Centre No.						Paper Reference	Surname	Initial(s)
Candidate No.						6 P H 0 4 / 1	Signature	

Paper Reference(s)

6PH04/1

Edexcel GCE

Physics

Advanced

Unit 4: Physics on the Move

Sample Assessment Material

Time: 1 hour 35 minutes

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
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Total	

Materials required for examination
Nil

Items included with question papers
Nil

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initial(s) and signature.
Check that you have the correct question paper.
Answer ALL the questions. Write your answers in the spaces provided in this question paper.
Some questions must be answered with a cross in a box (☒). If you change your mind, put a line through the box (☒) and then mark your new answer with a cross (☒).

Information for Candidates

The marks for individual questions and the parts of questions are shown in round brackets: e.g. **(2)**.
There are 18 questions in this question paper. The total mark for this paper is 80.
There are 20 pages in this question paper. Any blank pages are indicated.

Advice to Candidates

Quality of written communication will be taken into account in the marking of your responses to Questions 14, 17, and 18. These questions are indicated with an asterisk. Quality of written communication includes clarity of expression, the structure and presentation of ideas and grammar, punctuation and spelling.

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Answer ALL the questions.

For some questions, 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. Which of the following is the same unit as the farad?

☐ **A** Ω s

☐ **B** $\Omega\ s^{-1}$

☐ **C** Ω^{-1} s

☐ **D** $\Omega^{-1}\ s^{-1}$

(Total 1 mark) **Q1**

2. An emf will only be induced across the wing tips of an aircraft if it is flying horizontally in

☐ **A** a north-south direction

☐ **B** an east-west direction

☐ **C** a region where there is a horizontal component of the earth's magnetic field

☐ **D** a region where there is a vertical component of the earth's magnetic field.

(Total 1 mark) **Q2**

3. A top quark has a mass of 171 $\frac{\text{GeV}}{c^2}$. Its mass in kilograms is about

☐ **A** 3×10^{-31}

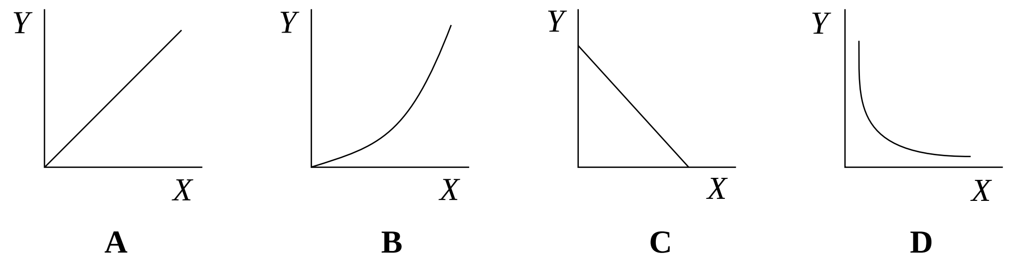
☐ **B** 3×10^{-28}

☐ **C** 3×10^{-25}

☐ **D** 3×10^{-19}

(Total 1 mark) **Q3**

The following are four possible graphs of a quantity *Y* plotted against another quantity *X*. Refer to these graphs when answering questions 4, 5 and 6.



4. Which graph **best** represents *Y* when it is the kinetic energy of an electron and *X* is its momentum?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

Q4

(Total 1 mark)

5. Which graph **best** represents *Y* when it is the electric field strength between two parallel plates with a constant potential difference across them and *X* is the distance apart of the plates?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

Q5

(Total 1 mark)

6. Which graph **best** represents *Y* when it is the radius of the circle described by an electron in a constant magnetic field at right angles to the path of the electron and *X* is the momentum of the electron?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

Q6

(Total 1 mark)

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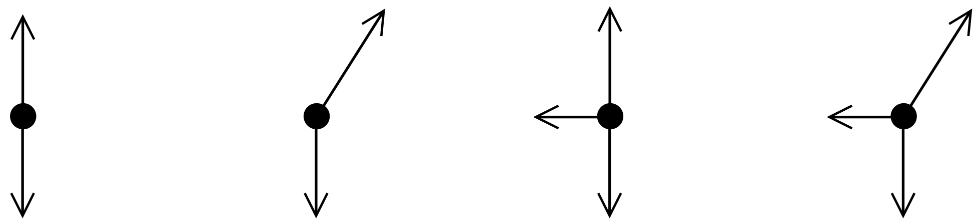
7. Each of the diagrams below is a free-body force diagram representing the forces acting on a body.



