Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	**Mark**
1	
2	
3	
4	
TOTAL	

General Certificate of Education
Advanced Level Examination
June 2011

Physics A PHYA5/2D

Unit 5D Turning Points in Physics
Section B

Monday 27 June 2011 9.00 am to 10.45 am

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 50 minutes 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 spaces provided. Do not write outside the box around each page or on blank pages.
- 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 35.
- 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.

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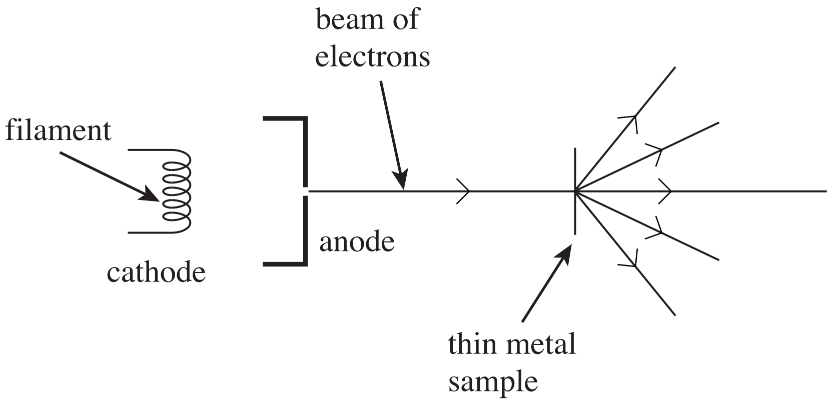
Section B

The maximum mark for this section is 35 marks. You are advised to spend approximately 50 minutes on this section.

1 In **Figure 1**, a beam of monoenergetic electrons is produced by thermionic emission from a wire filament in an evacuated tube. The beam is directed at a thin metal sample at normal incidence and it emerges from the sample in certain directions only, including its initial direction.

Figure 1



1 (a) (i) Name the physical process occurring at the thin metal sample in **Figure 1** which shows the electrons behaving as waves.

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(1 mark)

1 (a) (ii) Explain why the electrons need to be monoenergetic in order for them to emerge in certain directions only.

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(2 marks)

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1 (b) A transmission electron microscope (TEM) operating at an anode potential of 25 kV is used to observe an image of a thin sample.

1 (b) (i) Calculate the momentum of the electrons emerging from the anode, stating an appropriate unit.

answer = ...

(4 marks)

1 (b) (ii) Describe and explain how the resolution of the image would change if the anode potential were increased.

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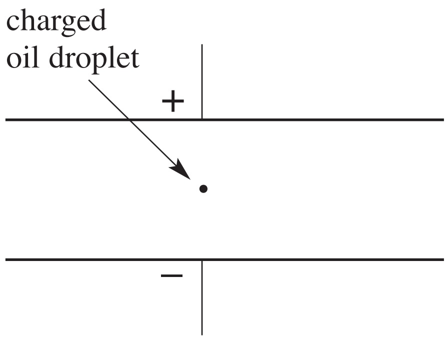
(3 marks)

10

2 In an experiment to measure the charge of the electron, a charged oil droplet of unknown mass was observed between two horizontal parallel metal plates, as shown in **Figure 2.**

Figure 2



2 (a) The droplet was observed falling vertically at its terminal speed when the pd between the plates was zero.

2 (a) (i) By considering the forces acting on the droplet as it falls at its terminal velocity, v, show that the radius, r, of the droplet is given by

$$r = \left(\frac{9\eta\, v}{2\rho\, g}\right)^{\frac{1}{2}}$$

where η is the viscosity of air and ρ is the density of the oil droplet.

(2 marks)

2 (a) (ii) Explain how the mass of the oil droplet can be determined from its radius, r.

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(1 mark)

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2 (b) (i) The two horizontal parallel metal plates were 5.0 mm apart. The mass of the droplet was 6.8×10^{-15} kg.
The droplet was held stationary when the plate pd was 690 V.

Calculate the charge of the oil droplet, expressing your answer to an appropriate number of significant figures.

answer C
(3 marks)

2 (b) (ii) Millikan made the first accurate measurements of the charge carried by charged oil droplets. Outline what Millikan concluded from these measurements.

