AQA

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname ______________________________

Forename(s) ______________________________

Candidate signature ______________________________
I declare this is my own work.

A-level
PHYSICS

Paper 3
Section B Turning points in physics

Time allowed: The total time for both sections of this paper is 2 hours. You are advised to spend approximately 50 minutes on this section.

Materials

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

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.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 35.
- You are expected to use a scientific calculator where appropriate.
- A Data and Formulae Booklet is provided as a loose insert.

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

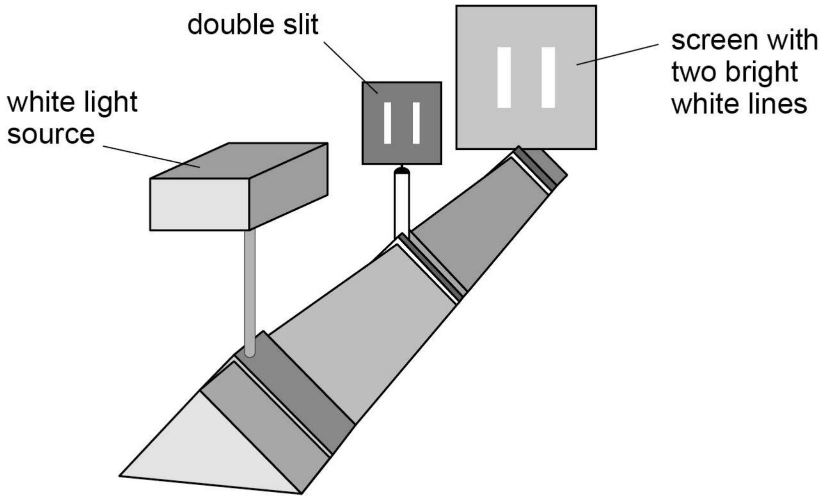
Section B

Answer **all** questions in this section.

0 1 In the 17th century, Isaac Newton proposed a theory to explain some of the properties of light. An alternative theory of light was proposed by Christiaan Huygens at about the same time.

A student uses the arrangement in **Figure 1** to investigate the two theories.

Figure 1



0 1 . 1 The student observes two bright white lines on the screen.

Explain how this observation supports Newton's theory of light.

[2 marks]

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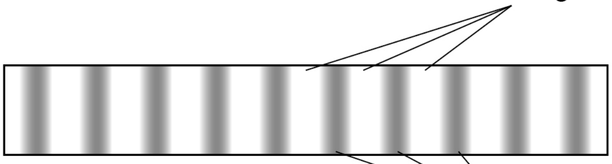
0 1 . 2 The student makes alterations to the apparatus in **Figure 1**.
Figure 2 shows the red and dark fringes that the student now observes on the screen.

Figure 2



Identify the alterations made by the student and explain how the observations in **Figure 2** support Huygens' theory of light.

In your answer you should:

- identify alterations made to the apparatus in **Figure 1**
- outline the key features of Huygens' theory
- explain how the result of this experiment supports Huygens' theory.

[6 marks]

Answer space for this question continues on the next page

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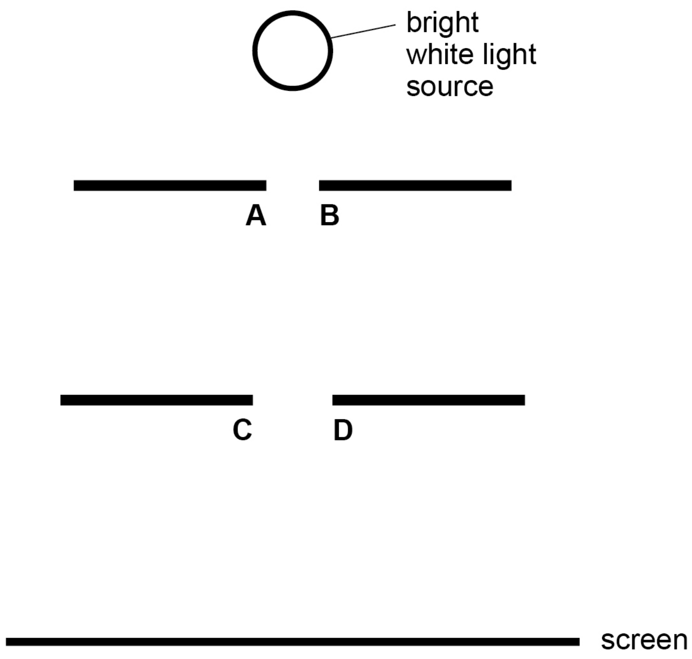
0 1 . 3 Shortly before the work of Newton and Huygens, Francesco Grimaldi carried out an experiment into the behaviour of light. **Figure 3** shows Grimaldi's arrangement.

