InkPhysics

QUESTION WORKBOOK

The nature of light

Turning points · Year 13

AQA 3.12.2.1, 3.12.2.2, 3.12.2.3 · OCR A 4.4.3(f)

18 questions · 52 marks

PRINT EDITION

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SECTION A · Warm-up

A1 Give two reasons why Newton's corpuscular theory of light was preferred over Huygens' wave theory for over a century. [2]

A2 Explain, in general terms, why bright and dark fringes appear in Young's double slit experiment. [2]

A3 State what the constants ε_0 and μ_0 each describe. [2]

A4 State two behaviours of light that Newton's corpuscular theory and Huygens' wave theory could both explain. [2]

A5 State the nature of an electromagnetic wave. [2]

SECTION B · Standard

B1 Calculate the speed of electromagnetic waves predicted by Maxwell's formula $c = 1/\sqrt{(\mu_0\varepsilon_0)}$, using $\mu_0 = 4\pi \times 10^{-7}$ H m^{-1} and $\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}, and state the significance of the result. [3]

B2 Hertz set up stationary radio waves with adjacent nodes 1.65 m apart, using an oscillator of frequency 9.1×10^7 Hz. Calculate the wave speed and state what the result demonstrated. [3]

B3 In Fizeau's experiment a wheel with 720 teeth first blocked the returning light at 12.6 revolutions per second, with the mirror 8.63 km away. Calculate the speed of light this gives. [4]

B4 Explain why Young's fringes cannot be accounted for by a particle theory of light. [3]

B5 In a double slit experiment, light from the two slits arrives at a point on the screen with a path difference of 2.5 wavelengths. State and explain what is observed at this point. [2]

B6 The speed of light in free space is 3.00×10^{8} m s^{-1} and $\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}. Use Maxwell's formula $c = 1/\sqrt{(\mu_0 \varepsilon_0)}$ to determine a value for ε_0, the permittivity of free space. [3]

SECTION C · Stretch

C1 Measurements descended from Fizeau's method later compared the speed of light in air and in water. Explain why this comparison was decisive between the two theories of light. [3]

C2 Explain the significance of Hertz's experiments for the understanding of the electromagnetic spectrum. [4]

C3 Young published his double slit results in 1801, yet the wave theory was not generally accepted for decades. Suggest why. [2]

C4 A physics society plans to repeat Fizeau's experiment with a wheel of 600 teeth and a mirror on a hillside 9.5 km away. Their motor can spin the wheel at up to 15 revolutions per second. Deduce whether they will be able to observe the first blocking of the returning light. $c = 3.0 \times 10^{8}$ m s^{-1}. [4]

C5 In Fizeau's experiment the wheel's rotation rate is slowly increased beyond the first blocking, up to twice that rate. Explain what is seen at the eyepiece as this happens. [3]

C6 Light does in fact diffract, yet for over a century nobody observed it doing so and shadows appeared perfectly sharp. Suggest why the diffraction of light escaped detection, and explain why sharp shadows appeared to support Newton. [3]

C7 Describe Fizeau's determination of the speed of light, and explain how the speed is calculated from the measurements. State one reason the measurement was significant. [5]