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

Which diagram best illustrates the forces acting on a charged sphere, supported on a nylon thread, in equilibrium alongside a second similarly charged sphere?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

Q7

(Total 1 mark)

8. A π^+ pion is composed of which combination of quarks?

☒ **A** ud

☒ **B** $\bar{u}d$

☒ **C** $u\bar{d}$

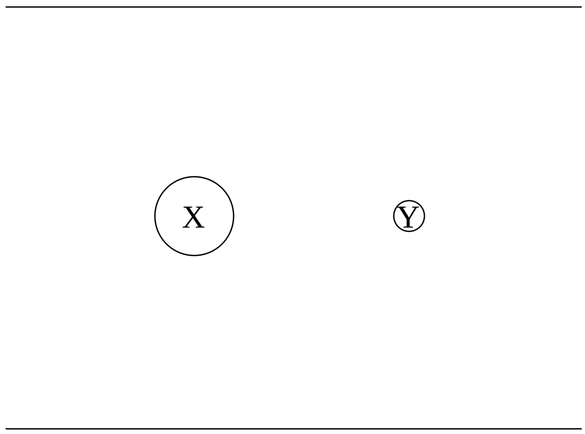
☒ **D** $\bar{u}\bar{d}$

Q8

(Total 1 mark)

Leave blank

The diagram shows two charged spheres X and Y, of masses 2*m* and *m* respectively, which are just prevented from falling under gravity by the uniform electric field between the two parallel plates. Use the diagram when answering questions 9 and 10.



9. Which of the following is a property of a **uniform** electric field?

☒ **A** The field strength is the same at all points.

☒ **B** The field acts equally in all directions.

☒ **C** The field produces no force on a stationary charged particle.

☒ **D** The field produces a force on a moving charged particle which is always perpendicular to its direction of travel.

Q9

(Total 1 mark)

10. If the plates are moved closer together

☒ **A** X and Y will both remain stationary.

☒ **B** X and Y will both move upwards with the same acceleration.

☒ **C** X will have a greater upward acceleration than Y.

☒ **D** Y will have a greater upward acceleration than X.

Q10

(Total 1 mark)

11. Figure 1 shows the London Eye, a tourist attraction in the form of a very large wheel. Passengers ride in capsules, describing a vertical circle at constant speed. Figure 2 is a free-body force diagram showing the forces acting on a passenger in one of the capsules at point X of the circle.

Figure 1

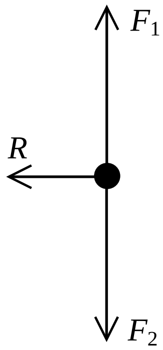


Figure 2

A teacher asks the class why the forces F_1 and F_2 are equal and opposite. A student suggests that this is because of Newton's third law.

(a) State **two** reasons why the forces F_1 and F_2 cannot be a Newton's third law pair.

Reason 1 ....

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Reason 2 ....

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(2)

(b) Explain why the forces F_1 and F_2 must be equal and opposite.

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(2)

(c) State what causes the force R.

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(1)

Q11

(Total 5 marks)

Leave blank

12. (a) State what is meant by the term **baryon**.

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.... **(1)**

(b) In β^- decay a neutron decays into a proton.

Explain how the quark structure of the baryon changes in this process.

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.... **(2)**

Q12

(Total 3 marks)

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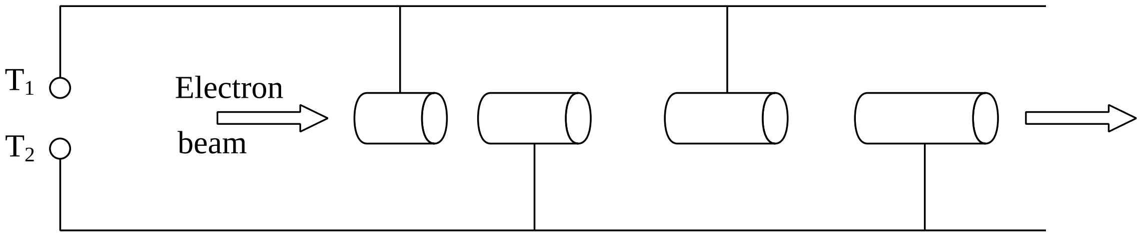
13. Quarks were discovered using the Stanford Linear Accelerator (SLAC). The diagram below shows the principle of a linear accelerator (LINAC).



(a) State what is connected between terminals T_1 and T_2.

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(2)

(b) Explain why the electrons travel with constant velocity whilst in the cylinders.

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(2)

(c) Explain why the cylinders gradually increase in length along the accelerator.

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(2)

Q13

(Total 6 marks)

Leave blank

***14.** At the start of the 20th century it was thought that the atom contained an even distribution of positive charge with electrons embedded in it. Rutherford directed a series of experiments using α-particles to investigate the structure of the atom.

In 1913 Rutherford wrote that "the observations on the scattering of α-particles by matter afford strong experimental evidence for the theory that the atom consists of a positively charged nucleus of minute dimensions surrounded by a compensating distribution of negative electrons".

Outline the experimental observations to which Rutherford is referring and explain how they led him to this deduction.