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(2 marks)

8

Turn over for the next question

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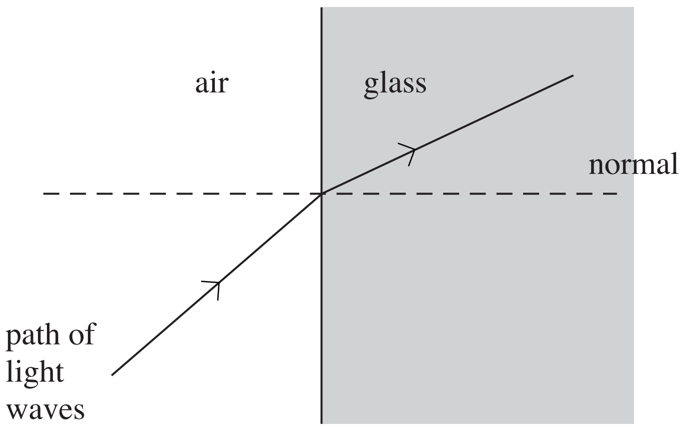
3 (a) Newton suggested a theory that light is composed of corpuscles. He used his theory to explain the refraction of a light ray travelling from air to glass, as shown in **Figure 3**. Huygens explained the refraction of light using his own theory that light consists of waves.

Figure 3



3 (a) (i) State **one** reason why Huygens' theory of light was rejected for many years after it was first proposed, in favour of Newton's corpuscular theory of light.

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(1 mark)

3 (a) (ii) Explain why the eventual measurement of the speed of light in water led to the definite conclusion that light consists of waves and not corpuscles.

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(2 marks)

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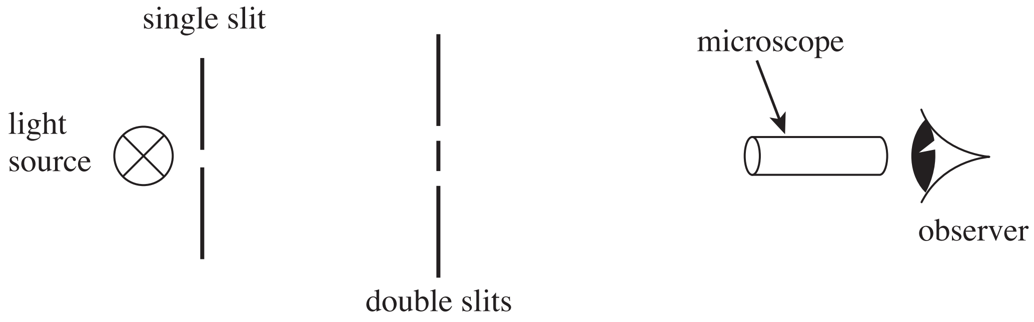
3 (b) Young demonstrated that a pattern of alternate bright and dark fringes was observed when light from a narrow single slit passed through double slits, as shown in **Figure 4**.

Figure 4



Newton's corpuscular theory predicted incorrectly that just two bright fringes would be formed in this pattern. Use Huygens' theory of light to explain why more than two bright fringes are formed in this pattern.

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

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(6 marks)

9

Turn over ▶

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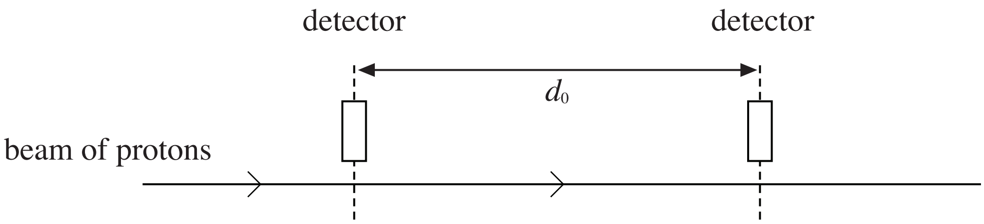
4 In an experiment, a beam of protons moving along a straight line at a constant speed of $1.8 \times 10^8\,\mathrm{m\,s^{-1}}$ took 95 ns to travel between two detectors at a fixed distance d_0 apart. As shown in **Figure 5**.

Figure 5



4 (a) (i) Calculate the distance d_0 between the two detectors in the frame of reference of the detectors.

answer = ... m

(1 mark)

4 (a) (ii) Calculate the distance between the two detectors in the frame of reference of the protons.

answer = ... m

(2 marks)

4 (b) A proton is moving at a speed of $1.8 \times 10^{8}\,\mathrm{m\,s^{-1}}$

Calculate the ratio

$$\frac{\text{kinetic energy of the proton}}{\text{rest energy of the proton}}$$

answer = ...

(5 marks)

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END OF QUESTIONS

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