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| For Examiner's Use | |
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| Examiner's Initials | |
| Question | Mark |
| 1 | |
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General Certificate of Education
Advanced Level Examination
January 2011

# Physics A PHYA4/2

## Unit 4 Fields and Further Mechanics
## Section B

**Thursday 27 January 2011 1.30 pm to 3.15 pm**

**For this paper you must have:**
- a calculator
- a ruler
- a Data and Formulae Booklet.

**Time allowed**
- The total time for both sections of this paper is 1 hour 45 minutes. You are advised to spend approximately one hour on this section

**Instructions**
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the space provided. Answers written in margins or on blank pages will not be marked.
- Do all rough work in this book. Cross through any work you do not want to be marked

**Information**
- The marks for questions are shown in brackets.
- The maximum mark for this section is 50.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

*Do not write outside the box*

**There are no questions printed on this page**

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**ANSWER IN THE SPACES PROVIDED**

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Answer **all** questions
You are advised to spend approximately **one hour** on this section

**1** The Hubble space telescope was launched in 1990 into a circular orbit near to the Earth. It travels around the Earth once every 97 minutes.

**1 (a)** Calculate the angular speed of the Hubble telescope, stating an appropriate unit.

answer = .....
*(3 marks)*

**1 (b) (i)** Calculate the radius of the orbit of the Hubble telescope.

answer = ..... m
*(3 marks)*

**1 (b) (ii)** The mass of the Hubble telescope is $1.1 \times 10^4$ kg. Calculate the magnitude of the centripetal force that acts on it.

answer = ..... N
*(2 marks)*

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**2 (a)** State, in words, how the force acting on a body is related to the change in momentum of the body.

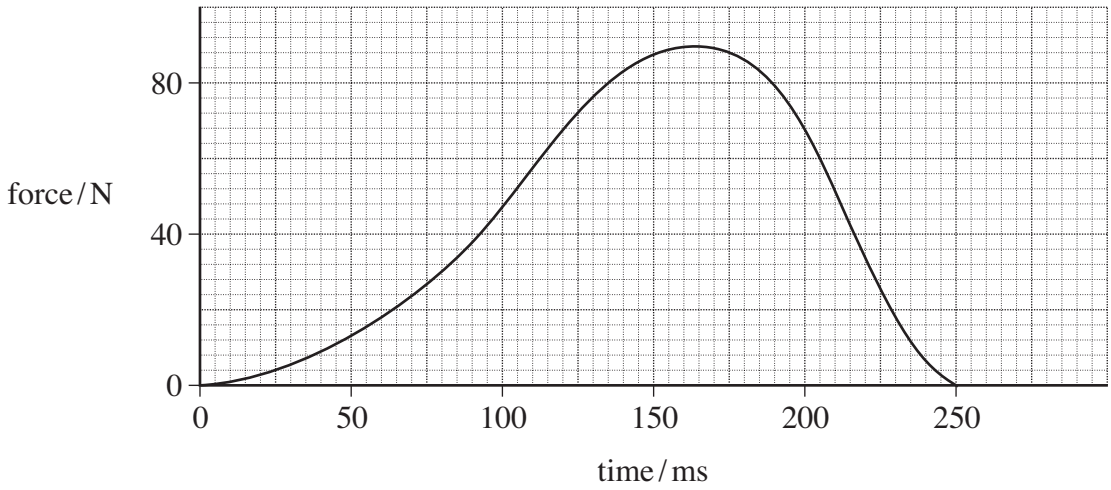
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*(1 mark)*

**2 (b)** A football of mass 0.42 kg is moving horizontally at 10 m s$^{-1}$ towards a footballer's boot, which then kicks it. **Figure 1** shows how the force between the boot and the ball varies with time while they are in contact.

**Figure 1**




**2 (b) (i)** What is the significance of the area enclosed by the line on a force–time graph and the time axis when a force acts on a body for a short time?

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*(1 mark)*

**2 (b) (ii)** Estimate the impulse that acts on the ball, stating an appropriate unit.

answer = .....