Figure 3



A bright white light source is used to illuminate a small circular aperture, **AB**.
The light from this aperture illuminates a second, slightly larger circular aperture, **CD**.

The light passing through both apertures arrives at a screen.

Newton's theory and Huygens' theory make different predictions about the appearance of the light on the screen.

Discuss these differences in appearance.

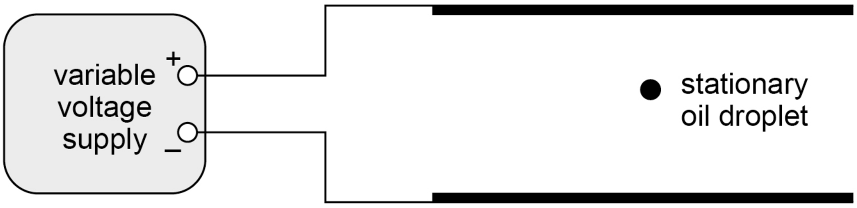
[3 marks]

11

0 2 Robert Millikan experimented with oil drops to determine a value for the electronic charge.

Figure 4 shows a stationary oil droplet between two horizontal metal plates. The plates are connected to a variable voltage supply so that the upper plate is positive. The oil droplet has mass m and charge Q.

Figure 4



0 2 . 1 State and explain the sign of the charge on the oil droplet.

[1 mark]

The variable voltage supply is set to zero volts. The oil drop falls. The constant speed v_1 of the falling oil droplet is found to be $3.8 \times 10^{-5}\ \text{m s}^{-1}$ and the following measurements are recorded:

density of oil = $910\ \text{kg m}^{-3}$
viscosity of air = $1.8 \times 10^{-5}\ \text{N s m}^{-2}$

0 2 . 2 Show that the mass m of the oil droplet is about 8×10^{-16} kg.

[3 marks]

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0 2 . 3 The variable voltage supply is adjusted so that the oil droplet rises at a constant speed v_2. The potential difference (pd) across the plates is V and the distance between the plates is d.

In his experiment, Millikan measured the constant speed v_1 of a falling droplet when the pd was zero. He compared this with the speed v_2 of the same droplet when the droplet was made to rise.

Show that $$\frac{v_2}{v_1} = \frac{VQ}{dmg} - 1$$

[2 marks]

0 2 . 4 The following measurements are made for the droplet in Question **02.2** when it is rising at constant speed.

$V = 715 \text{ V}$

$v_2 = 1.1 \times 10^{-4} \text{ m s}^{-1}$

The separation of the plates $d = 11.6 \text{ mm}$.

Deduce, using the equation in Question **02.3**, whether the value of the charge for this droplet is consistent with the currently accepted value of the electronic charge.

[3 marks]

Question 2 continues on the next page

Turn over ►

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0 2 . 5 After Millikan published his results, it was found that he had used a value for the viscosity of air that was smaller than the actual value.

Discuss the effect this error had on Millikan's value of the electronic charge.

[3 marks]

12

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Turn over for the next question

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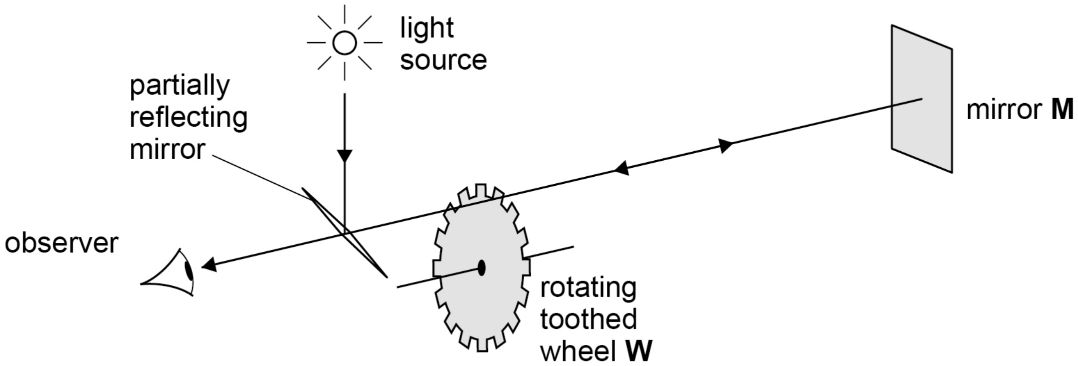
0 3 **Figure 5** shows the arrangement used by Fizeau to determine the speed of light.

Figure 5



The toothed wheel **W** is rotated and the reflected light from a distant mirror **M** is observed.