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.... **Q14**

(Total 5 marks)

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15. (a) A 2200 μF capacitor is charged to a potential difference of 12 V and then discharged through an electric motor. The motor lifts a 50 g mass through a height of 24 cm.

(i) Show that the energy stored in the capacitor is approximately 0.16 J.

Energy = ...

(2)

(ii) What is the efficiency of the electric motor in this situation?

Efficiency = ...

(2)

(b) The capacitor is charged to 12 V again and then discharged through a 16 Ω resistor.

(i) Show that the time constant for this discharge is approximately 35 ms.

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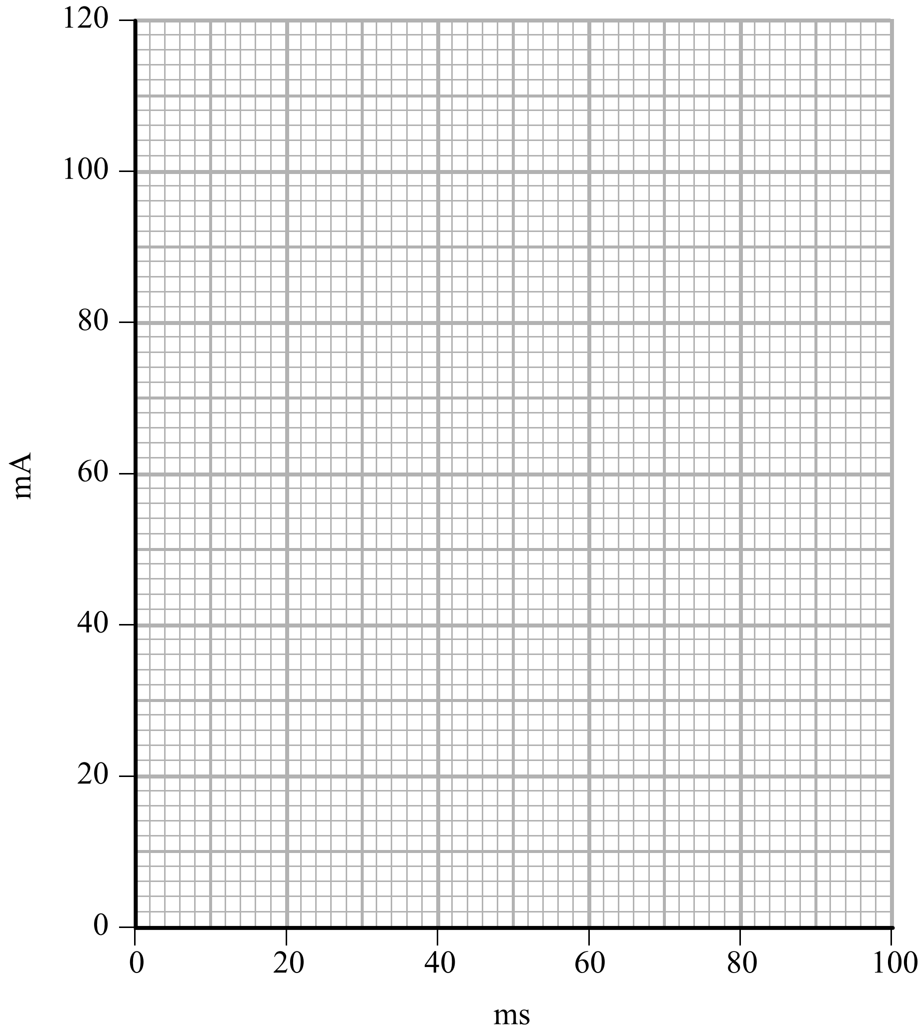
(1)

(ii) Sketch a graph of current against time for this discharge on the grid below. You should indicate the current at t = 0 and t = 35 ms.



(3)

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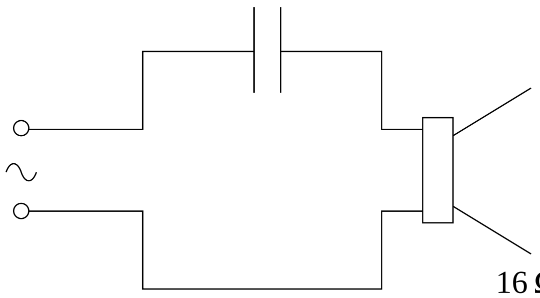
(c) Capacitors are used in audio systems when connecting the amplifier to the loudspeaker. In one such circuit the capacitor has a value of 2200 μF and the loudspeaker has a resistance of 16 Ω.



(i) The loudspeaker produces longitudinal waves. What is meant by longitudinal in this context?

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(2)

(ii) Ideally, the time constant for such a circuit should be much greater than the time period of the lowest frequency note. Discuss the extent to which this circuit would be effective if the lowest frequency note is 20 Hz.

