



Please write clearly in block capitals.

Centre number

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Candidate number

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Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

A-level PHYSICS

Paper 3 Section B Turning points in physics

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.

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.

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



Section B

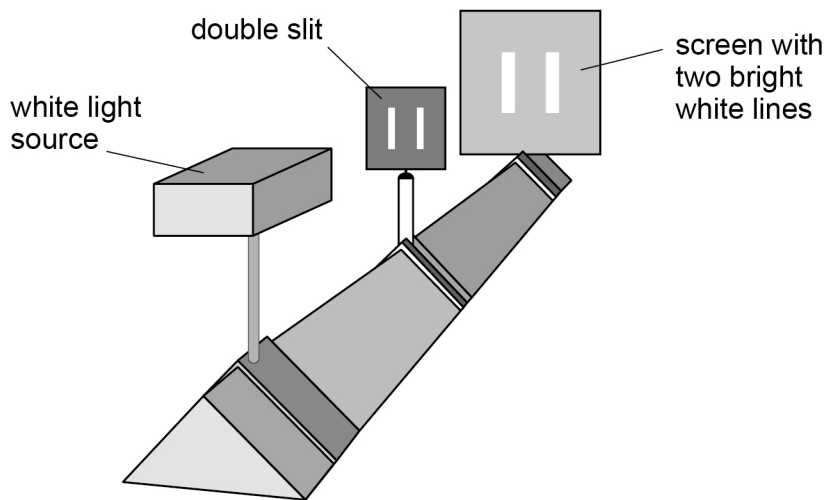
Answer **all** questions in this section.

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.

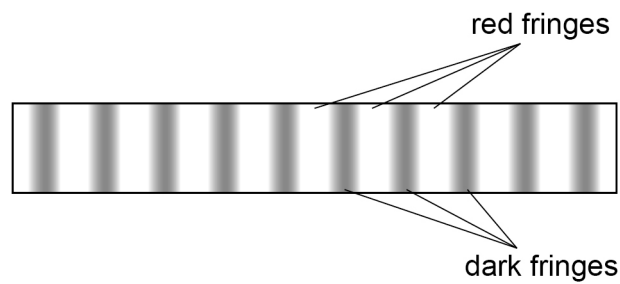
[2 marks]



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]

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Answer space for this question continues on the next page

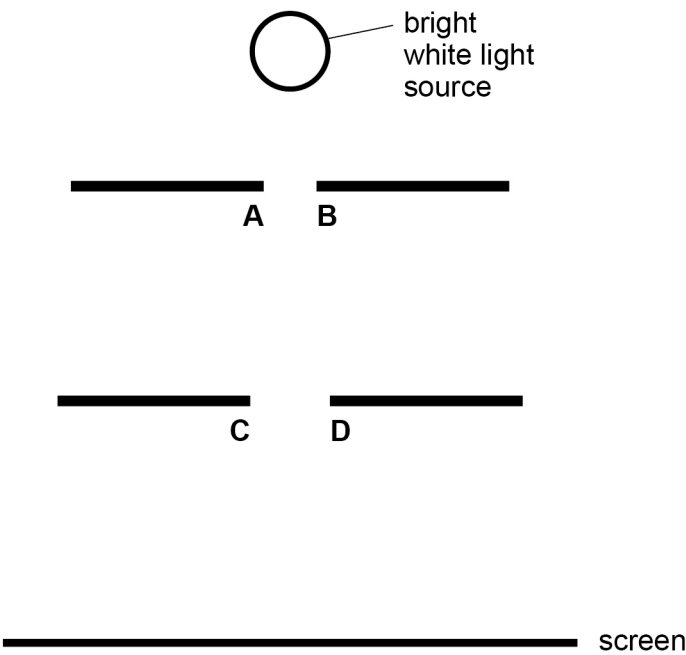
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0 1 . 3

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]

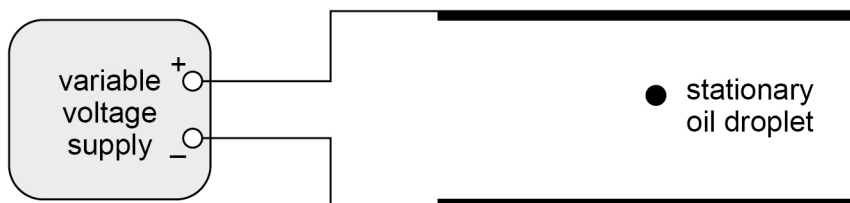


0 2

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:

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

0 2 . 2

Show that the mass m of the oil droplet is about $8 \times 10^{-16} \text{ kg}$.