The speed of light is calculated from the equation

$$c = 4dnf_0$$

where d is the distance from **W** to **M** and
n is the number of teeth on the rotating wheel **W**.

0 3 . 1 State what f_0 represents in the equation.

[2 marks]

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0 3 . 2 The experiment is attempted using a rotating wheel with 720 teeth that can be rotated at up to 620 revolutions per minute.
The distance between **W** and **M** is 8.5 km.

Deduce whether the speed of light can be determined with this particular arrangement.

[2 marks]

0 3 . 3 The determination of the speed of light took on extra significance when Maxwell derived the wave-speed equation

$$c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}$$

State how ε_0 and μ_0 are related to the types of field in the wave.

[2 marks]

ε_0 ______

μ_0 ______

6

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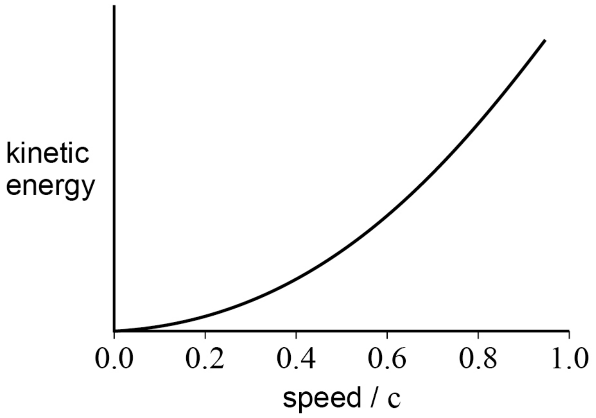
0 4 . 1 Bertozzi investigated how the kinetic energy of electrons varies with speed.

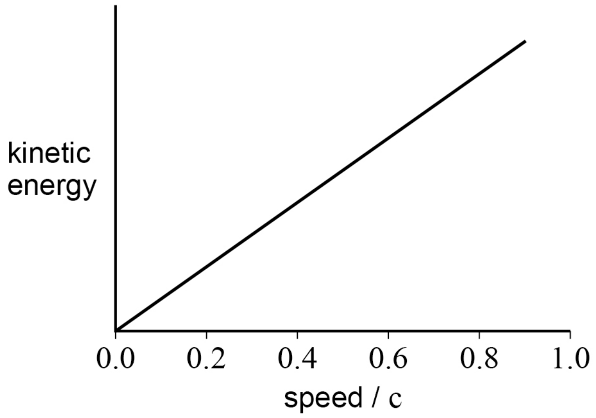
Which graph shows the variation of kinetic energy with speed?
Tick (✓) **one** box.

[1 mark]

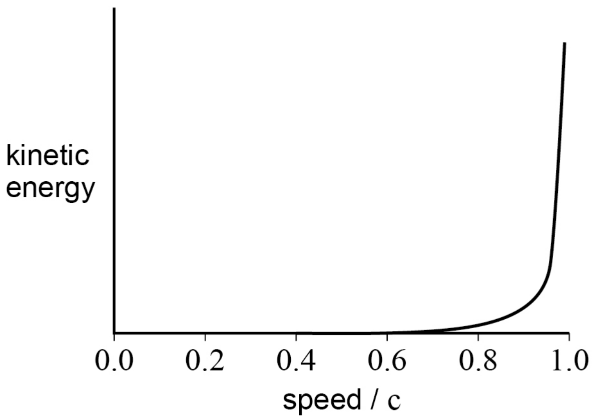
A



B



C



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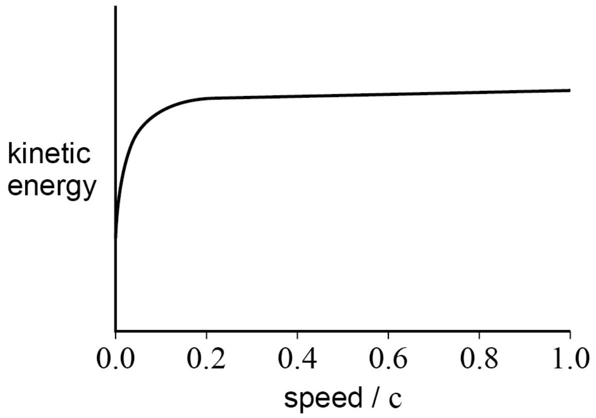

A ☐

B ☐

C ☐

D ☐

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0 4 . 2 Calculate the speed of a particle when its kinetic energy is equal to its rest energy.

[3 marks]

speed = ____________________ $m\ s^{-1}$

0 4 . 3 Discuss the change in the observed mass of a spring when it is stretched.

[2 marks]

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6

END OF QUESTIONS

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