have:
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.
- Answer the questions in the spaces provided
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Information

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- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

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- Check your answers if you have time at the end.

Turn over ▶

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SECTION A

Answer ALL questions.

For questions 1–7, 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 A particle completes 6.0 revolutions in 4.0 s. The angular velocity, in rad s^{-1}, is

☒ **A** 1.5

☒ **B** 9.4

☒ **C** 24

☒ **D** 150

(Total for Question 1 = 1 mark)

2 Which of the following is equivalent to the unit for energy?

☒ **A** kg m^2 s^{-2}

☒ **B** kg m s^{-2}

☒ **C** N s^2 kg^{-1}

☒ **D** N^2 s^2

(Total for Question 2 = 1 mark)

3 A radium nucleus decays by emitting an alpha particle. The speed of the recoiling nucleus is small compared to the speed of the alpha particle. This is because the

☒ **A** force acting on the recoiling nucleus is smaller than the force acting on the alpha particle

☒ **B** momentum is mainly concentrated in the alpha particle

☒ **C** momentum of the recoiling nucleus is smaller than the momentum of the alpha particle

☒ **D** recoiling nucleus has a much larger mass than the alpha particle

(Total for Question 3 = 1 mark)

4 The potential difference across a capacitor is V. The energy stored on the capacitor is X joules. The potential difference across this capacitor is increased to 3 V. The energy stored, in joules, is increased to

☒ **A** $3X$

☒ **B** $6X$

☒ **C** $9X$

☒ **D** $27X$

(Total for Question 4 = 1 mark)

5 Figure 1 shows a vertical plane square coil of 50 turns, carrying a current of 3.0 A. The length of each side of the coil is 4.0 cm. Figure 2 shows a view of this coil from above within a horizontal magnetic field of flux density 0.20 T.

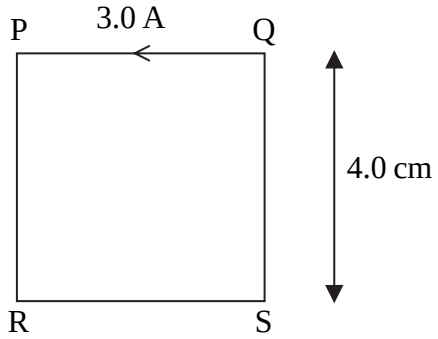


Figure 1

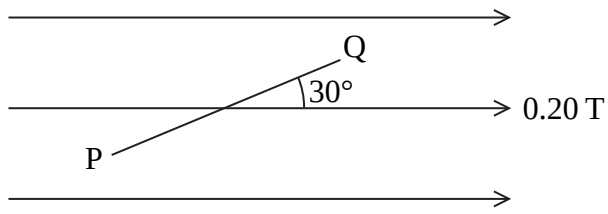


Figure 2

The force on side QS is

☒ **A** 120 N

☒ **B** 60 N

☒ **C** 1.2 N

☒ **D** 0.60 N

(Total for Question 5 = 1 mark)

6 An electron gun uses a potential difference to accelerate electrons from rest to a speed of 2.00×10^7 m s^{-1}.

(i) The potential difference is

☒ **A** 569 V

☒ **B** 1140 V

☒ **C** 2280 V

☒ **D** 4560 V

(ii) The de Broglie wavelength associated with electrons moving at 2.00×10^7 m s^{-1} is

☒ **A** 3.3×10^{-41} m

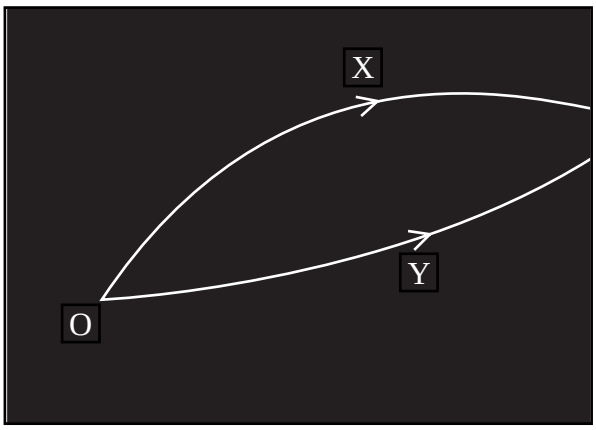
☒ **B** 5.0×10^{-14} m

☒ **C** 3.6×10^{-11} m

☒ **D** 5.0×10^{-8} m

(Total for Question 6 = 2 marks)

7 A particle detector shows tracks produced by two particles X and Y that were created by the decay of a lambda particle at O.



(i) Which of the following is a valid conclusion from these facts?

☒ **A** X is a negatively charged particle.

☒ **B** Y is a positively charged particle.

☒ **C** The lambda particle is neutral.

☒ **D** The magnetic field is acting into the plane of the paper.

(ii) Which of the following is a correct statement about momentum at the decay?

☒ **A** The vector sum of the momenta of X and Y must equal that of the lambda particle.

☒ **B** The momentum of X is equal to that of Y.

☒ **C** The total momentum of this system is zero.

☒ **D** The vector sum of the momenta of X and Y must equal zero.

(iii) Which of the following is a correct statement about energy at the decay?

☒ **A** The energy of X must be greater than that of Y.

☒ **B** The combined energy of X and Y must be more than the energy of the lambda particle.

☒ **C** The mass of the lambda particle must equal the combined energy of X and Y.

☒ **D** The mass energy of the lambda particle must equal the total energy of X and Y.

(Total for Question 7 = 3 marks)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

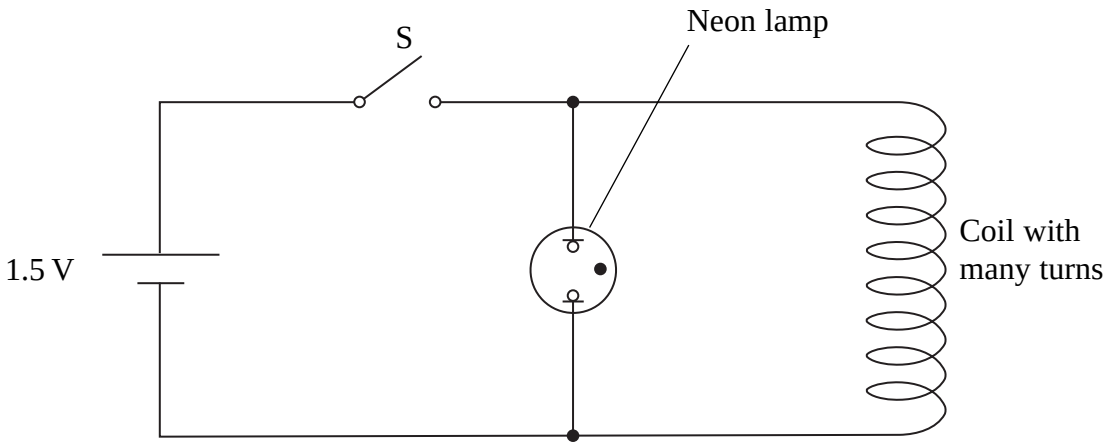
Answer ALL questions in the spaces provided.

***8** Rutherford designed an experiment to see what happened when alpha particles were directed at a piece of gold foil. Summarise the observations and state the conclusions Rutherford reached about the structure of gold atoms.

(5)

(Total for Question 8 = 5 marks)

9 A 1.5 V cell is connected to a switch S, a neon lamp and a coil with many turns as shown. Nothing is observed when the switch is closed but the neon lamp flashes as soon as it is opened.
The neon lamp flashes when the potential difference across it is about 200 V.

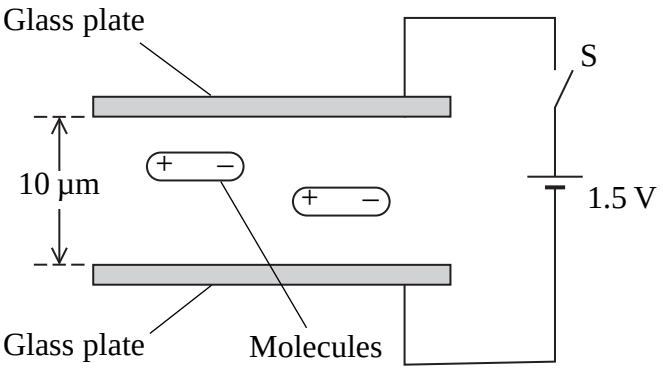


Use Faraday's law to explain why the lamp flashes once when the switch S is **opened**.

(4)

(Total for Question 9 = 4 marks)

10 Liquid crystal displays (LCDs) are made from two parallel glass plates, 10 μm apart, with liquid crystal molecules between them. The glass is coated with a conducting material.



The molecules are positive at one end and negative at the other. They are normally aligned parallel with the glass plates as shown.

The switch S is closed and 1.5 V is applied across the glass plates.

(a) Calculate the electric field strength between the plates.

(2)

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Electric field strength = ...

(b) Explain what happens to the liquid crystal molecules.

(3)

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(Total for Question 10 = 5 marks)

11 The diagram represents a proton.

(a) Draw lines to represent its electric field.

(3)

(b) Calculate the electrostatic force on the electron in a hydrogen atom.

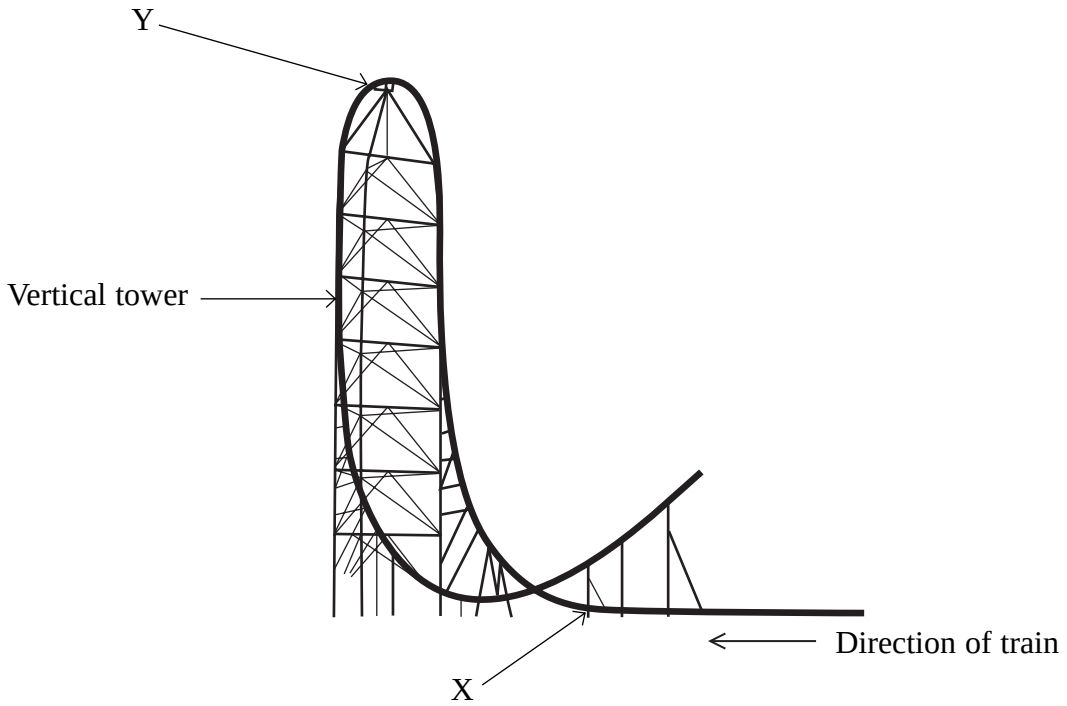
Average distance between proton and electron = 5.4×10^{-11} m

(3)

Force = ...

(Total for Question 11 = 6 marks)

12 Kingda Ka was the highest roller coaster in the world in 2007. A train is initially propelled along a horizontal track by a hydraulic system. It reaches a speed of 57 m s^{-1} from rest in 3.5 s. It then climbs a vertical tower before falling back towards the ground.



(a) Calculate the average force used to accelerate a fully loaded train along the horizontal track.

Total mass of fully loaded train = 12 000 kg

(2)

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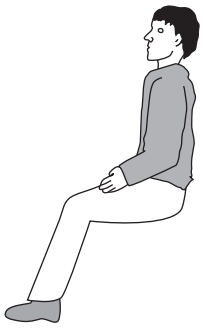
Force = ...

(b) Point X is just before the train leaves the horizontal track and moves into the first bend. Complete the free-body diagram below to show the two forces acting on a rider in the train at this point.

(3)



(c) The mass of the rider is m and g is the acceleration of free fall. Just after point X, the reaction force of the train on the rider is $4mg$ and can be assumed to be vertical. This is referred to as a g-force of $4g$.
Show that the radius of curvature of the track at this point is about 100 m.

(3)

(d) Show that the speed of the train as it reaches the top of the vertical tower is about 20 m s^{-1}. Assume that resistance forces are negligible.

The height of the vertical tower is 139 m.

(2)

(e) Riders will feel momentarily weightless if the vertical reaction force becomes zero. The track is designed so that this happens at point Y.

Calculate the radius of the track at point Y.

(2)

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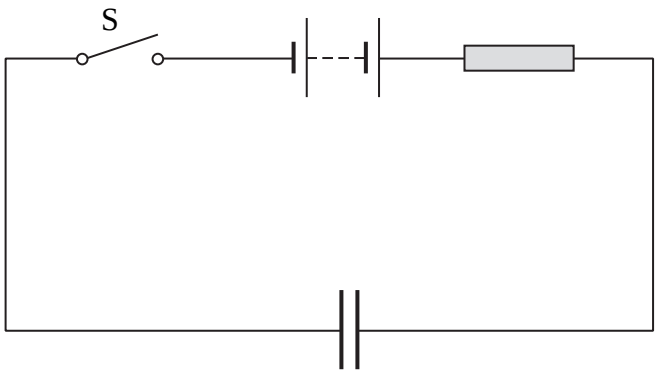
Radius = ...

(Total for Question 12 = 12 marks)

13 An uncharged capacitor is connected into a circuit as shown.



(a) Describe what happens to the capacitor when the switch S is closed.

(2)

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(b) A student models the behaviour of the circuit using a spreadsheet. The student uses a 100 μF capacitor, a 3.00 kΩ resistor and 5.00 V power supply. The switch is closed at time t = 0 s.

	A	B	C	D	E
1	t / s	I / mA	ΔQ / μC	Q / μC	p.d. across capacitor/V
2	0	1.67	167	167	1.67
3	0.1	1.11	111	278	2.78
4	0.2	0.74	74	352	3.52
5	0.3	0.49	49	401	4.01
6	0.4	0.33	33	434	4.34
7	0.5	0.22	22	456	4.56
8	0.6	0.15	15	471	4.71
9	0.7	0.10	10	480	4.80
10	0.8	0.07	7	487	4.87

(i) Explain how the value in cell C4 is calculated.

(2)

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(ii) Explain how the value in cell E3 is calculated.

(2)

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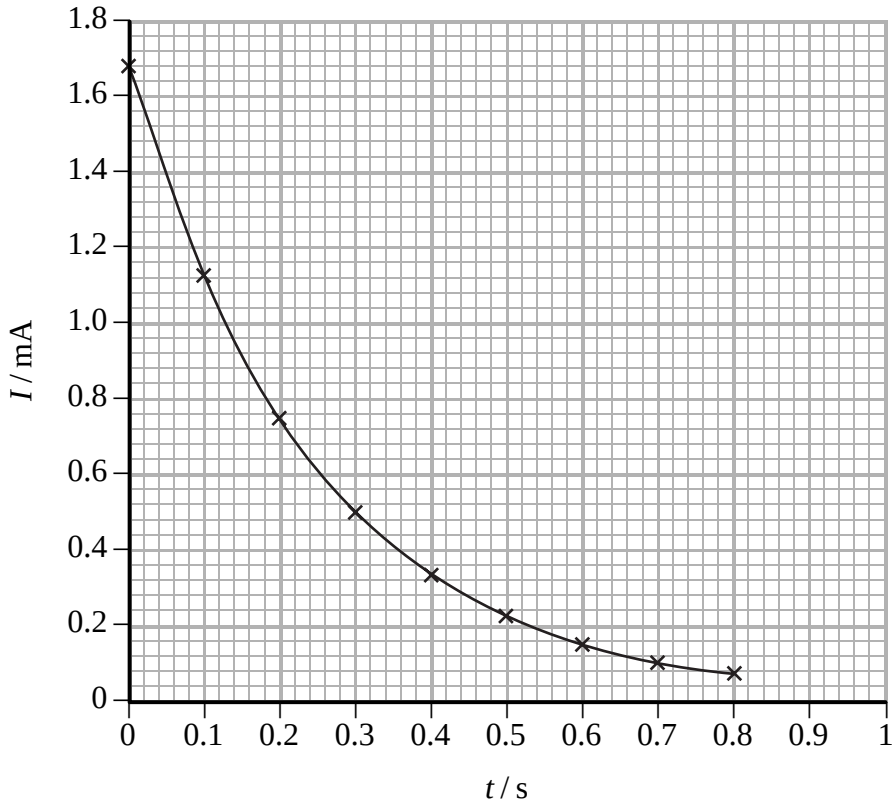
(c) The graph shows how the spreadsheet current varies with time.



(i) Use the graph to show that the time constant is approximately consistent with the component values.

(4)

(ii) The student thinks that the graph is an exponential curve. How would you use another graph to confirm this?

(3)

(Total for Question 13 = 13 marks)

***14** Pion radiotherapy is a new form of cancer treatment that has been extensively investigated for tumours of the brain. Pions are short lived sub-atomic particles and belong to a group called mesons.

(a) The following table lists some quarks and their charge.

Quark	Charge / *e*
Up (u)	$+\frac{2}{3}$
Down (d)	$-\frac{1}{3}$
Strange (s)	$-\frac{1}{3}$
Charm (c)	$+\frac{2}{3}$

On the list below circle the combination which could correspond to a π^+ pion.

(1)

uud $\quad$ $\bar{d}\bar{d}\bar{d}$ $\quad$ $u\bar{d}$ $\quad$ $s\bar{c}$

(b) The mass of a pion is 0.14 GeV/c^2 . Calculate the mass of a pion in kg.

(3)

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Mass = ... kg

(c) Pions can be produced by accelerating protons using a cyclotron. Briefly explain the role of electric and magnetic fields within a cyclotron.

(5)

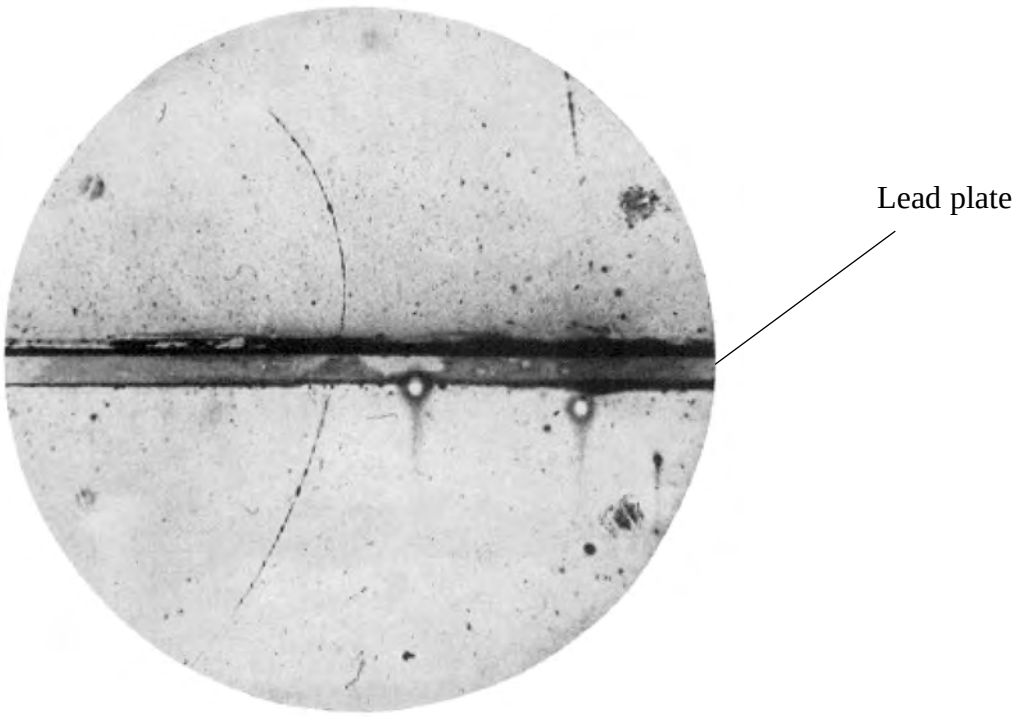
(d) When pions are used to treat brain tumours they are slowed by the tissue in the brain and cause little damage. When a pion is moving very slowly it may be absorbed by the nucleus of an atom. The atom nucleus then becomes unstable and breaks up into several fragments.

Explain why these fragments shoot out in all directions.

(3)

(Total for Question 14 = 12 marks)

15 The photograph shows the track of a positively charged particle either side of a lead plate.



The particle was deflected by a magnetic field of magnetic flux density 1.5 T. The field is perpendicular to the plane of the photograph.

(a) (i) Estimate the actual radius of the track above the lead plate.

The lead plate is 6 mm thick.

(3)

Radius = ...

(ii) Calculate the momentum of this particle above the lead plate.
Particle charge = 1.6×10^{-19} C

(2)

Momentum = ...

(b) Explain whether this particle was moving up or down through the lead plate.

(3)

(c) On the list below circle the correct direction of the magnetic field.

(1)

Into the page from left to right down the page out of the page up the page

(d) This particle was identified as a positron.

(i) Calculate the speed of the positron while it is moving above the lead plate.

(2)

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Speed = ...

(ii) Comment on your answer.