*(4 marks)*

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**2 (b) (iii)** Calculate the speed of the ball after it has been kicked, assuming that it returns along the same horizontal line it followed when approaching the boot. Express your answer to an appropriate number of significant figures.

answer = .....m s$^{-1}$

*(4 marks)*

**2 (c)** Discuss the consequences if the ball had approached the boot at a higher speed but still received the same impulse.

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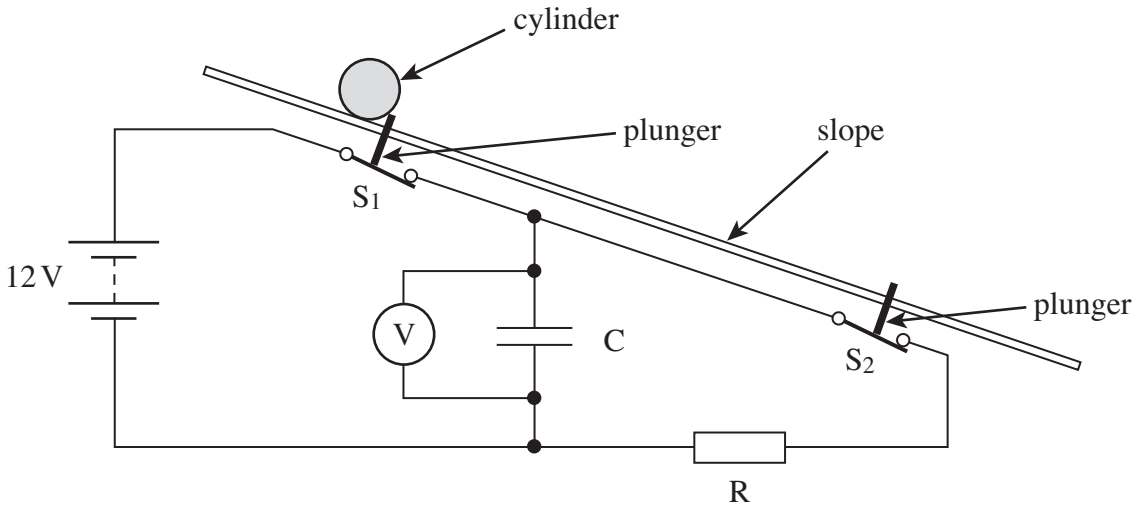
*(3 marks)*

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**3** A student was required to design an experiment to measure the acceleration of a heavy cylinder as it rolled down an inclined slope of constant gradient. He suggested an arrangement that would make use of a capacitor-resistor discharge circuit to measure the time taken for the cylinder to travel between two points on the slope. The principle of this arrangement is shown in **Figure 2**.

**Figure 2**




$S_1$ and $S_2$ are two switches that would be opened in turn by plungers as the cylinder passed over them. Once opened, the switches would remain open. The cylinder would be released from rest as it opened $S_1$. The pd across the capacitator would be measured by the voltmeter.

**3 (a)** Describe the procedure the student should follow, including the measurements he should make, when using this arrangement. Explain how he should use the measurements taken to calculate the acceleration of the cylinder down the slope.

The quality of your written communication will be assessed in this question.

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*(6 marks)*

**3 (b)** When the student set up his experiment using the arrangement shown in **Figure 2**, he used a 22 μF capacitor, C, and a 200 kΩ resistor, R. In one of his results, the initial pd was 12.0 V and the final pd was 5.8 V. The distance between the plungers was 2.5 m.

**3 (b) (i)** From the student's result, calculate the time taken for the cylinder to reach the second plunger.

answer = .....s

*(3 marks)*

**3 (b) (ii)** What value does this result give for the acceleration of the cylinder down the slope, assuming the acceleration is constant?