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(2)

Q15

(Total 12 marks)

Leave blank

16. (a) In their famous experiment conducted in 1932, Cockcroft and Walton accelerated protons through a potential difference of 300 kV and used them to bombard a lithium ($^{7}_{3}\text{Li}$) target. They found that two alpha particles were produced. The energy of the alpha particles was subsequently calculated from the tracks they made in a cloud chamber.

Complete the nuclear equation for this event.

$$^{7}_{3}\text{Li} + \qquad \longrightarrow$$

(2)

(b) Cockcroft and Walton reported to the Royal Society that "if momentum is conserved in the process, then each of the α-particles must take up equal amounts of energy, and from the observed range of the α-particles we conclude that an energy of 17.2 million electron-volts [MeV] would be liberated in this disintegration process".

(i) State **two** other properties, in addition to momentum, that are conserved in such a process.

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(2)

(ii) Use the data below to show that the energy released in this process is approximately 2.8×10^{-12} J.

Mass of lithium nucleus = 7.0143 u
Mass of proton = 1.0073 u
Mass of α-particle = 4.0015 u

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(4)

Leave blank

(iii) Hence discuss the extent to which Cockcroft and Walton's results confirm Einstein's prediction that E is equal to mc^2.

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(5)

Q16

(Total 13 marks)

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***17.** (a) State the principle of conservation of linear momentum.

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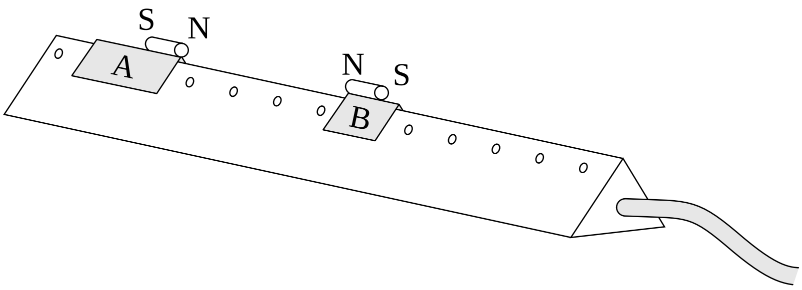
(2)

(b) The diagram shows two gliders on an air track. The magnets on the top of the gliders repel each other. The mass of glider A is 300 g and that of glider B is 100 g.



Glider A is given a push to start it moving towards glider B which is initially at rest.

Describe how you could determine the velocity of A before the gliders interact and the velocities of both A and B after the interaction. You may add to the diagram to show any additional apparatus required.

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(6)

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(c) A student obtains the following velocities:

velocity of A before interaction = 5.2 cm s^{-1}

velocity of A after interaction = 2.7 cm s^{-1}

velocity of B after interaction = 7.5 cm s^{-1}

Show if these results confirm that momentum is conserved in the interaction.

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(2) **Q17**

(Total 10 marks)

Leave blank

***18.** A do-it-yourself company is advertising a wind turbine that they state can deliver a power of 1 kW.

Their specification provides the following data:

- area swept out by the blades in one revolution = 2.4 m^2
- power output = 1 kW at a wind speed of 12.5 m s^{-1}
- typical operating speed of blades = 600 revolutions per minute

(a) (i) Show that the length of each blade is approximately 0.9 m.

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(1)

(ii) Show that the angular velocity of the blades at the typical operating speed is approximately 63 rad s^{-1}.

....

....

(1)

(iii) Calculate the speed at which the tips of the blades will then be travelling.

Speed = ...

(1)

(b) The theoretical power available from a wind turbine is given by

$$p = ½\, \rho A v^3$$

where ρ = density of air = 1.3 kg m^{-3}
A = area swept out by blades per revolution
v = wind speed

(i) Show that when the wind speed is 12.5 m s^{-1}, the theoretical power from the advertised turbine is about 3 kW.

Power = ...

(2)

Leave blank

(ii) Suggest two reasons why the actual power is less than the theoretical power.

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(2)

(c) The manufacturer has to ensure that when the turbine is attached to a chimney stack, the force exerted on the chimney does not cause it to collapse. The turbine is designed to cut out at a wind speed of 14 m s^{-1}.

(i) Calculate the mass of air hitting the blades each second when the wind speed is 14 m s^{-1}.

Mass of air = ...

(2)

(ii) Hence calculate the maximum force that the wind could exert on the blades.

Maximum force ....

(2)

Leave blank

(d) The average wind speed in the UK is $5.8\,m\,s^{-1}$, which results in an actual average power output of 100 W. Discuss whether it would be better for the environment to replace some filament light bulbs with low energy bulbs than to use this turbine. Assume each filament light bulb is rated at 100 W and each low energy bulb is rated at 11 W.

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(5)

Q18

(Total 16 marks)

TOTAL FOR PAPER: 80 MARKS

END