(2)

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(Total for Question 15 = 13 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

Write your name here

Surname	Other names

Edexcel GCE

Centre Number	Candidate Number

Physics

Advanced

Unit 4: Physics on the Move

Friday 18 June 2010 – Morning
Time: 1 hour 35 minutes

Paper Reference
6PH04/01

You must have:
Ruler

Total Marks

Instructions

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Turn over ▶

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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 The number of neutrons in a nucleus of $^{197}_{79}Au$ is

☒ **A** 79

☒ **B** 118

☒ **C** 197

☒ **D** 276

(Total for Question 1 = 1 mark)

2 Electric field strength can have the units

☒ **A** C m^{-1}

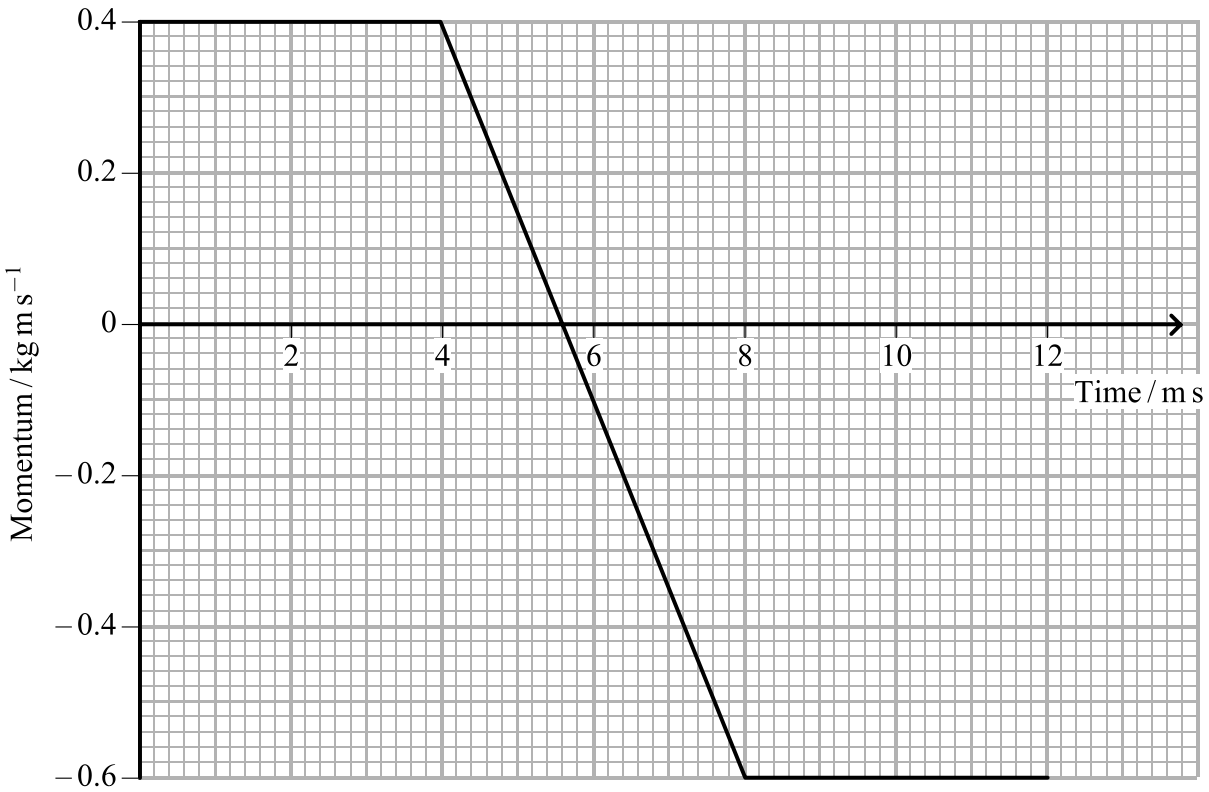
☒ **B** N C^{-1}

☒ **C** N V^{-1}

☒ **D** V m

(Total for Question 2 = 1 mark)

3 A tennis ball is travelling horizontally with a momentum of 0.4 kg m s^{-1} just before it is hit with a tennis racket. It rebounds horizontally from the tennis racket with a momentum of –0.6 kg m s^{-1}. The graph shows the variation in the momentum of the ball during this process.



The force exerted by the tennis ball on the racket is

☒ **A** 12 N

☒ **B** 100 N

☒ **C** 250 N

☒ **D** 1000 N

(Total for Question 3 = 1 mark)

4 The derivation of the formula $E_k = \frac{p^2}{2m}$ could include the expression

☒ **A** $\frac{1}{2} mv^2 = p^2$

☒ **B** $\frac{1}{2} m^2 v^2 = p^2$

☒ **C** $m^2 v^2 = \frac{p^2}{m}$

☒ **D** $m v^2 = \frac{p^2}{m}$

(Total for Question 4 = 1 mark)

5 The distance, in m, from an electron at which the electric field strength equals 6.4×10^8 J C^{-1} m^{-1} is

☒ **A** 1.7×10^{-19}

☒ **B** 6.0×10^{-19}

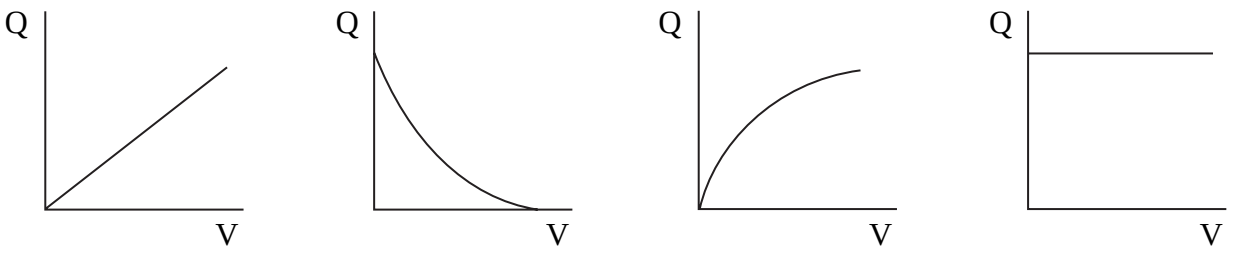
☒ **C** 2.2×10^{-18}

☒ **D** 1.5×10^{-9}

(Total for Question 5 = 1 mark)

6 An uncharged capacitor is connected to a battery.

Which graph shows the variation of charge with potential difference across the capacitor?



A ☒ **B** ☒ **C** ☒ **D** ☒

(Total for Question 6 = 1 mark)

7 Which of the following is **not** a valid conclusion from Rutherford's alpha particle scattering experiments?

☒ **A** The atom is mainly empty space.

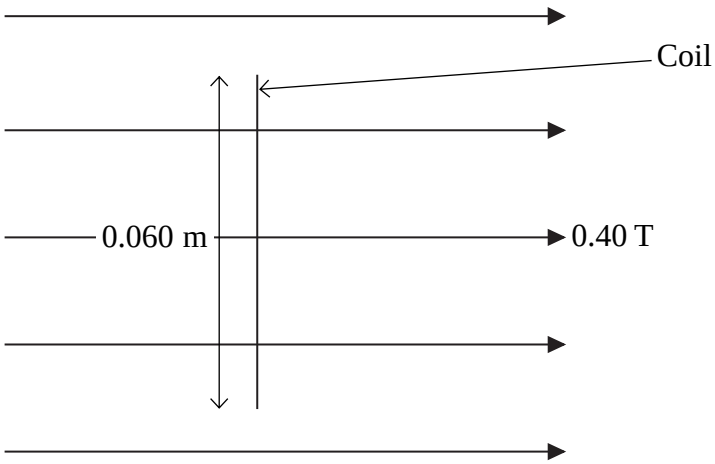
☒ **B** The nucleus contains protons and neutrons.

☒ **C** The nucleus must be charged.

☒ **D** The nucleus must be very small compared to the atom.

(Total for Question 7 = 1 mark)

8 A 50 turn square coil, side 0.060 m, is placed in a magnetic field of flux density 0.40 T. The plane of the coil is at right angles to the direction of the magnetic field.



The flux linkage with the coil is

☒ **A** 0.072 Wb

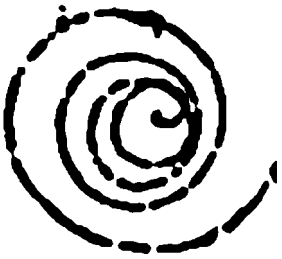
☒ **B** 0.45 Wb

☒ **C** 1.2 Wb

☒ **D** 333 Wb

(Total for Question 8 = 1 mark)

9 The diagram shows the path of an electron in a bubble chamber.



Which of the following can you deduce from the diagram?

☒ **A** The electron is moving anti-clockwise.

☒ **B** The electron is moving clockwise.

☒ **C** The magnetic field is acting out of the page.

☒ **D** The speed of the electron is increasing.

(Total for Question 9 = 1 mark)

10 Which one of the following quantities would the de Broglie equation be used to calculate?

☒ **A** The momentum of a moving particle.

☒ **B** The value of the Planck constant.

☒ **C** The wavelength of a moving electron.

☒ **D** The wavelength of a photon of light.

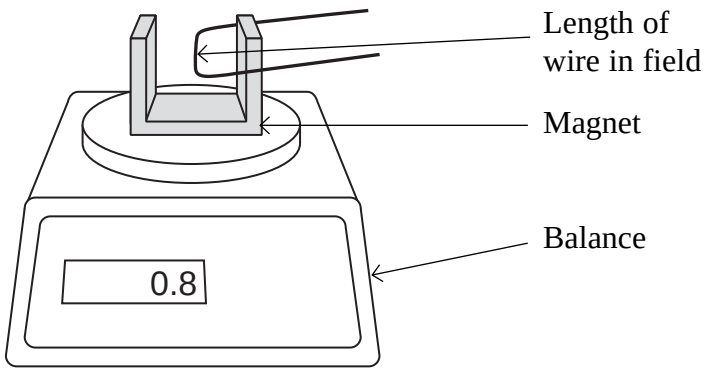
(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 The diagram shows a horizontal wire which is at right angles to a magnetic field. The magnetic field is produced by a horseshoe magnet which is on a balance adjusted to read zero when the current in the wire is zero.



When the current is 4 A, the reading on the balance is 0.8 gram.

The length of wire in the magnetic field is 0.05 m.

Calculate the average magnetic flux density along the length of the wire.

(3)

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Magnetic flux density = ...

(Total for Question 11 = 3 marks)

***12** Faraday's and Lenz's laws are summarised in the list of formulae as

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

(a) State the meaning of the term $N\phi$.

(2)

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(b) Explain the significance of the minus sign.

(3)

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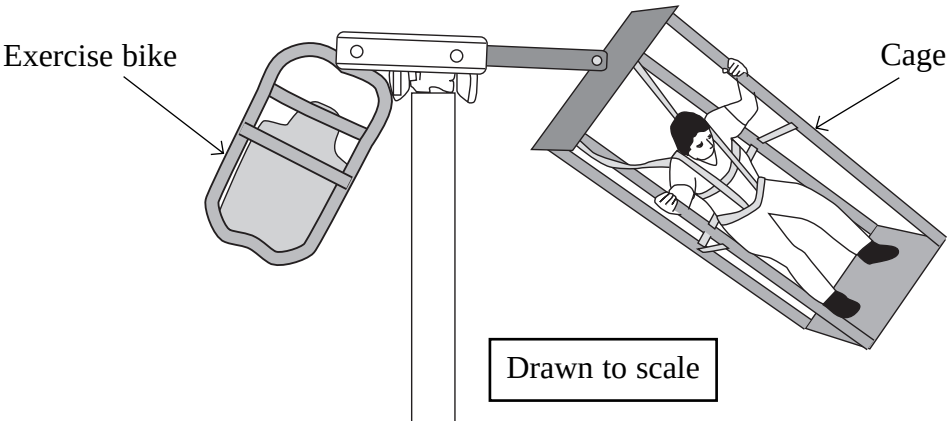
(Total for Question 12 = 5 marks)

13 Astronauts can be weakened by the long-term effects of microgravity. To keep in shape it has been suggested that they can do some exercise using a Space Cycle: a horizontal beam from which an exercise bike and a cage are suspended. One astronaut sits on the exercise bike and pedals, which causes the whole Space Cycle to rotate around a pole. Another astronaut standing in the cage experiences artificial gravity. When rotated at 20 revolutions per minute, this is of similar strength to the gravitational field on Earth.

Space Cycle



(a) Calculate the angular velocity, in rad s^{-1}, corresponding to 20 revolutions per minute.

(2)

Angular velocity = ...

(b) Use the diagram to estimate the radius of the path followed by the cage's platform and hence calculate the platform's acceleration.

(3)

Acceleration = ...

(Total for Question 13 = 5 marks)

***14** How tiny bacteria move is of interest in nanotechnology. Mycobacteria move by ejecting slime from nozzles in their bodies.

Explain the physics principles behind this form of propulsion.

(4)

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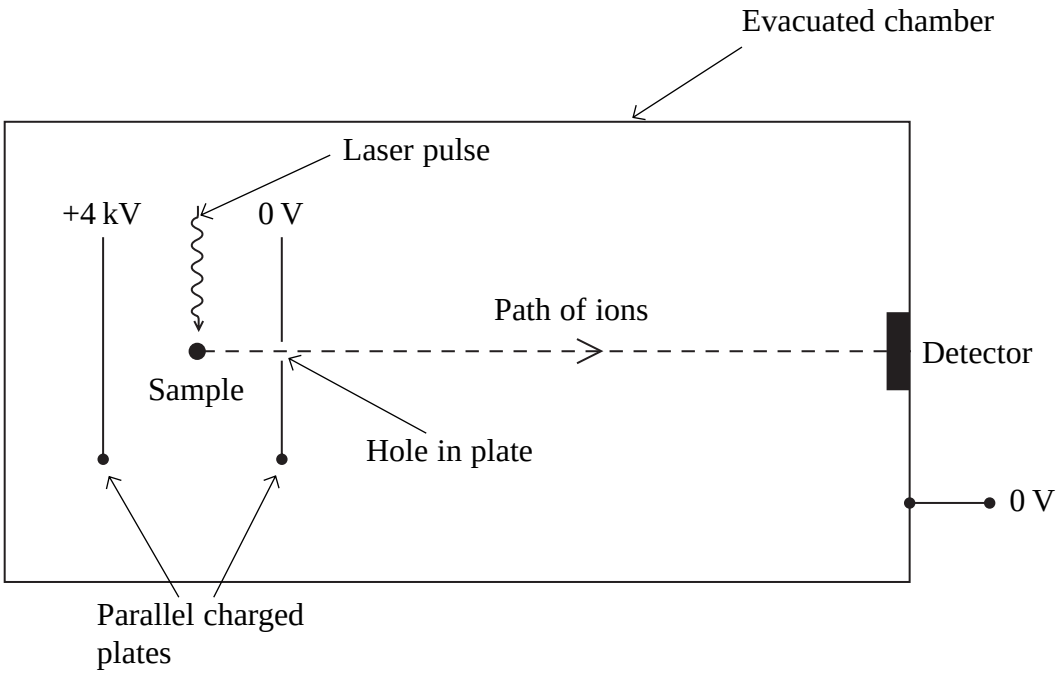
(Total for Question 14 = 4 marks)

15 Time-of-flight mass spectroscopy uses the arrangement below to measure the mass of molecules. A laser pulse knocks an electron out of a molecule in a sample leaving it as a positively charged ion.



(a) Add to the diagram to show the electric field lines between the two plates.

(3)

(b) The sample is midway between the charged plates. Show that the speed, v, of an ion as it reaches the hole in the plate is given by

$$v = \sqrt{\frac{6.4\times10^{-16}\ \text{joule}}{m}}$$

where m is the mass of the molecule in kg.

(3)

(c) The distance between the hole in the plate and the detector is 1.5 m. The time taken for a molecule to cover this distance is 23 μs.

Calculate the mass of this molecule.

(3)

Mass = ...

(d) There is some uncertainty in the time a molecule with a particular mass will take to cover this distance.

Suggest **two** reasons for this.

(2)

1 .....

2 .....

(Total for Question 15 = 11 marks)

16 Figure 1 shows the output from the terminals of a power supply labelled d.c. (direct current).

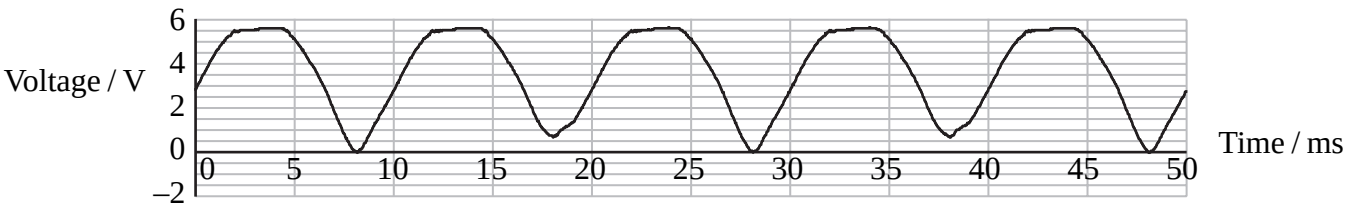


Figure 1

(a) An alternating current power supply provides a current that keeps switching direction.

Explain why the output shown in Figure 1 is consistent with the d.c. label.

(2)

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(b) A teacher suggests that certain electronic circuits require a constant voltage supply to operate correctly.

(i) A student places a capacitor across the terminals of this power supply. Suggest how this produces a constant voltage.

(2)

.....

.....

.....

.....

(ii) She uses a 10 μF capacitor. Calculate the maximum energy stored in the capacitor.

(3)

Maximum Energy = ...

(c) She now adds an electronic circuit to the power supply plus capacitor. Figure 2 shows the supply to the electronic circuit. This is shown in Figure 2.

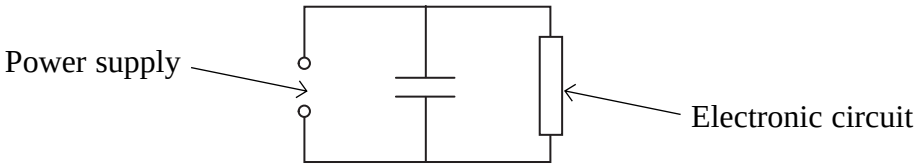

Figure 2

The variation in potential difference is shown by the graph in Figure 3.

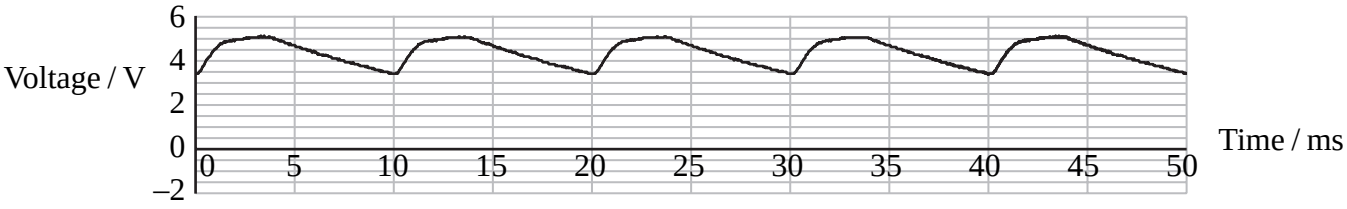

Figure 3

(i) Explain the shape of this graph.

(3)

(ii) Take readings from the graph to show that the resistance of the electronic circuit is in the range 1000 Ω to 2000 Ω.

(3)

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.....

(iii) Figure 3 shows that the voltage supplied to the electronic circuit still varies. How could the student make it more constant?

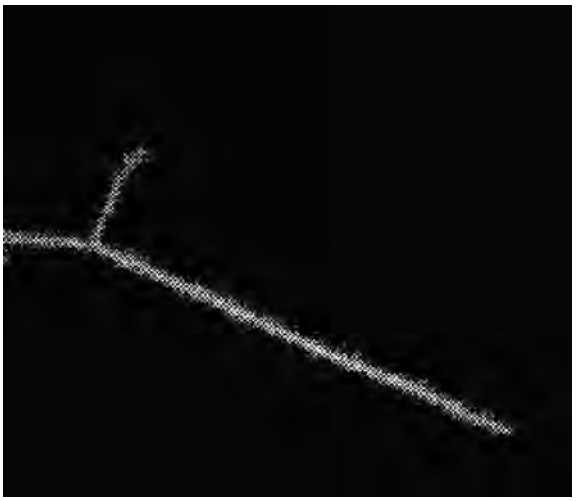
(1)

.....

.....

(Total for Question 16 = 14 marks)

17 A low-energy particle collides elastically with a stationary particle of the same mass. The particle enters from the left of the photograph.



(a) State what is meant by collides *elastically*.

(1)

.....

.....

(b) Sketch a labelled vector diagram to show how the momentum of the initial moving particle relates to the momenta of the two particles after the collision.

(2)

(c) Use your answers to (a) and (b) to confirm that the angle between the subsequent paths of both particles must be 90°.

(2)

.....

.....

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(d) (i) Explain the process by which a proton is given energy in a particle accelerator.

(3)

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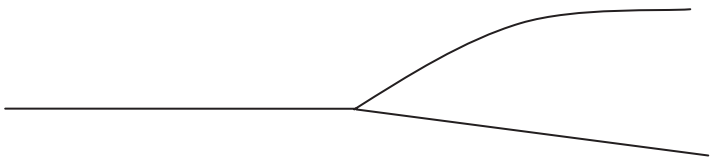
The diagram shows a collision between a high-energy proton (track from the left) and a stationary proton in a particle accelerator experiment.



(ii) Explain why the angle between the two paths is not 90°.

(2)

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.....

(e) Deduce the direction of the magnetic field in this particle accelerator experiment. Circle the correct direction from those given below.

(1)

left to right across the paper out of the plane of the paper into the plane of the paper

(Total for Question 17 = 11 marks)

***18** In 1961 Murray Gell-Mann predicted the existence of a new particle called an omega (Ω) minus. It was subsequently discovered in 1964.

At this time the quark model consisted of three particles, the properties of which are given in the table.

Quark	Charge	Predicted mass in MeV/c^2
Up (u)	$+\frac{2}{3}$	4
Down (d)	$-\frac{1}{3}$	4
Strange (s)	$-\frac{1}{3}$	80

(a) Explain what a charge of $+\frac{2}{3}$ means.

(1)

.....

.....

(b) State the predicted mass of, and the charge on a $\bar{s}$.

(2)

.....

.....

(c) Convert 4 MeV/c^2 to kg.

(3)

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Mass = ... kg

(d) The event which led to the discovery of the omega minus particle can be summarised as follows. A negative kaon collided with a stationary proton and produced a positive kaon, a neutral kaon and the omega minus.

(i) Kaons K consist of combinations of either an up or down quark plus a strange quark. The omega minus consists of three strange quarks.

Complete the following table by ticking the appropriate boxes.

(2)

	Meson	Baryon	Nucleon	Lepton
Negative kaon				
Omega minus				

(ii) Write an equation using standard particle symbols to summarise this event.

(2)

.....

.....

.....

.....