answer = .....m s$^{-2}$

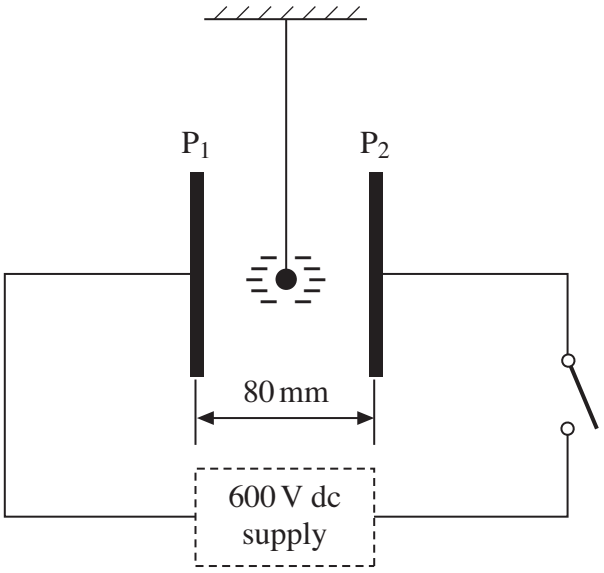
*(2 marks)*

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**4** **Figure 3** shows a small polystyrene ball which is suspended between two vertical metal plates, $\mathbf{P_1}$ and $\mathbf{P_2}$, 80 mm apart, that are initially uncharged. The ball carries a charge of –0.17 μC.

**Figure 3**




**4 (a) (i)** A pd of 600 V is applied between $\mathbf{P_1}$ and $\mathbf{P_2}$ when the switch is closed. Calculate the magnitude of the electric field strength between the plates, assuming it is uniform.

answer = .....V m$^{-1}$

*(2 marks)*

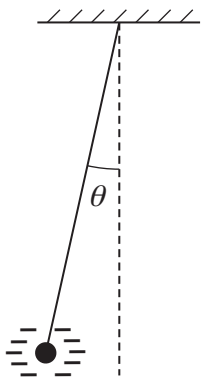
**4 (a) (ii)** Show that the magnitude of the electrostatic force that acts on the ball under these conditions is 1.3 mN.

*(1 mark)*

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**4 (b)** Because of the electrostatic force acting on it, the ball is displaced from its original position. It comes to rest when the suspended thread makes an angle $\theta$ with the vertical, as shown in **Figure 4**.

**Figure 4**




**4 (b) (i)** On **Figure 4**, mark and label the forces that act on the ball when in this position.

*(2 marks)*

**4 (b) (ii)** The mass of the ball is $4.8 \times 10^{-4}$ kg. By considering the equilibrium of the ball, determine the value of $\theta$.

answer = .....degrees

*(3 marks)*

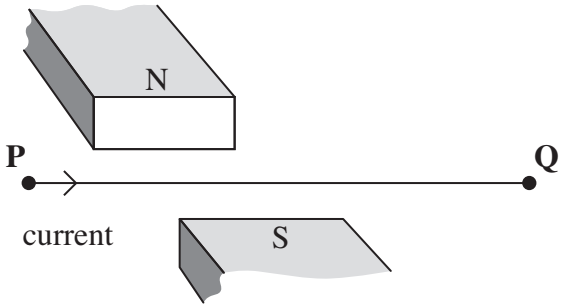
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**5** **Figure 5** shows a horizontal wire, held in tension between fixed points at **P** and **Q**. A short section of the wire is positioned between the pole pieces of a permanent magnet, which applies a uniform horizontal magnetic field at right angles to the wire. Wires connected to a circuit at **P** and **Q** allow an electric current to be passed through the wire.

**Figure 5**




**5 (a) (i)** State the direction of the force on the wire when there is a direct current from **P** to **Q**, as shown in **Figure 5**.

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*(1 mark)*

**5 (a) (ii)** In a second experiment, an alternating current is passed through the wire. Explain why the wire will vibrate vertically.

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*(3 marks)*

**5 (b)** The permanent magnet produces a uniform magnetic field of flux density 220 mT over a 55 mm length of the wire. Show that the maximum force on the wire is about 40 mN when there is an alternating current of rms value 2.4 A in it.

*(3 marks)*

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**5 (c)** The length of **PQ** is 0.40 m. When the wire is vibrating, transverse waves are propagated along the wire at a speed of 64 m $s^{-1}$. Explain why the wire is set into large amplitude vibration when the frequency of the a.c. supply is 80 Hz.

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*(3 marks)*

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**END OF QUESTIONS**

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