[3 marks]



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

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

[3 marks]

[illegible]

12



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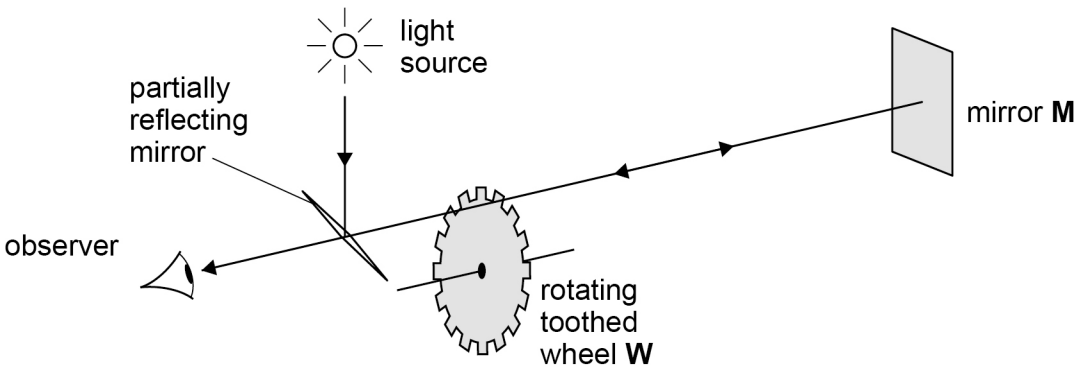
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0 3

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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03.2

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]

03.3

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

$$c = \frac{1}{\sqrt{\epsilon_0 \mu_0}}$$

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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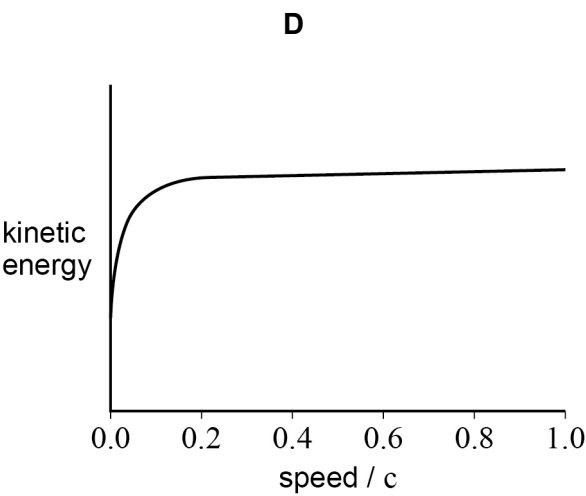
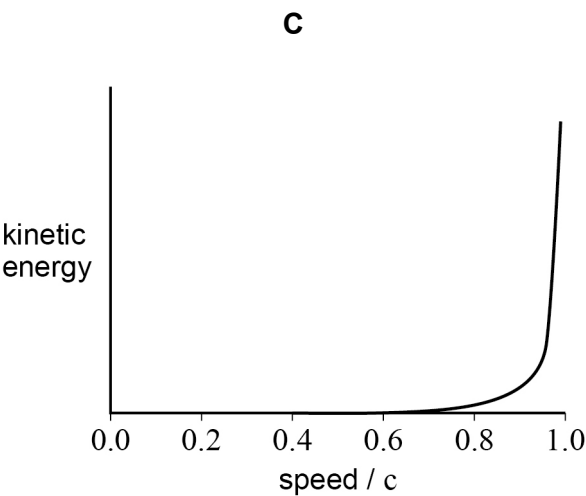
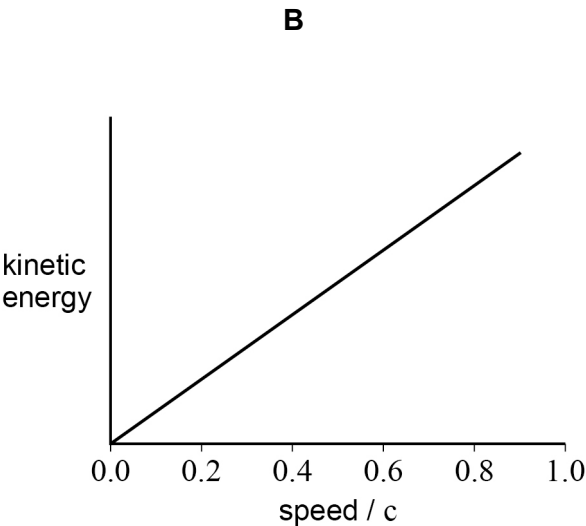
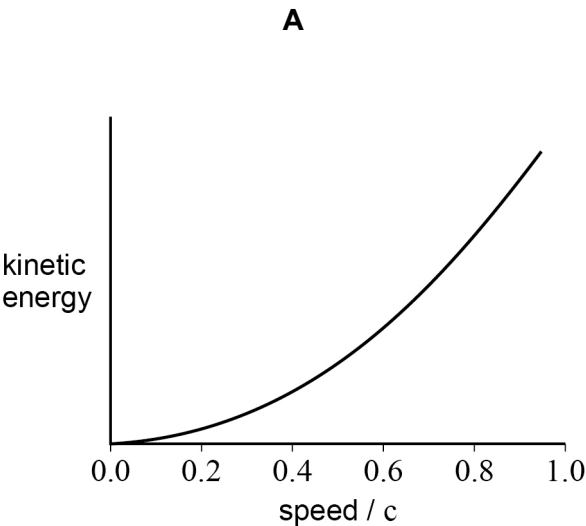


0 4 . 1

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 ☐

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]

6

END OF QUESTIONS



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Question number	Additional page, if required. Write the question numbers in the left-hand margin.