(iii) The negative kaon consists of $\bar{u}$ s. Deduce the quark structure of the other two kaons involved in this event.

(2)

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.....

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.....

(iv) The total mass of the three particles created after this event is larger than the total mass of the two particles before. Discuss the quantities that must be conserved in interactions between particles and use an appropriate conservation law to explain this increase in mass.

(5)

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(Total for Question 18 = 17 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

Write your name here

Surname	Other names

Centre Number | Candidate Number

Edexcel GCE

Physics

Advanced

Unit 4: Physics on the Move

Thursday 27 January 2011 – Afternoon
Time: 1 hour 35 minutes

Paper Reference
6PH04/01

You must have:
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.
- 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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N 3 7 9 6 9 A 0 1 2 4

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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 The area under a force-time graph represents

☒ **A** acceleration.

☒ **B** change in momentum.

☒ **C** displacement.

☒ **D** kinetic energy.

(Total for Question 1 = 1 mark)

2 A unit for flux linkage is the

☒ **A** tesla.

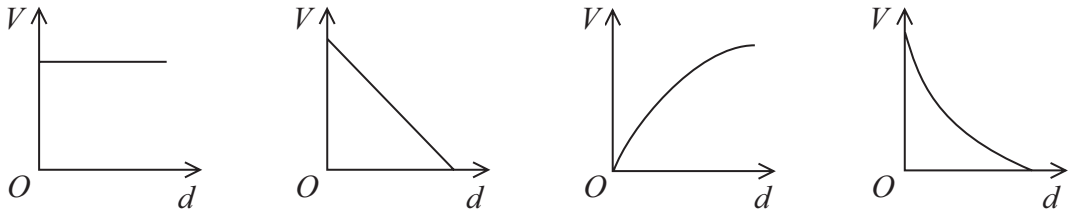
☒ **B** tesla per square metre.

☒ **C** weber.

☒ **D** weber per square metre.

(Total for Question 2 = 1 mark)

3 The electric field strength between two parallel plates is uniform. Which graph shows how the potential V varies with distance d from the positive plate?



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

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 3 = 1 mark)

4 The process by which electrons are released from a heated filament is known as

☒ **A** thermionic emission.

☒ **B** photoelectric emission.

☒ **C** ionisation.

☒ **D** excitation.

(Total for Question 4 = 1 mark)

5 A particle, mass 0.020 kg, is moving with an angular velocity of 3π rad s^{-1} around a circle of radius 0.50 m. The force, in N, responsible for this motion is

☒ **A** 0.03π towards the centre of the circle.

☒ **B** 0.03π away from the centre of the circle.

☒ **C** $0.09\pi^2$ towards the centre of the circle.

☒ **D** $0.09\pi^2$ away from the centre of the circle.

(Total for Question 5 = 1 mark)

6 The force on a proton at a point in an electric field is 4.8×10^{-19} N.

The electric field strength at that point is

☒ **A** 7.7×10^{-38} N C^{-1} in the opposite direction to the force.

☒ **B** 7.7×10^{-38} N C^{-1} in the same direction as the force.

☒ **C** 3.0×10^{-19} N C^{-1} in the opposite direction to the force.

☒ **D** 3.0 N C^{-1} in the same direction as the force.

(Total for Question 6 = 1 mark)

7 Which **one** of the following might **not** apply in interactions between sub atomic particles?

☒ **A** charge conservation

☒ **B** energy conservation

☒ **C** matter conservation

☒ **D** momentum conservation

(Total for Question 7 = 1 mark)

8 A pion could consist of

☒ **A** $u\bar{d}$

☒ **B** ud

☒ **C** uud

☒ **D** $uu\bar{d}$

(Total for Question 8 = 1 mark)

9 Data at the back of the examination paper can be used with the formula $\Delta E = c^2 \Delta m$ to calculate

☒ **A** the amount of energy in a proton.

☒ **B** the mass of coal that produces 6 MJ of energy when burnt.

☒ **C** the energy produced when an electron and a positron annihilate.

☒ **D** the energy produced when two protons collide.

(Total for Question 9 = 1 mark)

10 A particle X has kinetic energy E and momentum p. Another particle Y of the same mass as X has a momentum $2p$. The kinetic energy of Y is

☒ **A** $\frac{1}{2}E$

☒ **B** E

☒ **C** $2E$

☒ **D** $4E$

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 A particle called a B meson has been observed to decay into an antiproton plus a lambda (Λ) particle. The lambda particle consisted of an up, a down and a charmed quark.
The following table summarises the charges on these quarks.

Quark	Charge / *e*
Up (u)	$+\frac{2}{3}$
Down (d)	$-\frac{1}{3}$
Charm (c)	$+\frac{2}{3}$

(a) Circle the correct word from the list below to describe the lambda particle.

(1)

Baryon Lepton Meson Anti-particle

(b) Calculate the charge on the lambda particle.

(1)

.....

.....

Charge = ...

(c) Write an equation using standard particle symbols for this decay.

(2)

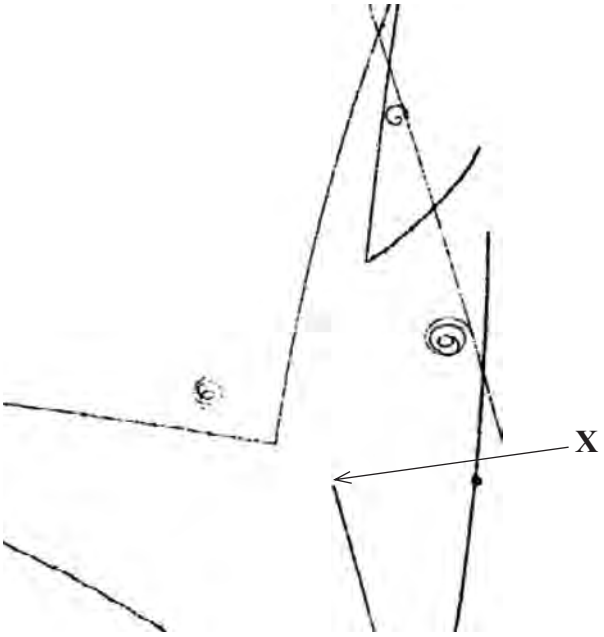
.....

.....

.....

(Total for Question 11 = 4 marks)

***12** The photograph shows tracks produced by charged particles in a bubble chamber.



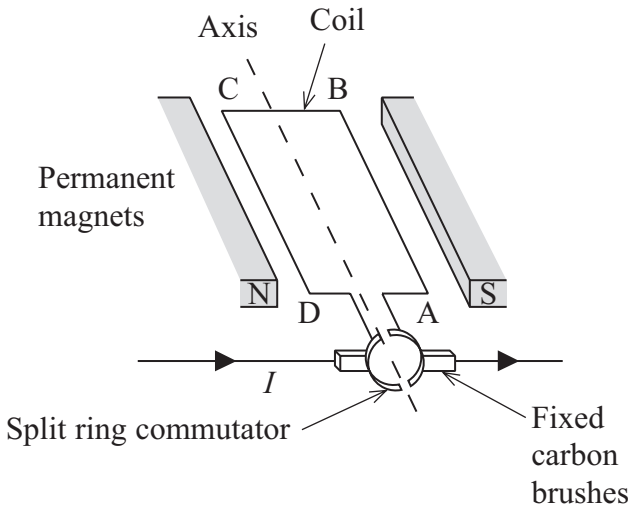
At X, an incoming charged particle interacts with a stationary proton to produce a neutral lambda particle and a neutral kaon particle. Both these particles later decay into other particles.

With reference to the photograph, describe and explain the evidence provided for this event.

(4)

(Total for Question 12 = 4 marks)

13 The simplified diagram shows a d.c. electric motor. The split ring commutator consists of two copper semicircular sections attached to either end of a coil. Fixed carbon brushes rub against, and make electrical connections to, the split ring commutator.



(a) Explain why the coil turns and why it continues to rotate. Add to the diagram to help your explanation.

(4)

*(b) When the motor is first switched on the current I is large. As the coil turns faster, the current decreases.

Explain these observations.

(4)

(Total for Question 13 = 8 marks)

14 Muons have the same charge as electrons and can be produced by particle experiments. Muons belong to a family of fundamental particles called leptons. Muons have a short life and decay to electrons. Exotic atoms can be produced in which muons have been substituted for electrons. For example, muonic hydrogen consists of a proton and a muon.

(a) What is meant by a fundamental particle?

(1)

.....

(b) Sketch the electric field around a muon.

(3)

(c) The mass of a muon is 106 MeV/c^2. Show that its mass is about 200 times that of an electron.

(3)

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.....

(d) Calculate the electric force between the muon and proton in the muonic hydrogen atom.

distance between muon and proton = 2.7×10^{-13} m

(2)

Electric force = ...

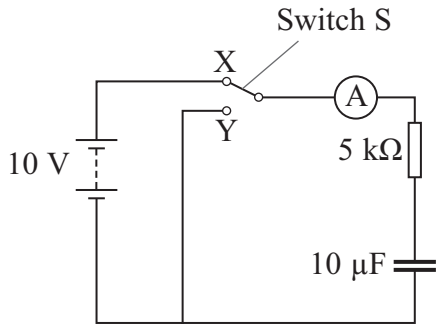
(e) Emission line spectra in the X-ray region of the electromagnetic spectrum can be detected from muonic hydrogen atoms.

Outline the atomic processes that produce emission spectra and suggest why they are X-rays in this case.

(3)

(Total for Question 14 = 12 marks)

15 A student sets up the circuit shown in the diagram.



(a) (i) She moves switch S from X to Y. Explain what happens to the capacitor.

(2)

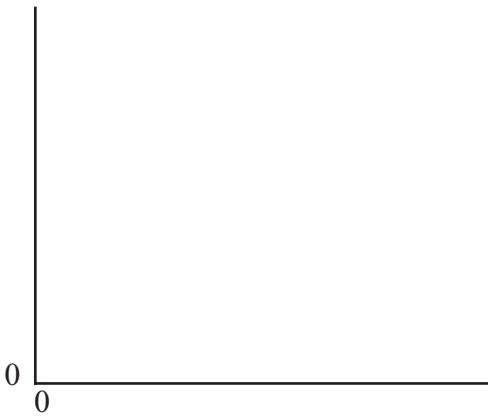
.....

.....

.....

(ii) On the axis below, sketch a graph to show how the current in the ammeter varies with time from the moment the switch touches Y. Indicate typical values of current and time on the axes of your graph.

(3)



(iii) Describe how the graph would appear when the switch is moved back to X.

(2)

.....

.....

.....

(b) Calculate the maximum energy stored on the capacitor in this circuit.

(2)

.....

.....

.....

Maximum energy = ...

(c) The student wants to use this circuit to produce a short time delay, equal to the time it takes for the potential difference across the capacitor to fall to 0.07 of its maximum value.

Calculate this time delay.

(2)

.....

.....

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.....

.....

Time delay = ...

(Total for Question 15 = 11 marks)

16 (a) Describe the key observations of the alpha particle scattering experiments which led to Rutherford's nuclear model of the atom.

(3)

(b) Experiments at Stanford University's linear accelerator (linac) accelerate electrons up to energies of 20 GeV.

(i) State the main features of a linac.

(3)

(ii) Calculate the de Broglie wavelength of 20 GeV electrons. At these energies, the following relativistic equation applies $E = pc$.

(3)

De Broglie wavelength = ...

(iii) Suggest why these electrons would be particularly useful for investigating nuclear structure.

(1)

(iv) These electrons can be aimed at a hydrogen target. Some of these electrons are scattered at large angles by the protons whilst others pass straight through.

Suggest what this tells you about the structure of a proton.

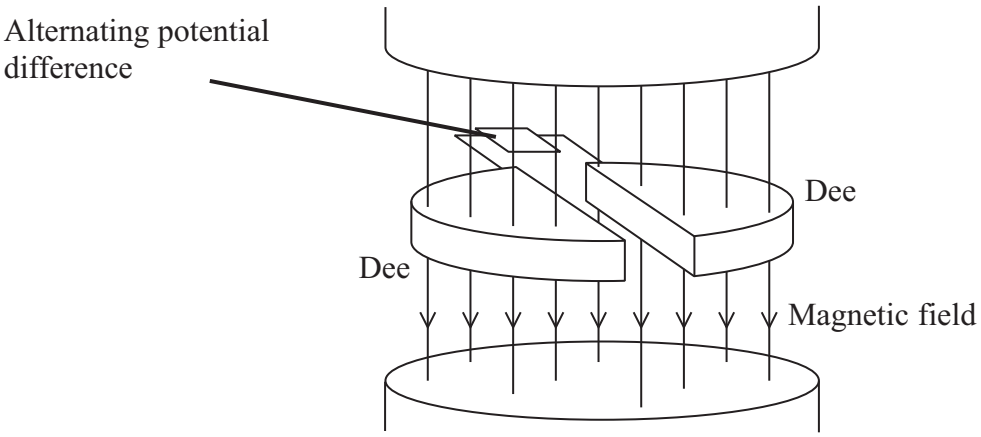
(2)

(v) The scattering process is inelastic. What is meant by an inelastic collision?

(1)

(Total for Question 16 = 13 marks)

17 (a) A cyclotron can be used to accelerate charged particles.



Explain the purpose of the magnetic field in a cyclotron. You may add to the diagram if you wish.

(2)

(b) A beam of low-speed protons are introduced into a cyclotron.

(i) Show that the number of revolutions per second, f, completed by the protons is given by

$$f = \frac{eB}{2\pi m}$$

where e is the electronic charge
B is the uniform magnetic flux density within the cyclotron
m is the mass of the proton.

(3)

(ii) An alternating potential difference is placed across the two dees to increase the energy of the protons.

Explain why the potential difference that is used is alternating.

(2)

(iii) Initially, whilst the proton speeds are low, the frequency at which the potential difference has to alternate is constant.

Explain how the frequency must change as the protons gain more and more energy.

(2)

(c) In the Large Hadron Collider at CERN, protons follow a circular path with speeds close to the speed of light. X-rays can be produced by free protons which are accelerating.

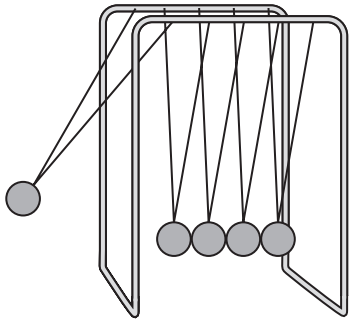
Explain why this provides a source of X-rays even though the speeds of the protons are constant.

(2)

(Total for Question 17 = 11 marks)

18 A student is using a 'Newton's Cradle'. This consists of a set of identical solid metal balls hanging by threads from a frame so that they are in contact with each other.

She initially pulls one ball to the side as shown.



She releases the ball, it collides with the nearest stationary ball and stops. The ball furthest to the right immediately moves away. The middle three balls remain stationary.

*(a) Explain what measurements the student would take and describe how she would use them to investigate whether momentum had been conserved in this event.

(4)

(b) The student makes the following observations:

- the ball on the right returns and collides with a similar result; this repeats itself a number of times
- after a while, the middle balls are also moving
- shortly afterwards, the balls all come to rest.

Discuss these observations in terms of energy.

(3)

(Total for Question 18 = 7 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

Write your name here

Surname	Other names

Centre Number | Candidate Number

Edexcel GCE

Physics

Advanced
Unit 4: Physics on the Move

Tuesday 21 June 2011 – Morning
Time: 1 hour 35 minutes

Paper Reference
6PH04/01

You must have:
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.
- 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 3 8 4 1 6 A 0 1 2 4

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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 A body is falling freely under gravity. The rate at which the body's momentum is changing is equal to its

☒ **A** acceleration.

☒ **B** kinetic energy.

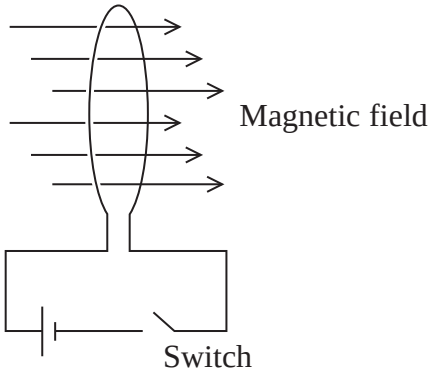
☒ **C** potential energy.

☒ **D** weight.

(Total for Question 1 = 1 mark)

---

2 A circular loop of thin wire is placed so that its plane is perpendicular to a magnetic field as shown.



As the switch is closed, the loop of wire will

☒ **A** become a circle of smaller radius.

☒ **B** not change.

☒ **C** rotate about its centre.

☒ **D** rotate so that its plane is parallel to the field.

(Total for Question 2 = 1 mark)

---

3 The unit of the time constant for a resistor-capacitor circuit is

☒ **A** $\Omega\ F^{-1}$

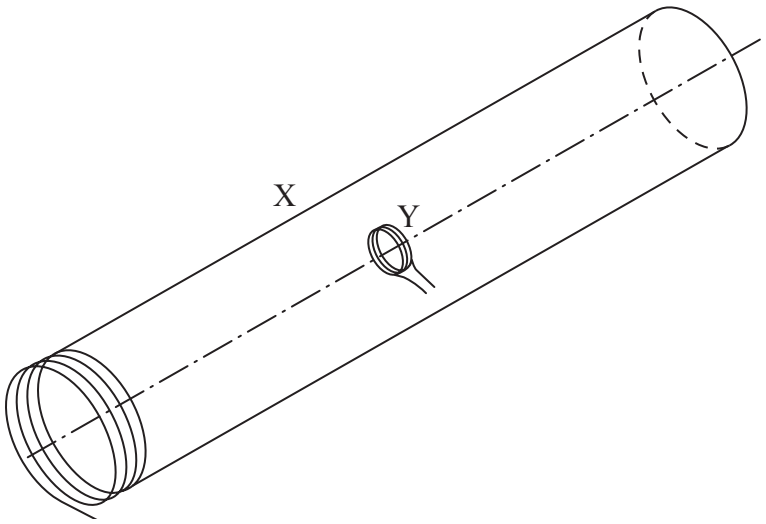
☒ **B** $\Omega\ C$

☒ **C** s

☒ **D** s F

(Total for Question 3 = 1 mark)

4 The diagram represents two coils. Coil X has 1000 turns and a cross-sectional area of 10 cm^2. It is carrying a current which produces a field of magnetic flux density 0.002 T. Coil Y has 50 turns and a cross-sectional area of 4 cm^2.



The flux linkage with coil Y is

☒ **A** 0.4 Wb

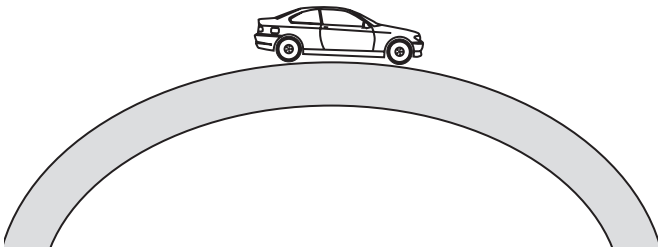
☒ **B** 2×10^{-3} Wb

☒ **C** 4×10^{-5} Wb

☒ **D** 8×10^{-7} Wb

(Total for Question 4 = 1 mark)

5 A car, mass m, drives over a circular hump-back bridge of radius r with a constant speed v.



When it is at the top of the bridge, the force on the car from the bridge is given by

☒ **A** mg

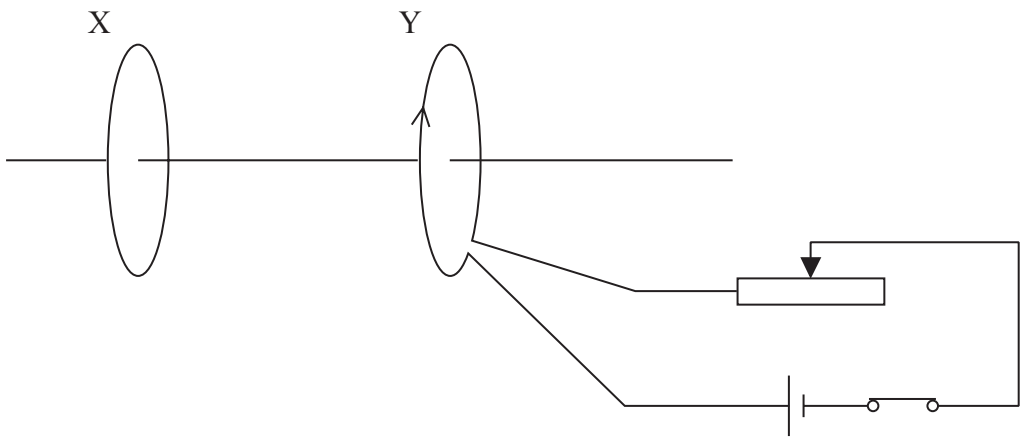
☒ **B** $\frac{mv^2}{r} + mg$

☒ **C** $\frac{mv^2}{r} - mg$

☒ **D** $mg - \frac{mv^2}{r}$

(Total for Question 5 = 1 mark)

6 The diagram represents two identical coils X and Y. The planes of both coils are parallel and their centres lie on a common axis.



Coil Y is connected to a cell, a variable resistor and a closed switch.

Under which of the following circumstances would a current be induced in coil X in the same direction as the current shown in coil Y?

- ☒ **A** The coils are moved closer together.
- ☒ **B** The switch is opened.
- ☒ **C** The resistance of the variable resistor is decreased.
- ☒ **D** No change is made to the arrangement.

(Total for Question 6 = 1 mark)

7 A proton is moving in a circle, radius 1.5 m, within a magnetic field of flux density 0.020 T. The speed of the proton is

- ☒ **A** 4.8×10^{-21} m s^{-1}
- ☒ **B** 2.9×10^{6} m s^{-1}
- ☒ **C** 5.3×10^{9} m s^{-1}
- ☒ **D** 1.8×10^{25} m s^{-1}

(Total for Question 7 = 1 mark)

8 A positron is found to have a mass of 1.8×10^{-29} kg. It can be concluded that this positron is

☒ **A** a proton.

☒ **B** travelling at close to the speed of light.

☒ **C** travelling at a non-relativistic speed.

☒ **D** travelling in a circle.

(Total for Question 8 = 1 mark)

9 The mass in MeV/c^2 of a 1.8×10^{-29} kg positron is

☒ **A** 10

☒ **B** 3.2×10^{-59}

☒ **C** 3.3×10^{-8}

☒ **D** 1.0×10^{7}

(Total for Question 9 = 1 mark)

10 The Large Hadron Collider is designed to accelerate protons to very high energies for particle physics experiments. Very high energies are required to

☒ **A** annihilate hadrons.

☒ **B** collide hadrons.

☒ **C** create particles with large mass.

☒ **D** produce individual quarks.

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 The de Broglie wave equation can be written $\lambda = \sqrt{\frac{h^2}{2mE_k}}$ where m is the mass of a particle and E_k is its kinetic energy.

(a) Derive this equation. Use the list of equations at the end of this question paper.

(2)

(b) An electron is accelerated through a potential difference of 2500 V.

Using the equation $\lambda = \sqrt{\frac{h^2}{2mE_k}}$ calculate the de Broglie wavelength of this electron.

(3)

Wavelength = ...

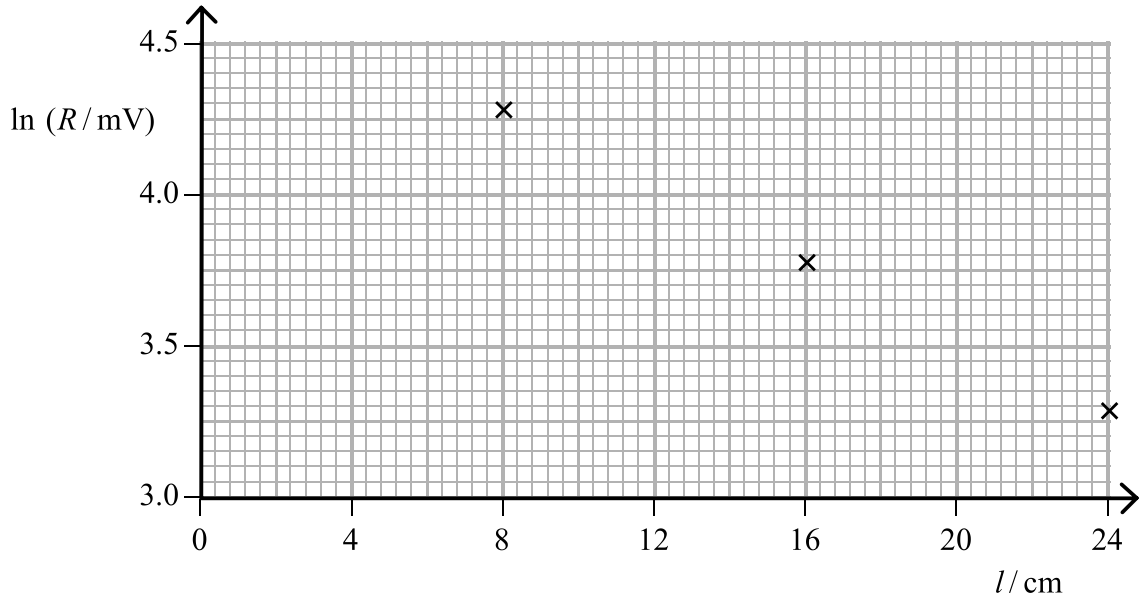
(Total for Question 11 = 5 marks)

12 A student carries out a practical involving a length of jelly. She places an infrared transmitter at one end and a receiver at the other. She obtains the following results.

Length of jelly l / cm	Receiver reading R / mV	ln (R / mV)
8.0	72	4.28
12.0	57	
16.0	43	3.76
20.0	33	
24.0	26	3.26

(a) Complete the table above and the graph below.

(2)



(b) The student reads that infrared light in jelly can be mathematically modelled using the equation $R = R_0e^{-\mu l}$ where μ is a constant.

Use your graph to determine a value of μ for the jelly.

(2)

.....

.....

.....

μ = ...

(Total for Question 12 = 4 marks)

13 A student needs to order a capacitor for a project. He sees this picture on a web site accompanied by this information: capacitance tolerance ±20%.

Taking the tolerance into account, calculate

(a) the maximum charge a capacitor of this type can hold.

(3)

.....

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Maximum charge = ...

(b) the maximum energy it can store.

(2)

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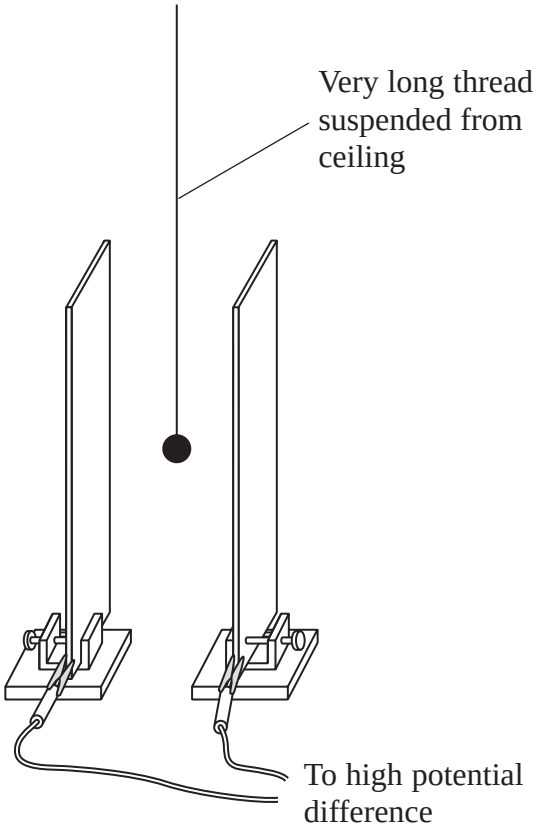
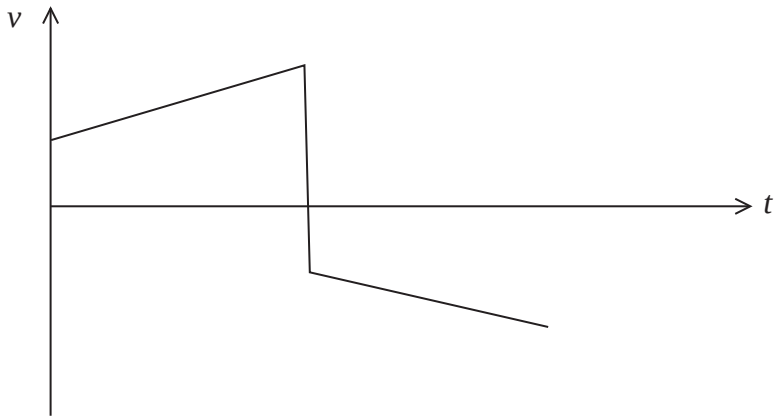
Maximum energy = ...

(Total for Question 13 = 5 marks)

***14** A student has been asked to talk to her class about electric fields. As part of her presentation she hangs a table tennis ball, covered in a carbon coating, between two parallel plates connected to a high potential difference.



She pulls the ball across so that it touches one of the plates and then releases it.
The ball then continues to bounce between the two plates.
She sketches a graph of velocity v of the ball with time t from the time the ball leaves a plate until it returns.



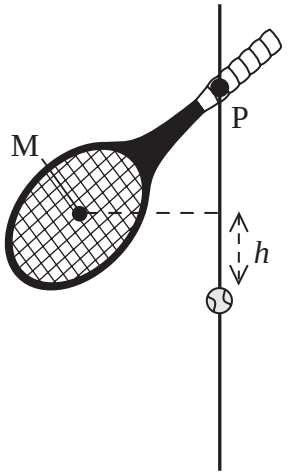
Explain the shape of the velocity-time graph for the ball from when it leaves one plate until it returns to the same plate. Ignore the weight of the ball.

(4)

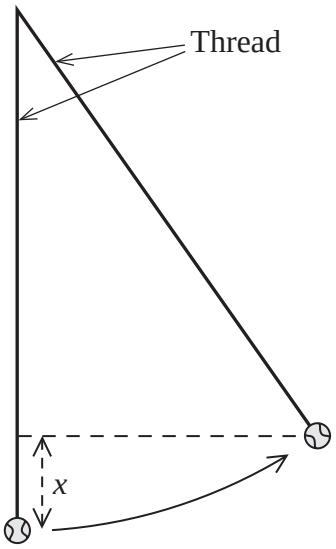
(Total for Question 14 = 4 marks)

15 A student is carrying out an investigation into collisions between a bat and a ball.

The bat is pivoted at a point P so that it can swing freely. The centre of mass M of the bat swings through an arc and hits the ball. M moves through a height *h* as shown below.



The ball is suspended vertically by a thread. The bat hits the ball which swings to a maximum height *x*.



One set of measurements is $h = 0.030$ m $x = 0.10$ m

(a) Show that the speed of M just before the collision is about 0.8 m s^{-1}.

(2)

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.....

(b) The student calculates the speed of the ball just after the collision to be 1.4 m s^{-1}.
The mass of the bat is 320 g and the ball is 55 g.

Calculate the speed of the bat just after the collision and state one assumption you make.

(4)

Speed of bat = ...

Assumption: .....

(c) Determine whether the collision was elastic or inelastic.

(3)

(d) Discuss your conclusion with reference to possible uncertainties in the measurements of *x*.

(2)

(Total for Question 15 = 11 marks)

16 (a) Sketch the electric field surrounding the gold nucleus drawn below.

(3)

(b) The spreadsheet shown approximately models the behaviour of an alpha particle as it approaches a gold nucleus.

The proton number of gold is 79.
mass of alpha particle = 6.64×10^{-27} kg

	A	B	C	D	E
1	**Distance from gold nucleus / m**	**Magnitude of force on alpha particle / N**	**Time interval / s**	**Velocity at end of time interval / m s^{-1}**	**Displacement of alpha particle in time interval / m**
2	8.60E-14	4.92E+00	1.00E-21	1.53E+07	1.56E-14
3	7.04E-14	7.34E+00	1.00E-21	1.42E+07	1.47E-14
4	5.57E-14	1.17E+01	1.00E-21	1.24E+07	1.33E-14
5	4.24E-14	2.02E+01	1.00E-21	9.34E+06	1.09E-14
6	3.15E-14	3.66E+01	1.00E-21	3.83E+06	6.58E-15
7	2.49E-14	5.84E+01	1.00E-21	−4.97E+06	−5.69E-16
8	2.55E-14	5.59E+01	1.00E-21	−1.34E+07	−9.18E-15
9	3.47E-14	3.02E+01	1.00E-21	−1.79E+07	−1.57E-14
10	5.03E-14	1.43E+01	1.00E-21	−2.01E+07	−1.90E-14

(i) Show how cell B3 is calculated.

(2)

.....

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.....

.....

(ii) Show how cell D5 is calculated.

(3)

.....

.....

.....

.....

(iii) Show how cell E6 is calculated.

(2)

.....

.....

(iv) Suggest a value for the maximum radius of a gold nucleus based on the results from this spreadsheet.

(1)

Maximum radius = ...

*(c) Describe the conclusions Rutherford reached about the structure of gold atoms as a result of the alpha particle scattering experiments.

(3)

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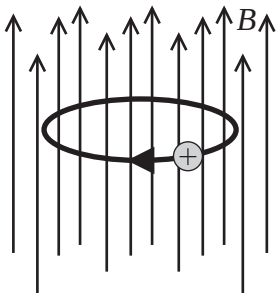
(Total for Question 16 = 14 marks)

17 A strong magnetic field of flux density B can be used to trap a positive ion by making it follow a circular orbit as shown.



(a) Explain how the magnetic field maintains the ion in a circular orbit. You may add to the diagram above if you wish.

(2)

.....

.....

(b) Show that the mass m of the ion will be given by

$$m = \frac{Bq}{2\pi f}$$

where q is the charge on the ion and f is the number of revolutions per second.

(3)

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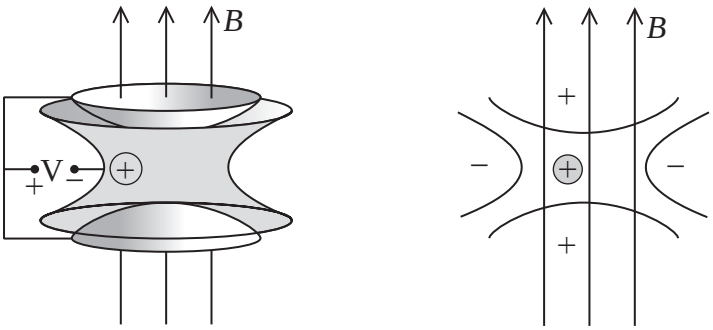
(c) The above arrangement will not prevent a positive ion from moving vertically. To do this, a weak electric field is applied using the arrangement shown below.



(i) Explain how the electric field prevents the ion moving vertically.

(2)

.....

.....

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.....

(ii) This device is known as a Penning Trap. It can be used to determine the mass of an ion to an accuracy of 3 parts in 10 million.

Confirm that the mass of a sulphur ion can be measured to the nearest 0.00001u.

mass of sulphur ion = 32.0645u

(2)

.....

.....

.....

(iii) Under certain conditions nuclei of sulphur emit a gamma ray with a known energy of 2.2 MeV.

Calculate the resulting loss in mass of a sulphur ion in u and confirm that this value could be determined by the Penning Trap technique.

(4)

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(Total for Question 17 = 13 marks)

18 Evidence for a charm quark was discovered in 1974 at the linear accelerator (linac) at Stanford University.

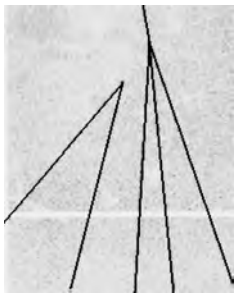
(a) Why do the tubes of a linac become progressively longer down its length?

(1)

.....

.....

(b) This image shows the decay of a D^0 meson into a positively charged kaon and a negatively charged pion.



(i) Mark on the image the point P at which this decay occurs.

(1)

(ii) Give **two** reasons for choosing this point.

(2)

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.....

(iii) Write an equation for this decay event.

(2)

.....

.....

.....

.....

*(iv) State and discuss how three conservation laws apply to this decay event.

(6)

Question 18 continues on the next page

(c) The table below shows some quarks and their properties.

Quark	Charge / *e*
Up (u)	$+\frac{2}{3}$
Down (d)	$-\frac{1}{3}$
Strange (s)	$-\frac{1}{3}$
Charm (c)	$+\frac{2}{3}$

(i) Circle the correct combination of quarks in the list below which corresponds to a D^0 meson.

(1)

$c\bar{u}$ cds $c\bar{s}$ cud

(ii) Suggest a possible quark combination of the positively charged kaon.

(1)

.....

.....

(Total for Question 18 = 14 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

Write your name here

Surname	Other names

Centre Number | Candidate Number

Edexcel GCE

Physics

Advanced

Unit 4: Physics on the Move

Tuesday 24 January 2012 – Afternoon
Time: 1 hour 35 minutes

Paper Reference
6PH04/01

You must have:
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.
- 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 ▶

P39849A

1/1/1/1/1/

P 3 9 8 4 9 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 The momentum of a particle is p. The kinetic energy of the particle is doubled.

The momentum is now

☒ **A** $\sqrt{2}\,p$

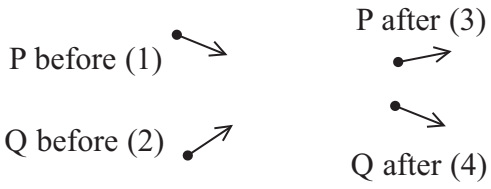
☒ **B** $2p$

☒ **C** $4p$

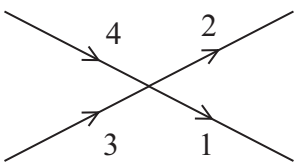
☒ **D** $8p$

(Total for Question 1 = 1 mark)

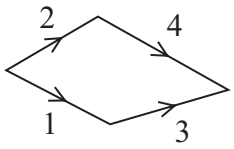
2 The diagram represents the collision between two sub-atomic particles P and Q moving with momenta 1 and 2 respectively. After the collision they have momenta 3 and 4 respectively.



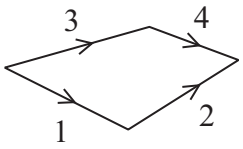
Which vector diagram best shows the correct relationship for the momenta of P and Q?



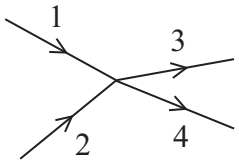
A



B



C



D

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 2 = 1 mark)

3 A student is sitting on the right-hand side in a bus, facing the direction of travel. The bus goes round a bend to the left. The student remains in the same position within the bus.

The student experiences

☒ **A** a force to the left and a force to the right.

☒ **B** a resultant force to the left.

☒ **C** a resultant force to the right.

☒ **D** no resultant force.

(Total for Question 3 = 1 mark)

4 The unit of flux linkage is

☒ **A** T

☒ **B** T m^{-2}

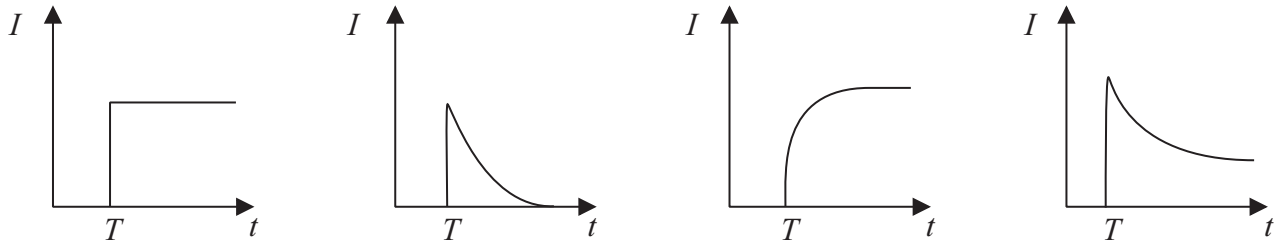
☒ **C** Wb

☒ **D** Wb m^{-2}

(Total for Question 4 = 1 mark)

5 An electric motor is connected via a switch to a battery. A graph is plotted to show the variation of current *I* with time *t*. The switch is closed at time *T*.

Which of the following graphs is correct?



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

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 5 = 1 mark)

6 Deuterium $^{2}_{1}H$ is an isotope of hydrogen.

An atom of deuterium has

		protons	neutrons	electrons
☒	**A**	1	2	2
☒	**B**	1	1	1
☒	**C**	2	1	2
☒	**D**	1	0	1

(Total for Question 6 = 1 mark)

7 The rest mass of a proton is 1.67×10^{-27} kg. This mass, in MeV/c^2 is approximately

☒ **A** 2.4×10^{-20}

☒ **B** 3.1×10^{-6}

☒ **C** 1.0

☒ **D** 940

(Total for Question 7 = 1 mark)

8 A positive kaon (K^+) is a meson which includes a strange quark. Its structure could be

☒ **A** $u\bar{s}$

☒ **B** us

☒ **C** $\bar{s}\bar{d}\bar{d}$

☒ **D** usd

(Total for Question 8 = 1 mark)

9 The K^+ is likely to decay to

☒ **A** $\pi^+ + \mu^- + \bar{\nu}_\mu$

☒ **B** $\pi^+ + \pi^0$

☒ **C** $\pi^+ + \pi^-$

☒ **D** $\pi^0 + \mu^- + \bar{\nu}_\mu$

(Total for Question 9 = 1 mark)

10 The de Broglie wavelength of a moving tennis ball is calculated as 1×10^{-33} m. This means that the moving tennis ball

☒ **A** diffracts through a narrow slit.

☒ **B** does not behave as a particle.

☒ **C** does not display wave properties.

☒ **D** is travelling at the speed of light.

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 (a) Explain what is meant by a uniform electric field.

(2)

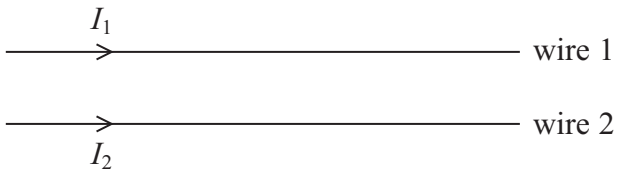
(b) Describe how a uniform electric field can be demonstrated in a laboratory.

(3)

(Total for Question 11 = 5 marks)

***12** In 1820 Hans Oersted did an experiment with an electric current in a wire. He noticed that whenever the current was on, it affected a compass needle lying near the wire.

A few years later, André Ampere observed that two parallel wires attract each other if they are carrying current in the same direction.



Explain André Ampere's observation. You may wish to add to the diagram.

(5)

(Total for Question 12 = 5 marks)

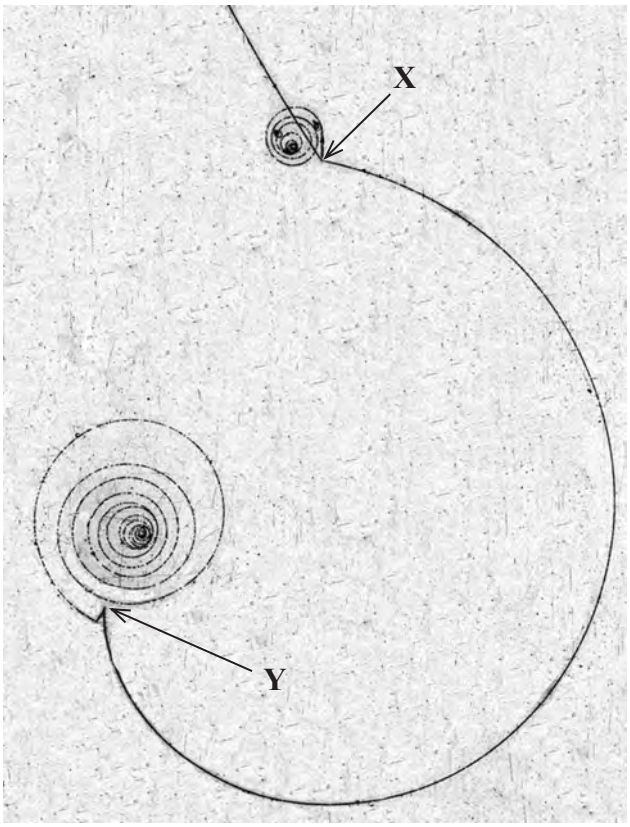
***13** At the beginning of the last century, experiments were performed using alpha particles and gold foil. The alpha particles were directed at the gold foil and a detector was used to see if and where they were scattered.

Summarise the results from these experiments and the conclusions that were drawn from them.

(5)

(Total for Question 13 = 5 marks)

14 The photograph shows tracks in a particle detector.



(a) Explain the role of a magnetic field in a particle detector.

(2)

(b) Explain how you can tell that track XY was produced by a particle moving from X to Y rather than from Y to X.

(2)

(c) The particle that produced track XY was a π^+. Deduce the direction of the magnetic field in the photograph.

(1)

.....

.....

(d) At Y, the π^+ decayed into a positively charged muon (μ^+) and a muon neutrino. The μ^+ has a very short range before decaying into various particles, including a positron which produced the final spiral.

(i) Give **two** reasons why you can deduce that the muon neutrino is neutral.

(2)

1 .....

.....

.....

2 .....

.....

.....

(ii) Explain the evidence from the photograph for the production of the muon neutrino at Y.

(3)

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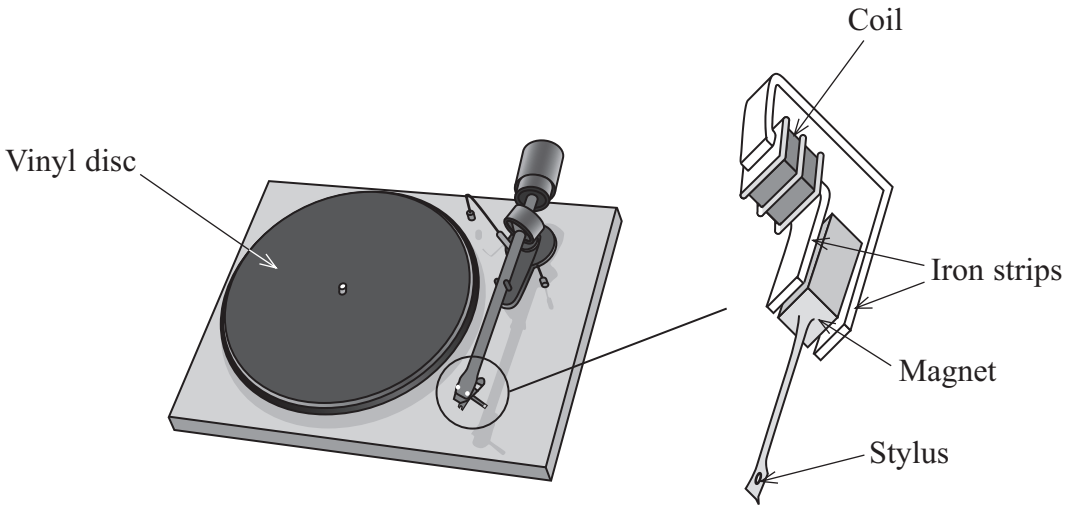
.....

(Total for Question 14 = 10 marks)

15 A vinyl disc is used to store music. When the disc is played, a stylus (needle) moves along in a groove in the disc. The disc rotates and bumps in the groove cause the stylus to vibrate.



The stylus is attached to a small magnet which is near to a coil of wire. When the stylus vibrates, there is a potential difference across the terminals of the coil.

(a) Explain the origin of this potential difference.

(4)

(b) The potential difference is then amplified and sent to a loudspeaker. Long-playing vinyl discs (LPs) have to be rotated at 33 rpm (revolutions per minute) so that the encoded bumps in the groove lead to the correct sound frequencies.

(i) Calculate the angular velocity of an LP.

(2)

Angular velocity = ...

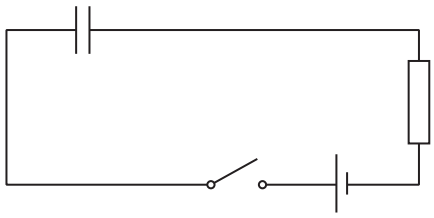
(ii) As the stylus moves towards the centre of the LP the encoded bumps must be fitted into a shorter length of groove.

Explain why the encoding of bumps in the groove becomes more compressed as the stylus moves towards the centre.

(3)

(Total for Question 15 = 9 marks)

16 The diagram shows a circuit that includes a capacitor.



(a) (i) Explain what happens to the capacitor when the switch is closed.

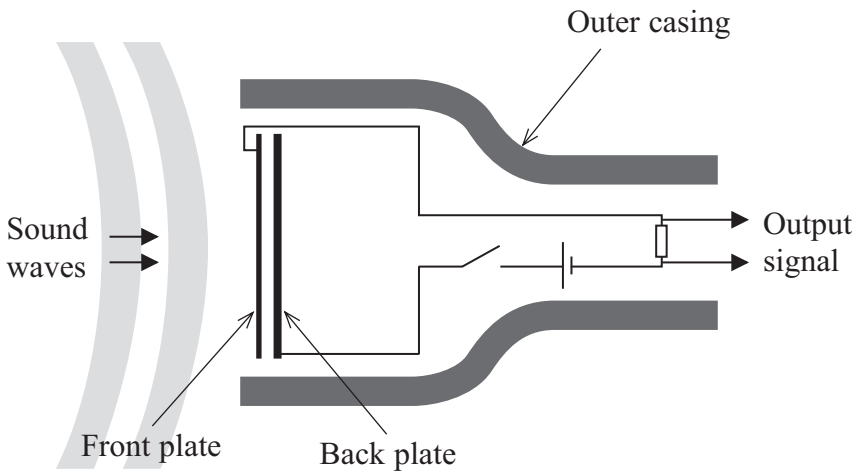
(2)

(ii) The potential difference (p.d.) across the resistor rises to a maximum as the switch is closed.

Explain why this p.d. subsequently decreases to zero.

(2)

*(b) One type of microphone uses a capacitor. The capacitor consists of a flexible front plate (diaphragm) and a fixed back plate. The output signal is the potential difference across the resistor.



The sound waves cause the flexible front plate to vibrate and change the capacitance. Moving the plates closer together increases the capacitance. Moving the plates further apart decreases the capacitance.

Explain how the sound wave produces an alternating output signal.

(4)

(c) A microphone has a capacitor of capacitance 500 pF and resistor of resistance 10 MΩ.

Explain why these values are suitable even for sounds of the lowest audible frequency of about 20 Hz.

(4)

(Total for Question 16 = 12 marks)

17 Anti-hydrogen atoms have been created at CERN. An anti-hydrogen atom consists of an anti-proton and a positron.

(a) Compare the properties of an anti-hydrogen atom with a hydrogen atom.

(2)

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.....

(b) Calculate the electrostatic force of attraction between the positron and the anti-proton.

Assume that the radius of the anti-hydrogen atom is 5.3×10^{-11} m.

(3)

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Force = ...

(c) Scientists want to find out if anti-hydrogen atoms emit the same spectra as hydrogen atoms. Anti-protons are relatively easy to contain, however, it is very difficult to contain anti-hydrogen atoms for any period of time.

Explain why it is difficult to contain anti-hydrogen atoms compared with anti-protons.

(2)

(d) The technology suggested in the science fiction series, Star Trek, for powering the Starship Enterprise relied on antimatter. When an anti-hydrogen atom meets a hydrogen atom, they annihilate and produce energy.

(i) How much energy, in joules, would be produced by the annihilation of just 1 milligram of anti-hydrogen atoms?

(3)

Energy = ... J

(ii) Anti-protons are required to produce anti-hydrogen atoms. The total production of anti-protons on Earth over the past 25 years adds up to only a few nanograms.

Suggest why so little anti-matter has been created.

(1)

(Total for Question 17 = 11 marks)

18 James Chadwick is credited with "discovering" the neutron in 1932.

Beryllium was bombarded with alpha particles, knocking neutrons out of the beryllium atoms. Chadwick placed various targets between the beryllium and a detector. Hydrogen and nitrogen atoms were knocked out of the targets by the neutrons and the kinetic energies of these atoms were measured by the detector.

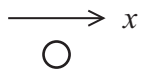
(a) The maximum energy of a nitrogen atom was found to be 1.2 MeV.

Show that the maximum velocity of the atom is about 4×10^6 m s^{-1}.

mass of nitrogen atom = $14u$, where $u = 1.66 \times 10^{-27}$ kg

(3)

(b) The mass of a neutron is Nu (where N is the relative mass of the neutron) and its initial velocity is x. The nitrogen atom, mass $14u$, is initially stationary and is then knocked out of the target with a velocity, y, by a collision with a neutron.



Neutron

Stationary nitrogen atom

(i) Show that the velocity, z, of the neutron after the collision can be written as

$$z = \frac{\mathrm{N}x - 14y}{\mathrm{N}}$$

(3)

(ii) The collision between this neutron and the nitrogen atom is elastic. What is meant by an elastic collision?

(1)

(iii) Explain why the kinetic energy E_k of the nitrogen atom is given by

$$E_k = \frac{Nu(x^2 - z^2)}{2}$$

(2)

(c) The two equations in (b) can be combined and z can be eliminated to give

$$y = \frac{2Nx}{N+14}$$

(i) The maximum velocity of hydrogen atoms knocked out by neutrons in the same experiment was 3.0×10^7 m s^{-1}. The mass of a hydrogen atom is $1u$.

Show that the relative mass N of the neutron is 1.

(3)

(ii) This equation can **not** be applied to all collisions in this experiment.

Suggest why.

(1)

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(Total for Question 18 = 13 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

Write your name here

Surname	Other names

Centre Number | Candidate Number

Edexcel GCE

Physics

Advanced

Unit 4: Physics on the Move

Monday 11 June 2012 – Afternoon
Time: 1 hour 35 minutes

Paper Reference
6PH04/01

You must have:
Protractor
Ruler

Total Marks

Instructions

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- **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
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  – *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.

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Turn over ▶

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1/1/1/1/1/1/C2

P 3 9 8 5 5 A 0 1 2 8

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 ☒.

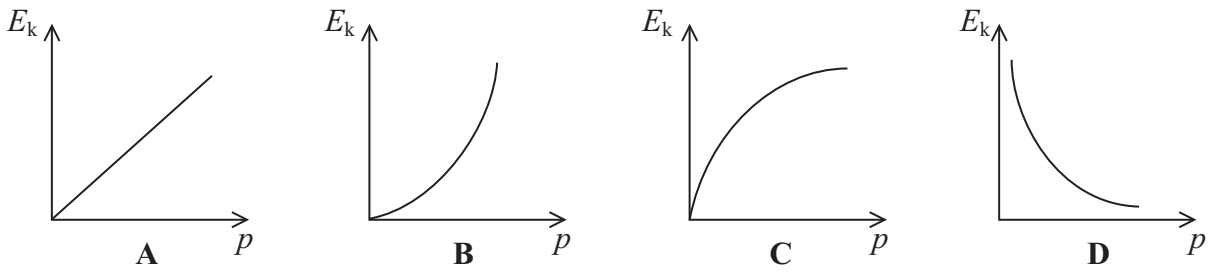
1 $^{208}_{82}Pb$ is the symbol for the heaviest, stable nucleus. The table shows possible numbers of neutrons and protons.

Which line of the table correctly shows the numbers of neutrons and protons for this nucleus?

	Number of neutrons	Number of protons
☒ **A**	82	208
☒ **B**	82	126
☒ **C**	126	82
☒ **D**	208	82

(Total for Question 1 = 1 mark)

2 A car is accelerated from rest. Which graph correctly shows how the kinetic energy E_k varies with momentum p?



☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 2 = 1 mark)

3 An inelastic collision is one in which

- ☒ **A** momentum is not conserved.
- ☒ **B** momentum and kinetic energy are not conserved.
- ☒ **C** momentum and kinetic energy are conserved.
- ☒ **D** kinetic energy is not conserved.

(Total for Question 3 = 1 mark)

4 A unit of electric field strength is

- ☒ **A** $J\ C^{-2}$
- ☒ **B** $N\ m^2\ C^{-2}$
- ☒ **C** $N\ m\ C^{-1}$
- ☒ **D** $N\ C^{-1}$

(Total for Question 4 = 1 mark)

5 A capacitor is discharging through a resistor and the time constant is 5.0 s. The time taken for the capacitor to lose half its charge is

- ☒ **A** 0.14 s
- ☒ **B** 0.81 s
- ☒ **C** 3.2 s
- ☒ **D** 3.5 s

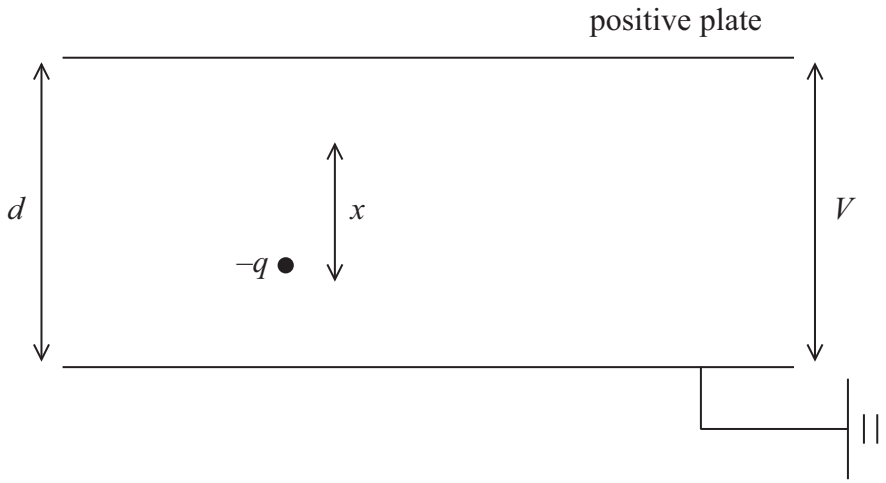
(Total for Question 5 = 1 mark)

6 Which one of the following statements does **not** help to explain why electrons can be used to probe the nuclei of atoms.

- ☒ **A** Electrons are negatively charged.
- ☒ **B** Electrons can have wavelengths similar in size to nuclear diameters.
- ☒ **C** Electrons can be accelerated to high energies.
- ☒ **D** Electrons can exhibit diffraction effects.

(Total for Question 6 = 1 mark)

7 The diagram shows two parallel plates a distance d apart. There is a potential difference V across the two plates. A particle, charge $-q$, is placed between the plates as shown. The particle is attracted to the positive plate and moves through a distance x.



Which of the following expressions gives the work done on the particle as it moves through the distance x?

☒ **A** $\frac{qV}{xd}$

☒ **B** $\frac{qVx}{d}$

☒ **C** $\frac{V}{xdq}$

☒ **D** $\frac{xV}{qd}$

(Total for Question 7 = 1 mark)

8 A coil of N turns and cross-sectional area A lies perpendicular to a magnetic field of flux density B. The magnetic flux linkage is X.

A second coil with twice the number of turns but half the cross-sectional area lies perpendicular to a magnetic field of flux density $2B$. The magnetic flux linkage with the second coil is

☒ **A** $\frac{X}{2}$

☒ **B** X

☒ **C** $2X$

☒ **D** $4X$

(Total for Question 8 = 1 mark)

9 A pion can decay to produce two leptons. Which one of the following is possible?

☒ **A** $\pi^+ \rightarrow e^+ + \nu_e$

☒ **B** $\pi^0 \rightarrow e^- + \nu_e$

☒ **C** $\pi^+ \rightarrow e^+ + e^-$

☒ **D** $\pi^0 \rightarrow \pi^+ + e^-$

(Total for Question 9 = 1 mark)

10 As a particle accelerates in a linac, it passes through drift tubes of increasing lengths. This is so that

☒ **A** the particle can be given more energy within each tube.

☒ **B** the frequency of the accelerating voltage can be constant.

☒ **C** the accelerating voltage can be as high as possible.

☒ **D** the time spent in the tube by the particle is longer.

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 The positively charged particles in the solar wind are accelerating away from the Sun. Some scientists have therefore concluded that the Sun is positively charged.

(a) Explain this conclusion.

(2)

.....

.....

.....

.....

(b) The circle below represents the Sun.

Complete the diagram to show the electric field produced by a positively-charged Sun.

(2)

(Total for Question 11 = 4 marks)

12 A spacecraft called Deep Space 1, mass 486 kg, uses an "ion-drive" engine. This type of engine is designed to be used in deep space.

The following statement appeared in a web site.

> The ion propulsion system on Deep Space 1 expels 0.13 kg of xenon propellant each day. The xenon ions are expelled from the spacecraft at a speed of 30 km s^{-1}. The speed of the spacecraft is predicted to initially increase by about 8 m s^{-1} each day.

Use a calculation to comment on the prediction made in this statement.

(4)

(Total for Question 12 = 4 marks)

13 An electron and a positron annihilate with the emission of two photons of equal energy.

Calculate the wavelength of the photons.

(5)

Wavelength = ...

(Total for Question 13 = 5 marks)

***14** A bubble chamber is a particle detector which makes use of electric and magnetic fields.

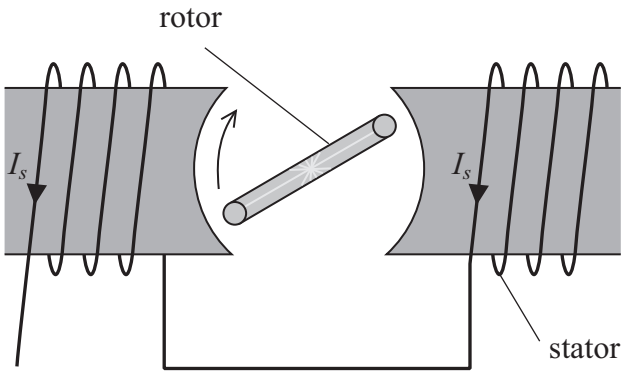
Explain the role of electric and magnetic fields in a particle detector.

(5)

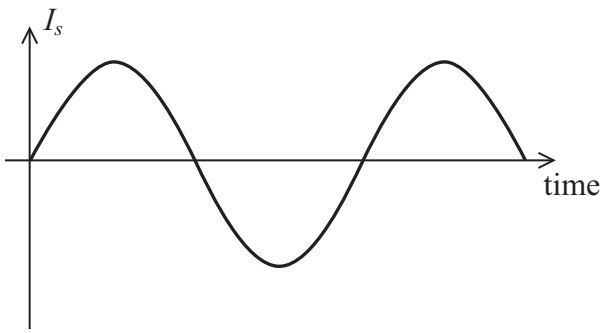
(Total for Question 14 = 5 marks)

15 The diagram represents a simple induction motor. An alternating current I_s is supplied to a stationary coil (stator). This coil is wrapped around an iron core.

A rotating coil (rotor) is shown end on in the diagram.



(a) The graph shows the variation of the alternating current I_s with time.



*(i) Explain how current is induced in the rotor coil.

(4)

(ii) Explain why the rotor turns.

(2)

(iii) State **two** ways of making the rotor turn faster.

(2)

1 .....

2 .....

(b) An induction motor is used to rotate the turntable in a record deck. Long-play records require the turntable to rotate at 33 revolutions per minute.

(i) Calculate the angular velocity of the turntable.

(3)

Angular velocity = ...

(ii) Calculate the acceleration of a speck of dust at the outside edge of a rotating record.

radius of record = 12.5 cm

(2)

.....

.....

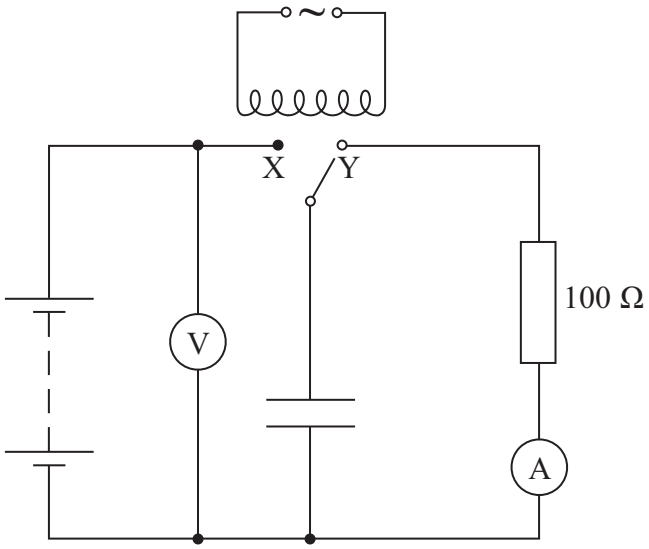
.....

.....

Acceleration = ...

(Total for Question 15 = 13 marks)

16 A student is investigating capacitors. She uses the circuit below to check the capacitance of a capacitor labelled 2.2 μF which has a tolerance of ±30%.



The switch flicks between contacts, X and Y, so that the capacitor charges and discharges *f* times per second.

(a) The capacitor must discharge fully through the 100 Ω resistor.

(i) Explain why 400 Hz is a suitable value for *f*.

(3)

(ii) Show that the capacitance C can be given by

$$C = \frac{I}{fV}$$

where I is the reading on the ammeter and V is the reading on the voltmeter.

(3)

(iii) The student records I as 5.4 mA and V as 5.0 V.

Calculate the capacitance C.

(2)

$C =$ .....

(iv) Explain whether you think this value is consistent with the tolerance given for this capacitor.

(2)

(b) Calculate the energy stored on the capacitor when it is charged to a potential difference of 5.0 V.

(2)

.....

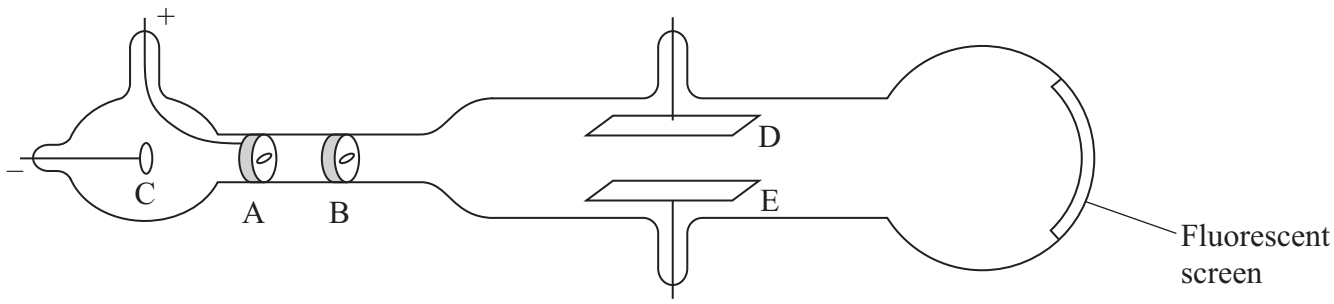
.....

.....

Energy = ...

(Total for Question 16 = 12 marks)

17 J J Thomson is credited with the discovery of the electron. He measured the 'charge to mass ratio' *e/m* for the electron, using the apparatus shown.



A metal disc at C emits electrons. A positively-charged disc at A accelerates the electrons along the tube. Slits in A and B produce a narrow horizontal beam of electrons. An electric field is produced between plates D and E, which can be used to deflect the beam vertically. The final position of the beam is shown on a fluorescent screen at the end of the tube.

(a) Describe how a metal disc can be made to emit electrons.

(2)

.....

.....

.....

.....

.....

(b) The length of plates D and E is l. Thomson deduced that the vertical component v_v of velocity gained by the electrons as they leave the plates is given by

$$v_v = \frac{Ee}{m} \times \frac{l}{v}$$

where E is the electric field strength between the plates and v is the velocity with which the electrons entered the field.

Show that this expression is correct.

(3)

(c) Thomson determined the angle θ at which the beam was deflected.

Suggest how this angle could be determined.

(3)

(d) The angle θ is also given by

$$\tan\theta = \frac{Ee}{m} \times \frac{l}{v^2}$$

Show that this equation is correct.

(2)

(e) Thomson replaced the electric field with a uniform magnetic field which acted over the same length as the plates. He adjusted the flux density B to obtain the same deflection on the screen.

For this arrangement he assumed that the vertical component of velocity gained by the electrons as they leave the plates is given by

$$v_V = \frac{Bev}{m} \times \frac{l}{v}$$

(i) Thomson just replaced the term eE in the equation in part (b) with Bev.

Suggest why he did this.

(1)

(ii) Give **two** reasons why the equation $v_V = \frac{Bev}{m} \times \frac{l}{v}$ is **not** correct.

(2)

1 .....

2 .....

(Total for Question 17 = 13 marks)

18 (a) Physicists were able to confidently predict the existence of a sixth quark. State why.

(1)

(b) The mass of the top quark was determined by an experiment. Collisions between protons and anti-protons occasionally produce two top quarks.

(i) How do the properties of a proton and an anti-proton compare?

(2)

(ii) After the collision the two top quarks move in opposite directions with the same speed.

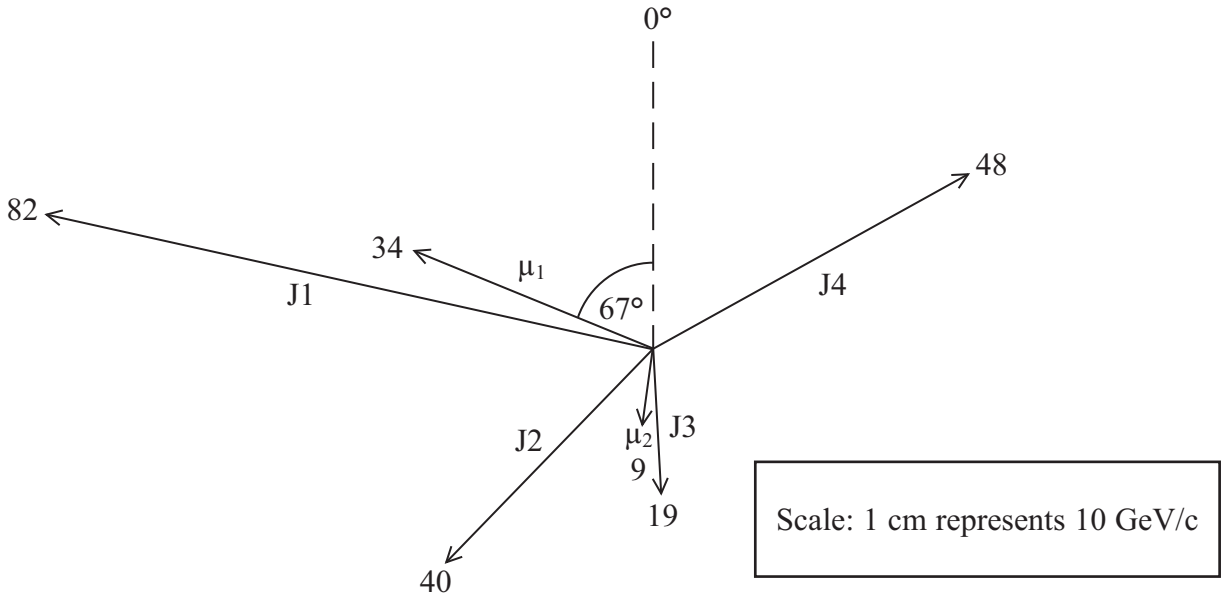
Explain why.

(2)

(c) The two top quarks decay rapidly into two muons and four jets of particles. These can be detected and their momenta measured.

The diagram shows an end-on view of the directions of the four jets (J1 to J4) of particles. The two muons are shown as μ_1 and μ_2. A muon neutrino is also produced but cannot be detected, so is **not** shown. Each momentum is measured in GeV/c.

The magnitude of the momentum for each particle or 'jet' is shown by the number printed at the end of each arrow.

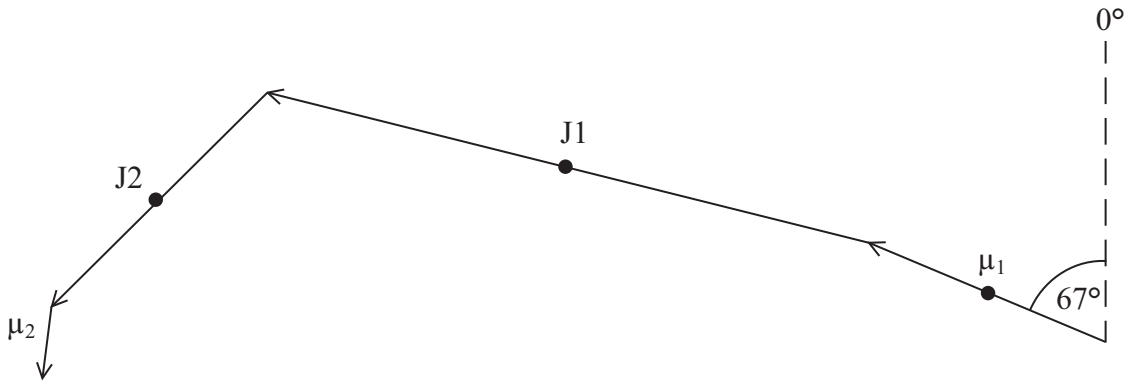


(i) Explain why GeV/c is a valid unit for momentum.

(2)

(ii) The vector diagram shown below is **not** complete. Add to the diagram arrows to represent the momenta of J3 and J4.

(2)



Scale: 1 cm represents 10 GeV/c

(iii) Complete the diagram to determine the magnitude of the momentum of the muon neutrino.

(1)

Momentum = ... GeV/c.

(iv) Show that the total energy of all the products of this event is about 300 GeV.

(1)

.....

.....

(v) Deduce the mass of a top quark in GeV/c^2.

(1)

.....

.....

(vi) Suggest why it took a long time to find experimental evidence for the top quark.

(2)

.....

.....

.....

.....

(Total for Question 18 = 14 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

Write your name here

Surname	Other names

Centre Number | Candidate Number

Edexcel GCE

Physics

Advanced

Unit 4: Physics on the Move

Wednesday 16 January 2013 – Afternoon
Time: 1 hour 35 minutes

Paper Reference
6PH04/01

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Ruler

Total Marks

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Turn over ▶

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P 4 1 6 2 9 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 A unit for magnetic flux is the

☒ **A** Wb

☒ **B** Wb m^2

☒ **C** T

☒ **D** T m^{-2}

(Total for Question 1 = 1 mark)

2 A body, initially at rest, explodes into two masses M_1 and M_2. These masses move apart with speeds v_1 and v_2 respectively.

The ratio v_1/v_2 is equal to

☒ **A** $\frac{M_1}{M_2}$

☒ **B** $\frac{M_2}{M_1}$

☒ **C** $\frac{\sqrt{M_1}}{\sqrt{M_2}}$

☒ **D** $\frac{\sqrt{M_2}}{\sqrt{M_1}}$

(Total for Question 2 = 1 mark)

3 Which of the following is a property of a uniform electric field?

☒ **A** A field that doesn't change over time.

☒ **B** A field that acts equally in all directions.

☒ **C** A field that only produces a force on moving charged particles.

☒ **D** A field that has the same strength at all points.

(Total for Question 3 = 1 mark)

4 A potential difference of 50 V is applied between two identical parallel aluminium plates. The plates are separated by a distance of 10 mm.

Which combination of potential difference and separation would double the electric field strength?

	Separation/mm	Potential difference/ V
☒ **A**	20	100
☒ **B**	20	25
☒ **C**	10	100
☒ **D**	10	25

(Total for Question 4 = 1 mark)

5 Which of the following is **not** a vector quantity?

☒ **A** electric field strength

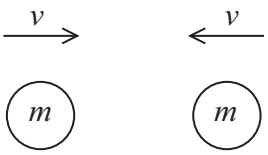
☒ **B** magnetic flux density

☒ **C** momentum

☒ **D** potential difference

(Total for Question 5 = 1 mark)

6 Two identical spheres of mass m are both travelling with a speed v towards each other.



The spheres collide head-on.

Which of the following statements **must** be true after the collision?

☒ **A** total momentum = $2mv$

☒ **B** total momentum = 0

☒ **C** total kinetic energy = mv^2

☒ **D** total kinetic energy = 0

(Total for Question 6 = 1 mark)

7 A cyclist travels along a straight horizontal road at a steady speed. A net force of 20 N is then applied for 6 s. The change in momentum of the cyclist is

☒ **A** 3.3 kg m s^{-1}

☒ **B** 26 kg m s^{-1}

☒ **C** 120 kg m s^{-1}

☒ **D** 720 kg m s^{-1}

(Total for Question 7 = 1 mark)

8 A conductor of length 50 mm carries a current of 3.0 A at 30° to a magnetic field of magnetic flux density 0.40 T.

The magnitude of the magnetic force acting on the conductor is

☒ **A** 0.030 N

☒ **B** 0.050 N

☒ **C** 30 N

☒ **D** 52 N

(Total for Question 8 = 1 mark)

9 An alpha particle and a beta particle both move into the same uniform magnetic field which is perpendicular to their direction of motion. The beta particle travels at 15 times the speed of the alpha particle.

The ratio of the force on the beta particle to the force on the alpha particle is

☒ **A** 3.7

☒ **B** 7.5

☒ **C** 30

☒ **D** 60

(Total for Question 9 = 1 mark)

10 The tubes of a linear accelerator (linac) get progressively longer down its length because

☒ **A** the accelerating particles become relativistic.

☒ **B** the frequency of the applied potential difference changes.

☒ **C** the accelerating particles must spend the same time in each tube.

☒ **D** the accelerating particles gain mass.

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 Early in the twentieth century physicists observed the scattering of alpha particles after they had passed through a thin gold foil. This scattering experiment provided evidence for the structure of the atom.

(a) State why it is necessary to remove the air from the apparatus that is used for this experiment.

(1)

.....

(b) From the results of such an experiment give **two** conclusions that can be deduced about the nucleus of an atom.

(2)

Conclusion 1 .....

.....

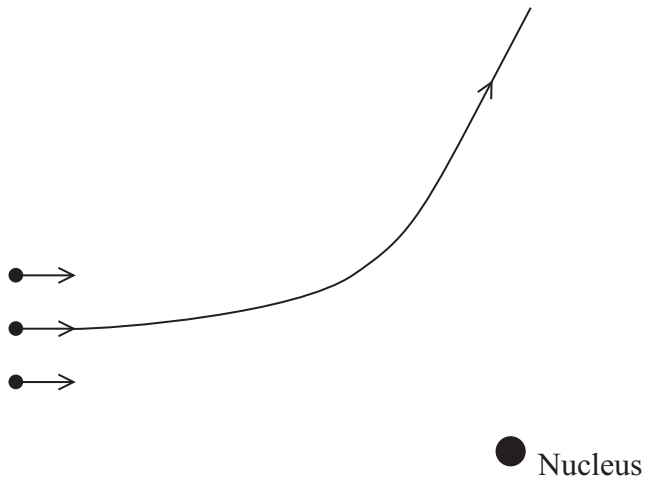
Conclusion 2 .....

.....

(c) The diagram shows three α-particles, all with the same kinetic energy. The path followed by one of the particles is shown.

Add to the diagram to show the paths followed by the other two particles.

(3)



(Total for Question 11 = 6 marks)

12 The electron in a hydrogen atom can be described by a stationary wave which is confined within the atom. This means that the de Broglie wavelength associated with it must be similar to the size of the atom which is of the order of 10^{-10} m.

(a) (i) Calculate the speed of an electron whose de Broglie wavelength is 1.00×10^{-10} m.

(3)

Speed = ...

(ii) Calculate the kinetic energy of this electron in electronvolts.

(3)

Kinetic energy = ... eV

(b) When β radiation was first discovered, it was suggested that there were electrons in the atomic nucleus, but it was soon realised that this was impossible because the energy of such an electron would be too great.

Suggest why an electron confined within a nucleus would have a much greater energy than the energy calculated in (a)(ii).

(2)

(Total for Question 12 = 8 marks)

13 The London Eye consists of a large vertical circle with 32 equally-spaced passenger cabins attached to it. The wheel rotates so that each cabin has a constant speed of 0.26 m s^{-1} and moves around a circle of radius 61 m.

(a) Calculate the time taken for each cabin to make one complete revolution.

(2)

.....

.....

Time = ...

(b) Calculate the centripetal force acting on each cabin.

mass of cabin = 9.7×10^3 kg

(2)

.....

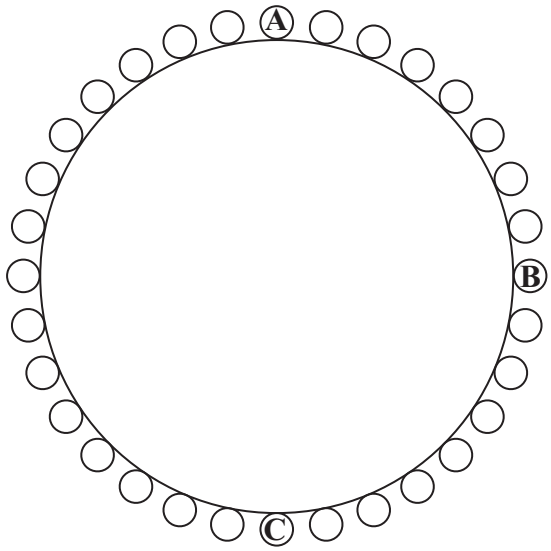
.....

.....

Centripetal force = ...

(c) (i) The diagram shows just the circle and the cabins.
Draw arrows to show the direction of the centripetal force acting on a person in a cabin when the person is at each of positions **A**, **B** and **C**.

(1)



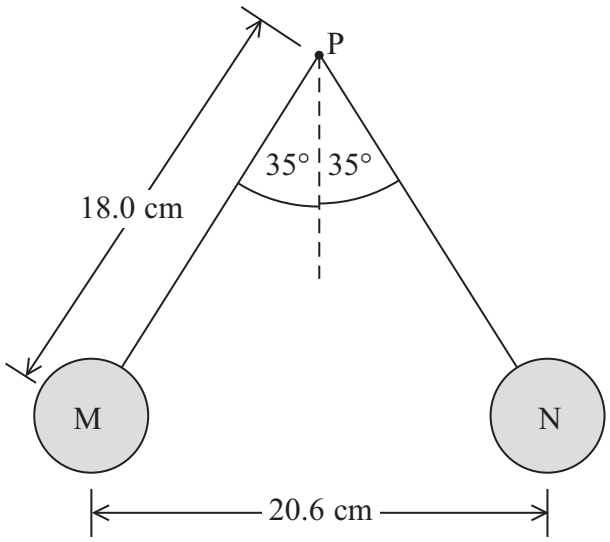
***(ii)** As the person in a cabin moves around the circle, the normal contact force between the person and the cabin varies.

State the position at which this force will be a maximum and the position at which it will be a minimum. Explain your answers.

(4)

(Total for Question 13 = 9 marks)

14 Two identical table tennis balls, M and N, are attached to non-conducting threads and suspended from a point P. The balls are each given the same positive charge and they hang as shown in the diagram. The mass of each ball is 2.7 g.



(a) Draw a free-body force diagram for ball M, label your diagram with the names of the forces.

(2)

(b) (i) Show that the tension in one of the threads is about 3×10^{-2} N.

(3)

(ii) Show that the electrostatic force between the balls is about 2×10^{-2} N.

(2)

(iii) Calculate the charge on each ball.

(3)

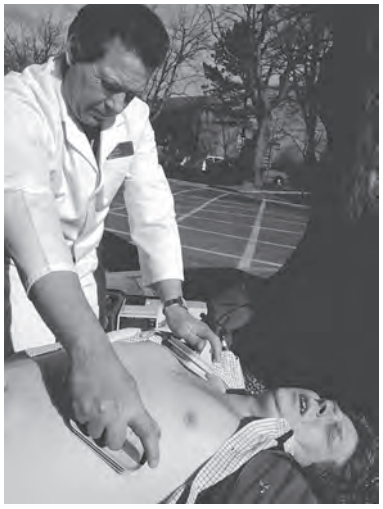
Charge = ...

(c) State and explain what would have happened if the charge given to ball M was greater than the charge given to ball N.

(2)

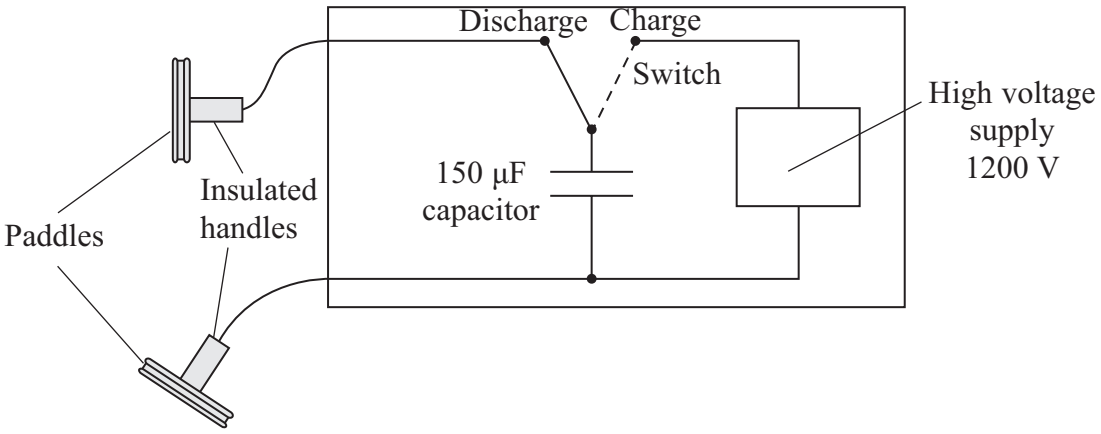
(Total for Question 14 = 12 marks)

15 A defibrillator is a machine that is used to correct an irregular heartbeat or to start the heart of someone who is in cardiac arrest.



The defibrillator passes a large current through the heart for a short time.

The machine includes a high voltage supply which is used to charge a capacitor. Two defibrillation 'paddles' are placed on the chest of the patient and the capacitor is discharged through the patient.



(a) The 150 μF capacitor is first connected across the 1200 V supply.

Calculate the charge on the capacitor.

(2)

.....

.....

Charge = ...

(b) Calculate the energy stored in the capacitor.

(2)

Energy stored = ...

(c) When the capacitor discharges there is an initial current of 14 A in the chest of the patient.

(i) Show that the electrical resistance of the body tissue between the paddles is about 90 Ω.

(1)

(ii) Calculate the time it will take for three quarters of the charge on the capacitor to discharge through the patient.

(3)

Time = ...

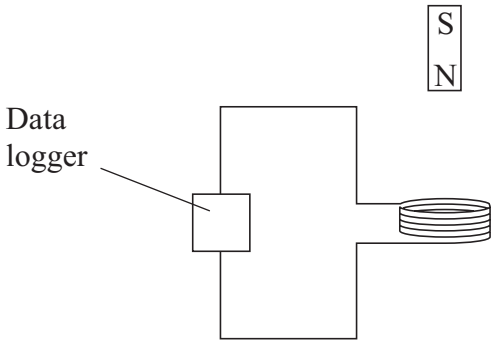
(iii) Body resistance varies from person to person. If the body resistance was lower, the initial current would be greater.

State how this lower body resistance affects the charge passed through the body from the defibrillator.

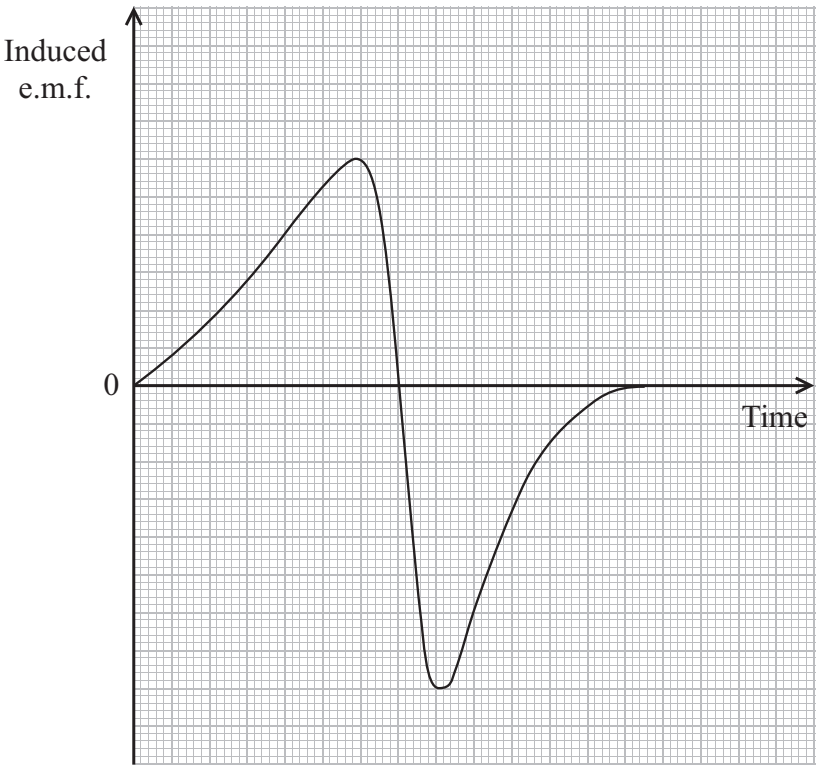
(1)

(Total for Question 15 = 9 marks)

16 A teacher demonstrates electromagnetic induction by dropping a bar magnet through a flat coil of wire connected to a data logger.



The data from the data logger is used to produce a graph of induced e.m.f. across the coil against time.

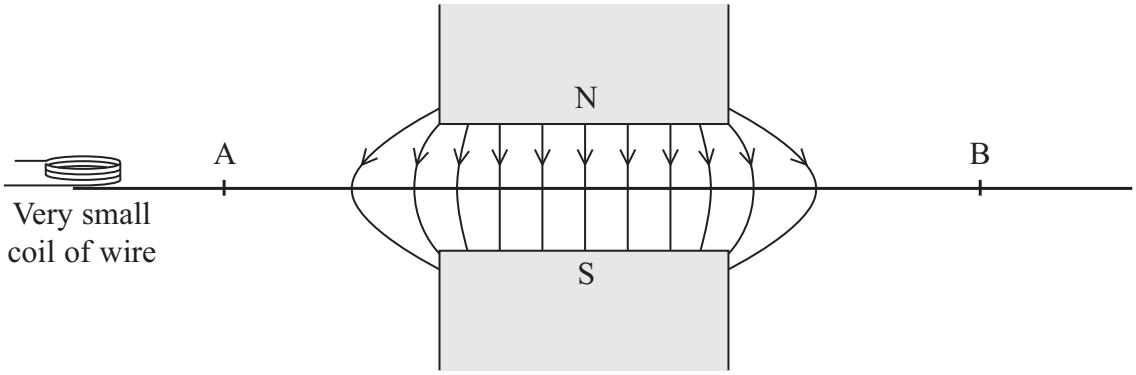


*(a) Explain the shape of the graph and the relative values on both axes.

(6)

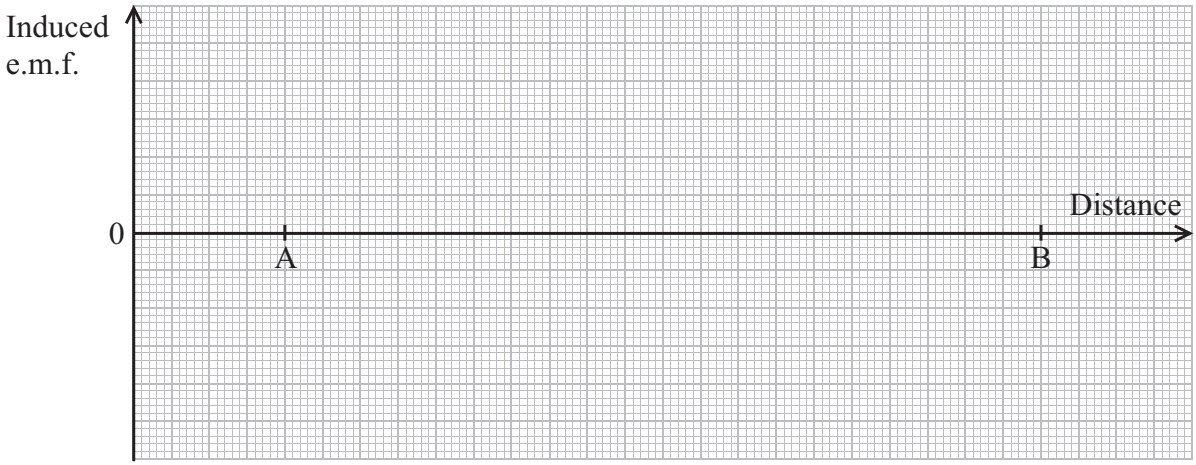
(b) The teacher then sets up another demonstration using a large U-shaped magnet and a very small coil of wire which is again connected to a data logger.

The north pole is vertically above the south pole and the coil is moved along the line AB which is midway between the poles. The magnetic field due to the U-shaped magnet has been drawn. The plane of the coil is horizontal.



Sketch a graph to show how the e.m.f. induced across the coil varies as the coil moves from A to B at a constant speed.

(4)



(Total for Question 16 = 10 marks)

17 In 2011 physicists at the Relativistic Heavy Ion Collider (RHIC) announced the creation of nuclei of anti-helium-4 which consists of anti-protons and anti-neutrons instead of protons and neutrons.

(a) 'Ordinary' helium-4 is written as $^{4}_{2}\text{He}$.

What do the numbers 4 and 2 represent?

(2)

(b) In the RHIC experiment, nuclei of gold $^{197}_{79}\text{Au}$ travelling at speeds greater than 2.99×10^{8} m s^{-1}, in opposite directions, collided, releasing energies of up to 200 GeV. After billions of collisions, 18 anti-helium nuclei had been detected.

(i) What is meant by 'relativistic' in the collider's name?

(1)

(ii) State why it is necessary to use very high energies in experiments such as these.

(1)

(iii) Show that the mass of a stationary anti-helium nucleus is about 4 GeV/c^2.

(4)

(iv) State why the small number of anti-helium nuclei produced only survive for a fraction of a second.

(1)

.....

.....

(v) A slow moving anti-helium nucleus meets a slow moving helium nucleus. If they were to combine to produce 2 high energy gamma rays, calculate the frequency of each gamma ray.

(2)

.....

.....

.....

.....

Frequency = ...

(c) There are two families of hadrons, called baryons and mesons. Baryons such as protons are made of three quarks.

(i) Describe the structure of a meson.

(1)

.....

.....

.....

(ii) Up quarks have a charge of +2/3e and down quarks a charge of –1/3e.
Describe the quark composition of anti-protons and anti-neutrons and use this to deduce the charge on each of these particles.

(4)

(Total for Question 17 = 16 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

Write your name here

Surname	Other names

Centre Number | Candidate Number

Edexcel GCE

Physics

Advanced

Unit 4: Physics on the Move

Thursday 13 June 2013 – Afternoon
Time: 1 hour 35 minutes

Paper Reference
6PH04/01

You must have:
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.
- 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 ▶

P41635A

1/1/1/1/

P 4 1 6 3 5 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 The nucleus of one of the isotopes of nickel is represented by $^{60}_{28}Ni$.

Which line correctly identifies a neutral atom of this isotope?

	Number of protons	Number of neutrons	Number of electrons
☒ **A**	28	32	28
☒ **B**	28	32	32
☒ **C**	28	60	28
☒ **D**	60	28	28

(Total for Question 1 = 1 mark)

2 A charged, non-magnetic particle is moving in a magnetic field.

Which of the following would **not** affect the magnetic force acting on the particle?

☒ **A** the magnitude of the charge on the particle

☒ **B** the strength of the magnetic field

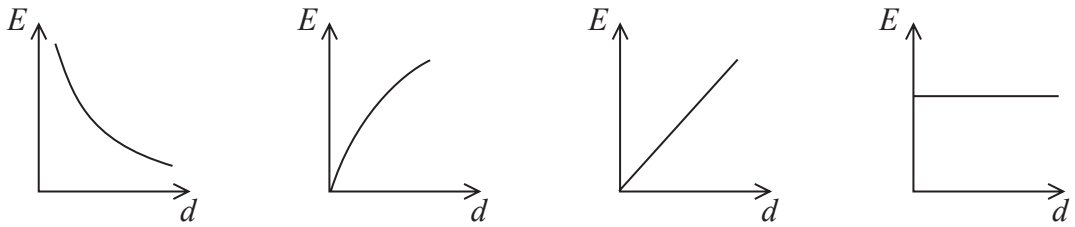
☒ **C** the velocity component parallel to the magnetic field direction

☒ **D** the velocity component perpendicular to the magnetic field direction

(Total for Question 2 = 1 mark)

3 Two parallel, conducting plates are connected to a battery. One plate is connected to the positive terminal and the other plate to the negative terminal. The plate separation d is gradually increased while the plates stay connected to the battery.

Select the graph that shows how the electric field strength E between the plates varies with separation d.



☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 3 = 1 mark)

---

4 A fairground roundabout makes 8 revolutions in 1 minute. The angular velocity of the roundabout is

☒ **A** 0.10 rad s^{-1}

☒ **B** 0.42 rad s^{-1}

☒ **C** 0.84 rad s^{-1}

☒ **D** 0.94 rad s^{-1}

(Total for Question 4 = 1 mark)

---

5 A correct re-statement of the equation $E_k = p^2/2m$ is

☒ **A** $\frac{1}{2}mv^2 = p^2$

☒ **B** $p^2 = m^2v^2$

☒ **C** $p^2/m = 2v^2$

☒ **D** $mv^2 = \frac{1}{2}p^2$

(Total for Question 5 = 1 mark)

---

6 A muon has a mass of 106 MeV/c^2.

The mass of a muon, to two significant figures, is

☒ **A** 1.7×10^{-11} kg

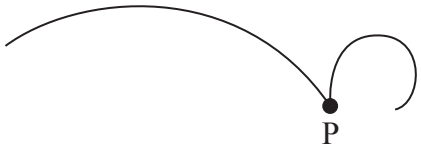
☒ **B** 5.7×10^{-20} kg

☒ **C** 1.9×10^{-28} kg

☒ **D** 1.9×10^{-34} kg

(Total for Question 6 = 1 mark)

7 The diagram shows the tracks from an event at a point P in a bubble chamber. A magnetic field is directed into the page.



The tracks cannot show the production of a proton-antiproton pair with equal kinetic energies because

☒ **A** the curvature is perpendicular to the magnetic field.

☒ **B** the tracks curve in different directions.

☒ **C** the tracks have different curvatures.

☒ **D** there is no track before point P.

(Total for Question 7 = 1 mark)

8 A racing car of mass 1200 kg travels at 0.63 rad s^{-1} around a bend of radius 50 m. The force on the car necessary for this motion is

☒ **A** 2.4×10^4 N away from the centre of the circle.

☒ **B** 2.4×10^4 N towards the centre of the circle.

☒ **C** 3.8×10^4 N away from the centre of the circle.

☒ **D** 3.8×10^4 N towards the centre of the circle.

(Total for Question 8 = 1 mark)

9 A cyclotron is a type of particle accelerator. It consists of two metal Dees which are connected to a high frequency voltage supply and are in a strong magnetic field.

The particles change their speed because

☒ **A** of the magnetic field they are in.

☒ **B** the voltage supply is alternating.

☒ **C** there is a potential difference between the two Dees.

☒ **D** the magnetic field is at right angles to the Dees.

(Total for Question 9 = 1 mark)

10 The de Broglie wavelength for neutrons used to study crystal structure is 1.2 nm.
mass of a neutron = 1.67×10^{-27} kg

The speed of these neutrons would be

☒ **A** 3.0×10^{6} m s^{-1}

☒ **B** 3.3×10^{2} m s^{-1}

☒ **C** 3.0×10^{-3} m s^{-1}

☒ **D** 3.3×10^{-7} m s^{-1}

(Total for Question 10 = 1 mark)

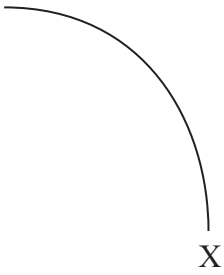
TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 Scientists studying anti-matter recently observed the creation of a nucleus of anti-helium 4, which consists of two anti-protons and two anti-neutrons.

The diagram represents the path of a proton through a magnetic field starting at point X.



Add to the diagram the path of an anti-helium 4 nucleus also starting at point X and initially travelling at the same velocity as the proton.

Explain any differences between the paths.

(5)

(Total for Question 11 = 5 marks)

12 The table gives some of the properties of the up, down and strange quarks.

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

There are nine possible ways of combining u, d and s quarks and their antiquarks to make nine different mesons. These are listed below

$u\bar{u}$ $u\bar{d}$ $u\bar{s}$ $d\bar{d}$ $d\bar{u}$ $d\bar{s}$ $s\bar{s}$ $s\bar{u}$ $s\bar{d}$

(a) From the list select the four strange mesons and state the charge and strangeness of each of them.

(4)

Meson	Charge/*e*	Strangeness

(b) Some of the mesons in the list have zero charge and zero strangeness.

Suggest what might distinguish these mesons from each other.

(1)

.....

.....

.....

(Total for Question 12 = 5 marks)

13 In an experiment to investigate the structure of the atom, α-particles are fired at a thin metal foil, which causes the α-particles to scatter.

(a) (i) State the direction in which the number of α-particles detected will be a maximum.

(1)

.....

(ii) State what this suggests about the structure of the atoms in the metal foil.

(1)

.....

(b) Some α-particles are scattered through 180°.

State what this suggests about the structure of the atoms in the metal foil.

(2)

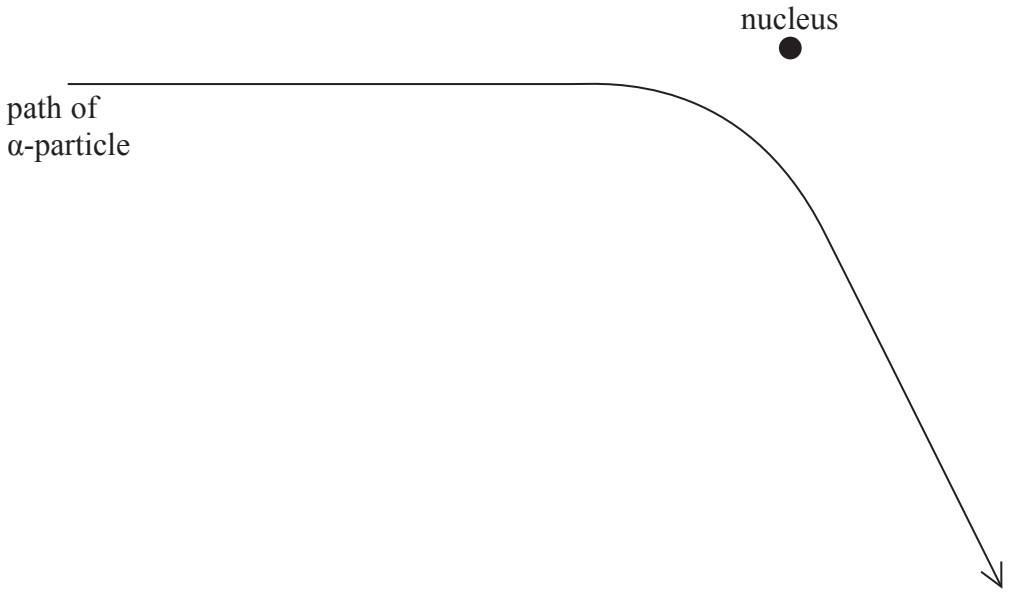
.....

.....

.....

.....

(c) The diagram shows the path of an α-particle passing near to a single nucleus in the metal foil.



(i) Name the force that causes the deflection of the α-particle.

(1)

(ii) On the diagram, draw an arrow to show the direction of the force acting on the α-particle at the point where the force is a maximum. Label the force F.

(2)

(iii) The foil is replaced by a metal of greater proton number.

Draw the path of an α-particle that has the same initial starting point and velocity as the one drawn in the diagram.

(2)

(Total for Question 13 = 9 marks)

14 A student is investigating how the potential difference across a capacitor varies with time as the capacitor is charging.

He uses a 100 μF capacitor, a 5.0 V d.c. supply, a resistor, a voltmeter and a switch.

(a) (i) Draw a diagram of the circuit he should use.

(2)

(ii) Suggest why a voltage sensor connected to a data logger might be a suitable instrument for measuring the potential difference across the capacitor in this investigation.

(1)

.....

.....

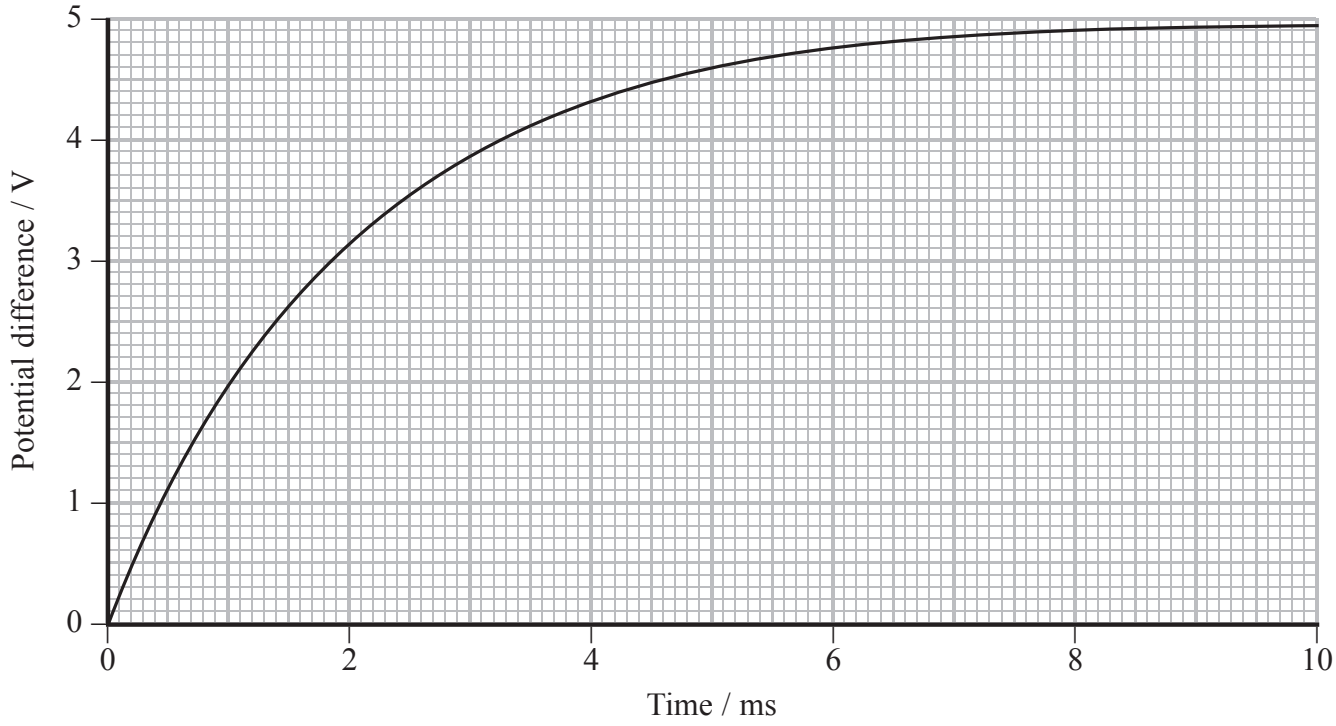
Turn over for Question 14(b)

(b) Calculate the maximum charge stored on the capacitor.

(2)

Charge = ...

(c) The graph shows how the potential difference across the capacitor varies with time as the capacitor is charging.



(i) Estimate the average charging current over the first 10 ms.

(2)

Average charging current = ...

(ii) Use the graph to estimate the initial rate of increase of potential difference across the capacitor and hence find the initial charging current.

(3)

Initial charging current = ...

(iii) Use the value of the initial charging current to find the resistance of the resistor.

(2)

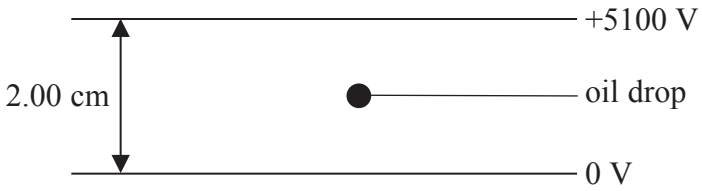
Resistance = ...

(Total for Question 14 = 12 marks)

15 The charge on an electron was originally measured in an experiment called the Millikan Oil Drop experiment.

In a simplified version of this experiment, an oil drop with a small electric charge is placed between two horizontal, parallel plates with a large potential difference (p.d.) across them. The p.d. is adjusted until the oil drop is stationary.

For a particular experiment, a p.d. of 5100 V was required to hold a drop of mass 1.20×10^{-14} kg stationary.



(a) Add to the diagram to show the electric field lines between the plates.

(3)

(b) State whether the charge on the oil drop is positive or negative.

(1)

(c) Complete the free-body force diagram to show the forces acting on the oil drop. You should ignore upthrust.

(2)

(d) (i) Calculate the magnitude of the charge on the oil drop.

(4)

Charge = ...

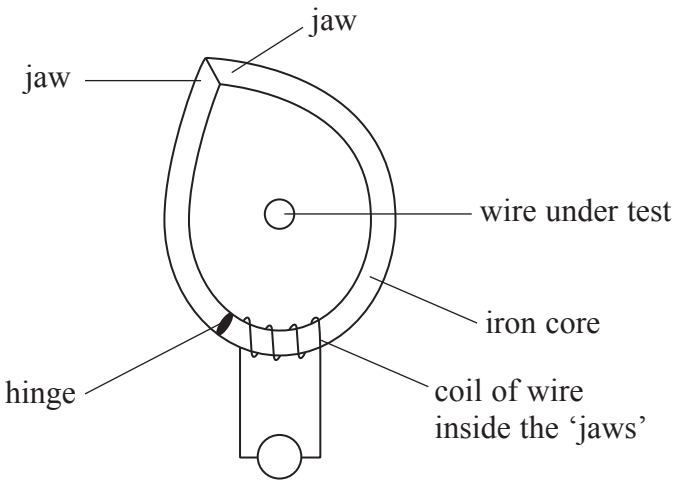
(ii) Calculate the number of electrons that would have to be removed or added to a neutral oil drop for it to acquire this charge.

(2)

Number of electrons = ...

(Total for Question 15 = 12 marks)

16 The photograph shows a digital clamp meter or 'amp-clamp'. This can be used to measure the current in the live wire coming from the mains supply without breaking the circuit.



The 'jaws' of the clamp are opened, placed around the wire carrying the current and then closed. Inside the 'jaws' is an iron core with a coil of wire wrapped around it.

*(a) Explain how an e.m.f. would be produced in the coil of wire inside the amp-clamp when the 'jaws' are placed around a wire carrying an alternating current.

(4)

(b) State why the amp-clamp cannot be used with a steady direct current.

(1)

(c) The amp-clamp cannot be used with a cable that is used to plug a domestic appliance like a lamp into the mains supply.

Explain why not.

(2)

(d) (i) Explain why the amp-clamp can be used to determine the magnitude of different alternating currents with the same frequency.

(2)

(ii) The amp-clamp may **not** be reliable when comparing alternating currents of different frequencies.

Suggest why not.

(2)

(Total for Question 16 = 11 marks)

17 (a) Explain what is meant by the principle of conservation of momentum.

(2)

(b) The picture shows a toy car initially at rest with a piece of modelling clay attached to it.

A student carries out an experiment to find the speed of a pellet fired from an air rifle. The pellet is fired horizontally into the modelling clay. The pellet remains in the modelling clay as the car moves forward. The motion of the car is filmed for analysis.

The car travels a distance of 69 cm before coming to rest after a time of 1.3 s.

(i) Show that the speed of the car immediately after being struck by the pellet was about 1 m s^{-1}.

(2)

(ii) State an assumption you made in order to apply the equation you used.

(1)

(iii) Show that the speed of the pellet just before it collides with the car is about 120 m s^{-1}

mass of car and modelling clay = 97.31g
mass of pellet = 0.84 g

(3)

(c) The modelling clay is removed and is replaced by a metal plate of the same mass. The metal plate is fixed to the back of the car. The experiment is repeated but this time the pellet bounces backwards.

*(i) Explain why the speed of the toy car will now be greater than in the original experiment.

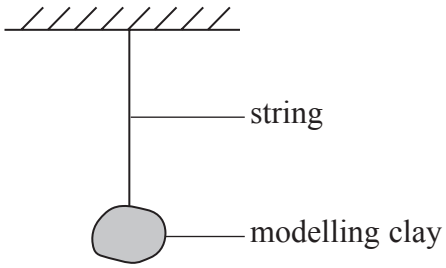
(3)

(ii) The film of this experiment shows that the pellet bounces back at an angle of 72° to the horizontal.

Explain why the car would move even faster if the pellet bounced directly backwards at the same speed.

(1)

(d) The student tests the result of the first experiment by firing a pellet into a pendulum with a bob made of modelling clay. She calculates the energy transferred.



The student's data and calculations are shown:

Data
mass of pellet = 0.84 g
mass of pendulum and pellet = 71.6 g
change in vertical height of pendulum = 22.6 cm

Calculations
change in gravitational potential energy of pendulum and pellet
= 71.6×10^{-3} kg × 9.81 N kg^{-1} × 0.226 m = 0.16 J
therefore kinetic energy of pendulum and pellet immediately after collision = 0.16 J
therefore kinetic energy of pellet immediately before collision = 0.16 J
therefore speed of pellet before collision = 19.5 m s^{-1}

There are no mathematical errors but her answer for the speed is too small.

State and explain which of the statements in the calculations are correct and which are not.

(4)

(Total for Question 17 = 16 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

Write your name here

Surname	Other names

Centre Number | Candidate Number

Edexcel GCE

Physics

Advanced

Unit 4: Physics on the Move

Thursday 13 June 2013 – Afternoon
Time: 1 hour 35 minutes

Paper Reference
6PH04/01R

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
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Information

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Advice

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

Turn over ▶

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P 4 3 3 2 3 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 A gymnast of mass 40 kg falls vertically onto a trampoline with a speed of 5 m s^{-1} and rebounds with the same speed.

She is in contact with the trampoline for 0.2 s. The average force exerted on the gymnast by the trampoline during this period is

☒ **A** 10 N

☒ **B** 20 N

☒ **C** 1000 N

☒ **D** 2000 N

(Total for Question 1 = 1 mark)

2 The drum of a washing machine rotates with an angular velocity of 8.5 rad s^{-1}. The time to complete 10 revolutions is

☒ **A** 0.85 s

☒ **B** 1.3 s

☒ **C** 3.7 s

☒ **D** 7.4 s

(Total for Question 2 = 1 mark)

3 Select the row in the table that correctly identifies what happens in an inelastic collision.

		Momentum	Kinetic energy	Total energy
☒	**A**	conserved	conserved	conserved
☒	**B**	not conserved	conserved	conserved
☒	**C**	conserved	not conserved	conserved
☒	**D**	conserved	not conserved	not conserved

(Total for Question 3 = 1 mark)

4 Two protons, separated by a distance x, experience a repulsive force F.
If the separation is reduced to $x/3$ the force between the protons will be

☒ **A** $F/9$

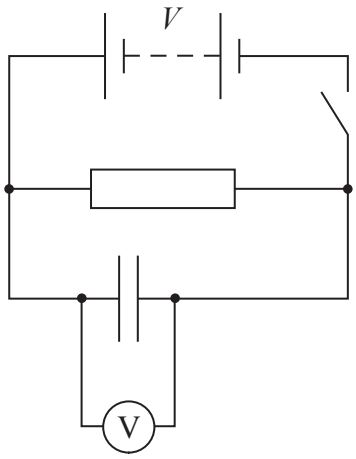
☒ **B** $F/3$

☒ **C** $3F$

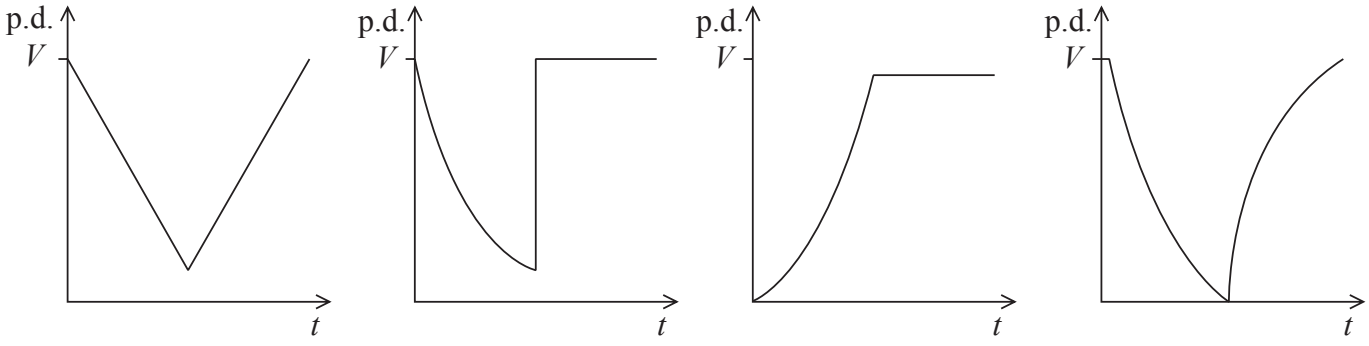
☒ **D** $9F$

(Total for Question 4 = 1 mark)

5 The capacitor shown in the circuit below is initially charged to a potential difference (p.d.) V by closing the switch.
The power supply has negligible internal resistance.



The switch is opened and the p.d. across the capacitor allowed to fall. A short time later the switch is closed again. Select the graph that shows how the p.d. across the capacitor varies with time, after the switch is opened.



☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 5 = 1 mark)

6 Charged particles are travelling at a speed v, at right angles to a magnetic field of flux density B. Each particle has a mass m and a charge Q.

Which of the following changes would cause a decrease in the radius of the circular path of the particles?

☒ **A** an increase in B

☒ **B** an increase in m

☒ **C** an increase in v

☒ **D** a decrease in Q

(Total for Question 6 = 1 mark)

7 The de Broglie wavelength associated with electrons moving at 2.5×10^6 m s^{-1} is

☒ **A** 2.9×10^{-4} m

☒ **B** 2.4×10^{-8} m

☒ **C** 2.9×10^{-10} m

☒ **D** 2.4×10^{-39} m

(Total for Question 7 = 1 mark)

8 Which of the following is **not** a valid conclusion from Rutherford's alpha particle scattering experiment?

☒ **A** The atom is mainly empty space.

☒ **B** The mass of the atom is mostly concentrated in the nucleus.

☒ **C** The nucleus must be positively charged.

☒ **D** The nucleus must be very small compared to the atom.

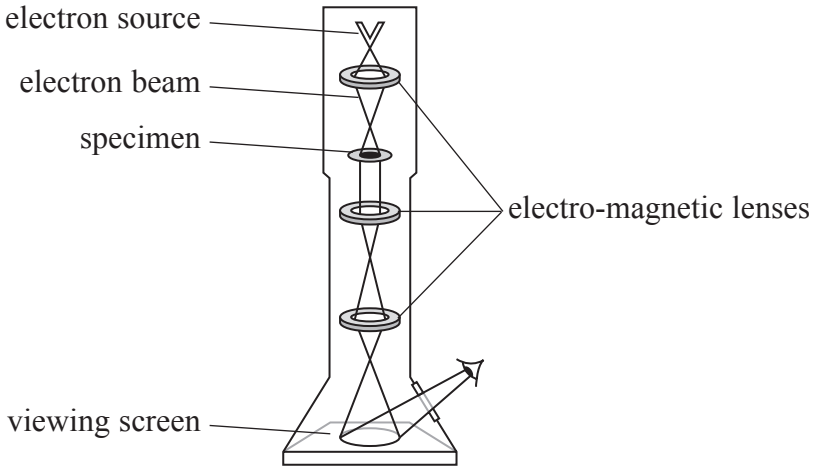
(Total for Question 8 = 1 mark)

9 Select the row in the table that correctly identifies the composition of a $^{235}_{92}U^{+}$ ion.

		Number of protons	Number of neutrons	Number of electrons
☒	**A**	92	143	91
☒	**B**	92	143	92
☒	**C**	92	235	91
☒	**D**	93	235	92

(Total for Question 9 = 1 mark)

10 A transmission electron microscope passes a beam of electrons through a tiny specimen to form an image on a viewing screen.



Due to the wave nature of electrons, diffraction occurs which can blur the image. To reduce this effect when viewing a smaller object the beam must contain

☒ **A** more electrons per second.

☒ **B** fewer electrons per second.

☒ **C** faster moving electrons.

☒ **D** slower moving electrons.

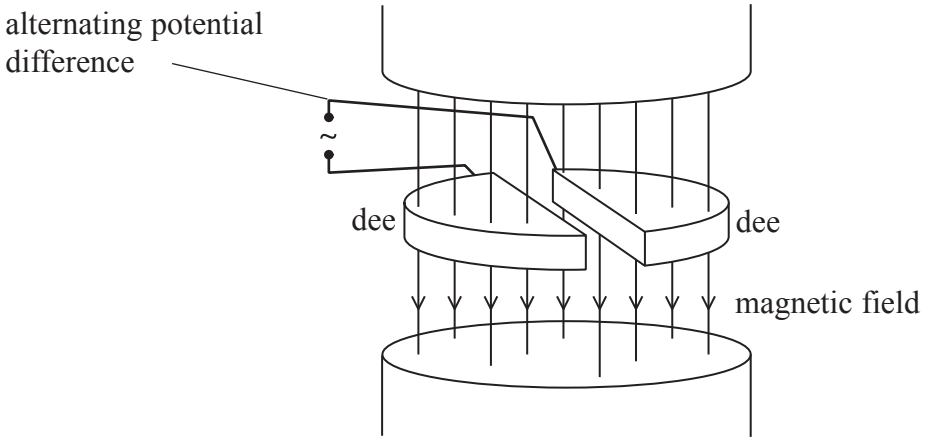
(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

***11** The diagram shows the basic structure of a cyclotron.



With reference to the magnetic field and the alternating potential difference explain how the cyclotron produces a beam of high speed particles.

(4)

(Total for Question 11 = 4 marks)

***12** In 2012 Neil Armstrong, the first man to step on the moon during the Apollo 11 lunar mission, died at the age of 82.

During this mission, a planned explosion caused the separation of the module in which Armstrong was travelling and the final-stage rocket. This explosion resulted in an increase in the speed of the module.

Discuss how the conservation of momentum and the conservation of energy apply to this situation.

(5)

(Total for Question 12 = 5 marks)

13 The magnetic force F that acts on a current-carrying conductor in a magnetic field is given by the equation

$$F = BIl.$$

(a) State the condition under which this equation applies.

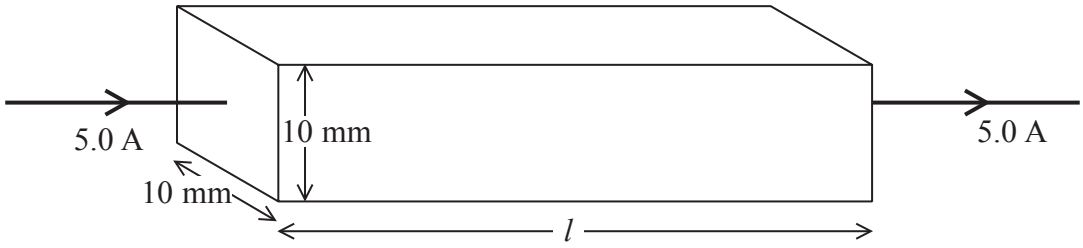
(1)

(b) The unit for magnetic flux density B is the tesla.

Express the tesla in base units.

(2)

(c) The diagram shows a rectangular bar of aluminium which has a current of 5.0 A through it.



The bar is placed in a magnetic field so that its weight is supported by the magnetic field.

Calculate the minimum value of the magnetic flux density B needed for this to occur.

density of aluminium = 2.7×10^3 kg m^{-3}

(3)

Minimum B = ...

(d) State the direction of the magnetic field.

(1)

.....

(Total for Question 13 = 7 marks)

14 Hadrons are a group of particles composed of quarks. Hadrons can be either baryons or mesons.

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

(1)

.....

(ii) State the quark structure of a meson.

(1)

.....

(b) State **one** similarity and **one** difference between a particle and its antiparticle.

(2)

Similarity .....

.....

Difference .....

.....

(c) (i) The table gives some of the properties of up, down and strange quarks.

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

One or more of these quarks combine to form a K^+, a meson with a strangeness of +1.

Write down the quark combination of the K^+.

(1)

.....

(ii) The K^+ can decay in the following way

$$K^+ \rightarrow \mu^+ + \nu_\mu$$

K^- is the antiparticle of the K^+.

Complete the equation below by changing each particle to its corresponding antiparticle in order to show an allowed decay for the K^- meson.

(2)

$$K^- \rightarrow$$

(iii) The rest mass of the K^+ is 494 MeV/c^2.

Calculate, in joules, how much energy is released if a K^+ meets and annihilates a K^-.

(3)

.....

.....

.....

Energy = ... J

(Total for Question 14 = 10 marks)

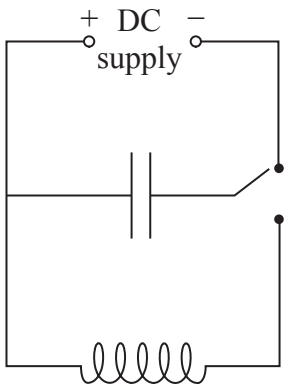
15 A particular experiment requires a very large current to be provided for a short time.

(a) An average current of 2.0×10^3 A is to be supplied to a coil of wire for a time of 1.4×10^{-3} s. The resistance of the coil is 0.50 Ω.

(i) Show that the charge that flows through the coil during this time is about 3 C.

(2)

(ii) The circuit shows how a capacitor could be charged and then discharged through the coil to provide the current.



The circuit contains a capacitor of capacitance 600 μF. This capacitor is suitable to provide the current for 1.4×10^{-3} s.

Explain why the capacitor is suitable.

(3)

(b) It can be assumed that the 600 μF capacitor completely discharges in 1.4×10^{-3} s.

(i) Calculate the potential difference of the power supply.

(2)

Potential difference = ...

(ii) Calculate the average power delivered to the coil in this time.

(3)

Average power = ...

(Total for Question 15 = 10 marks)

16 In order to make an object move around a circular path at a constant speed a resultant force must act on it.

(a) Explain why a resultant force is required and state the direction of this force.

(2)

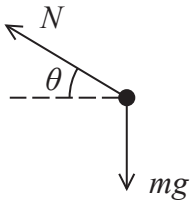
(b) When vehicles move around a bend on a level road, the resultant force is provided by friction between the tyres and the road. For a given vehicle and road surface there is a maximum value for this sideways frictional force.

Explain why roads designed for high-speed travel, such as motorways, do not have any sharp bends.

(2)

(c) Some cycling tracks are banked. When cornering, a cyclist moves up the track until the sideways frictional force is zero.

The free-body force diagram for a cyclist and bicycle is shown. The normal contact force exerted by the track is N and the weight of cyclist and bicycle is mg.



(i) By considering the vertical and horizontal motion, show that

$$\tan \theta = gr/v^2$$

where r is the radius of the cyclist's path and v is the cyclist's speed.

(3)

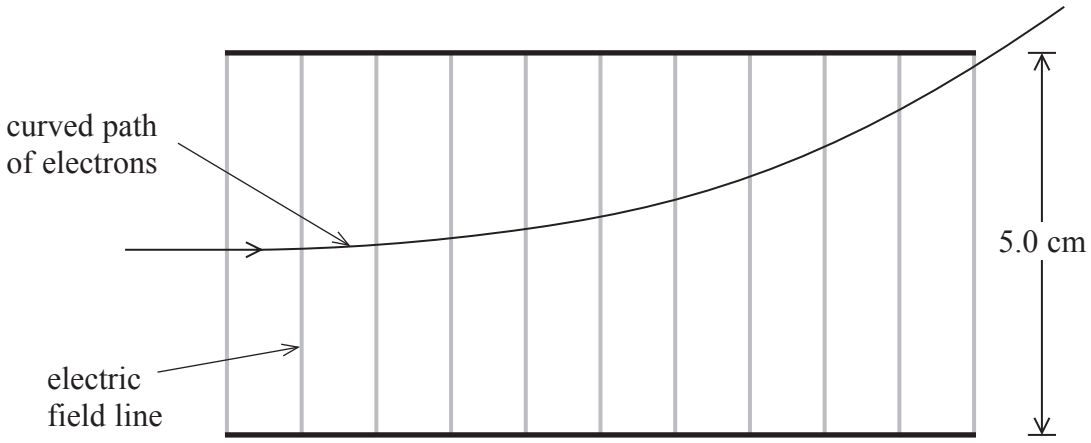
(ii) Calculate the value of θ for a cyclist travelling at 11.0 m s^{-1} around a bend of radius 18.7 m.

(2)

$\theta =$ .....

(Total for Question 16 = 9 marks)

17 A teacher uses an electron beam tube to demonstrate the behaviour of electrons in an electric field. The diagram shows the path of an electron in a uniform electric field between two parallel conducting plates.



(a) Mark on the diagram the direction of the electric field.

(1)

(b) The conducting plates are 5.0 cm apart and have a potential difference of 160 V across them.
Calculate the force on the electron due to the electric field.

(3)

Force = ...

(c) Explain why the path of the electron is curved between the plates and straight when it has left the plates.

(3)

(d) The electron was initially released from a metal by thermionic emission and then accelerated through a potential difference before entering the region of the electric field.

(i) State what is meant by thermionic emission.

(1)

.....

.....

(ii) In order to be able to just leave the plates as shown, the electron must enter the electric field between the plates with a speed of 1.2×10^7 m s^{-1}.

Calculate the potential difference required to accelerate an electron from rest to this speed.

(3)

.....

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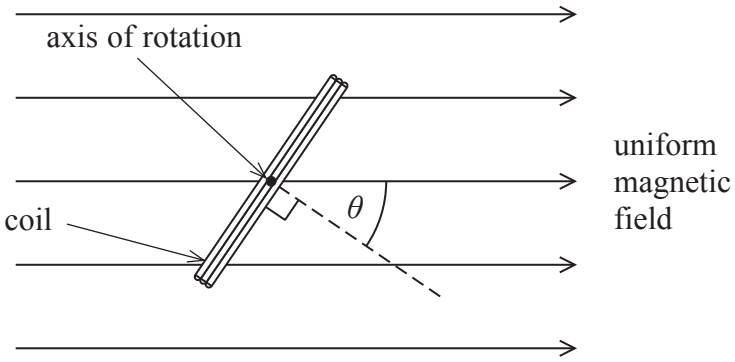
Potential difference = ...

(Total for Question 17 = 11 marks)

18 The diagram shows an end view of a simple electrical generator. A rectangular coil of wire is rotated in a uniform magnetic field of magnetic flux density 3.0×10^{-2} T. The axis of rotation is at right angles to the field direction.



(a) The coil has 200 turns and an area of 2.0×10^{-4} m^2.

Calculate the magnetic flux linkage for the coil when $\theta = 0°$.

(2)

Flux linkage = ...

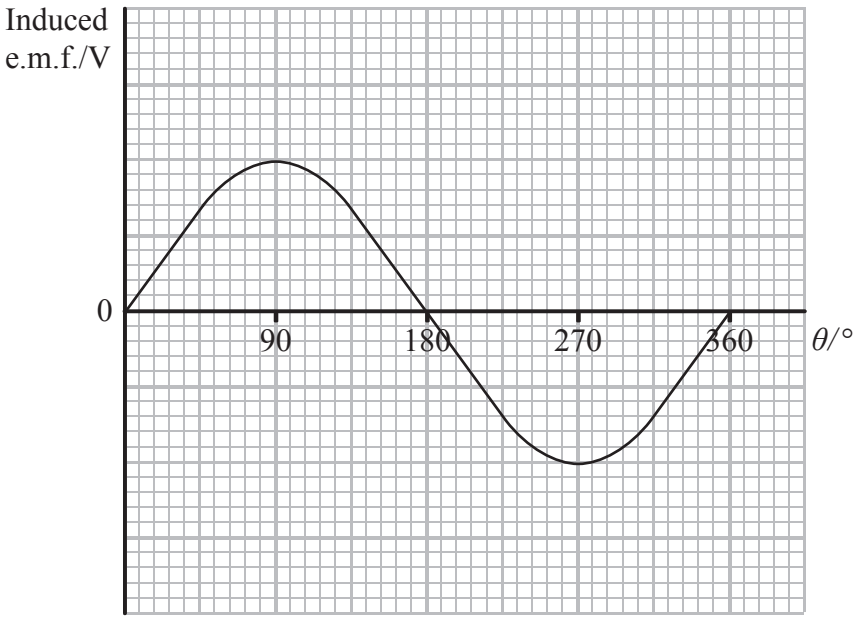
(b) The coil is rotated at a constant rate of 2 revolutions per second.

(i) Calculate the average e.m.f. induced in the time taken for the coil to rotate from $\theta = 0°$ to $\theta = 90°$.

(3)

Average e.m.f. = ...

(ii) The graph shows how the induced e.m.f. varies over one cycle of rotation of the coil.



Explain why the magnitude of the e.m.f. is smallest and greatest at the values of θ shown in the graph.

(3)

(iii) State and explain how the graph would differ if the coil rotated at a slower rate.

(2)

(c) Vehicles such as electric cars are driven by electric motors. These vehicles use regenerative braking to reduce the speed of the vehicle. The motor is operated as a generator during braking and the output from the generator is used to recharge the batteries of the car.

(i) Explain how using the motor as a generator slows the car down.

(2)

.....

.....

.....

.....

(ii) In practice, these vehicles also use friction braking as well as regenerative braking. This is because regenerative braking on its own will not fully stop a car. Suggest why.

(2)

.....

.....

.....

.....

(Total for Question 18 = 14 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	$\lambda = h/p$