GCE PHYSICS

S21-A420QS

Assessment Resource number 19

Light and Nuclei Resource A

1. *(a)* State what is meant by two coherent sources. [1]

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(b) In the 1700s, light was thought to consist of a stream of particles. In the 1800s, it was said to be a wave but since the early 1900s it has been accepted that light behaves both like a wave and like a particle (wave particle duality). Explain briefly the part that Young's double slit experiment played in this history. [2]

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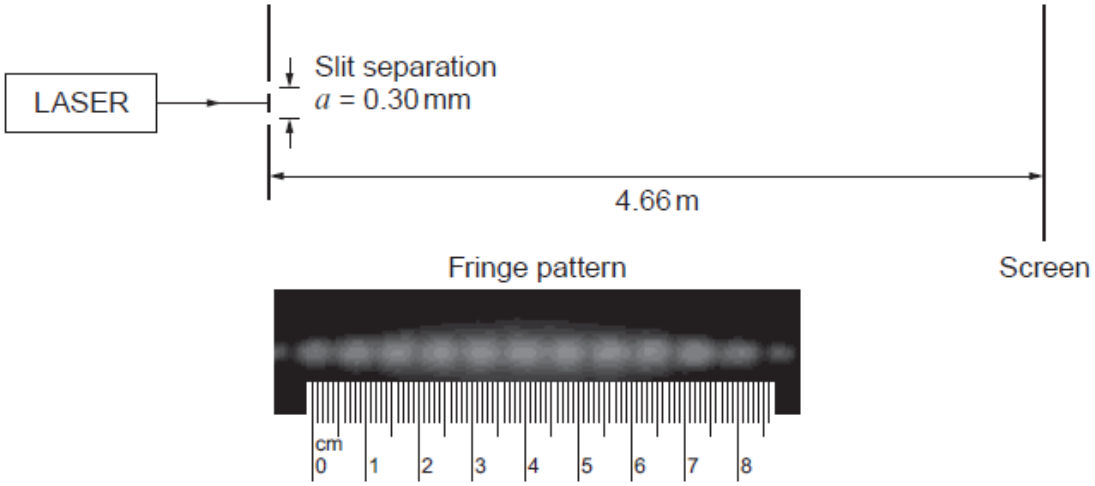
(c) Young's double slit experiment is carried out using laser light.



(i) Calculate the fringe separation from the above diagram. [2]

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(ii) The distance between the slits and the screen is 4.66 m. Calculate the wavelength of the laser light. [2]

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(iii) State one advantage and one disadvantage of using a large slit-to-screen distance. [2]

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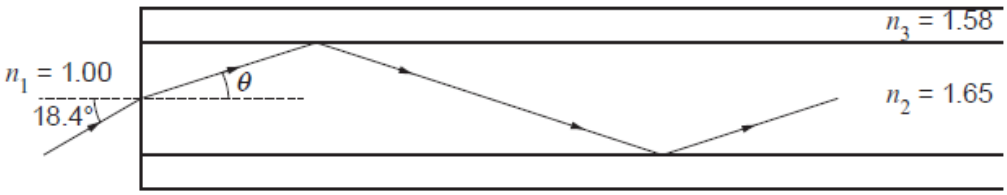
2. A light ray enters an optical fibre as shown.



(a) Show that the angle θ is approximately 10°. [2]

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(b) Deduce whether or not this light will propagate along the length of the optical fibre with total internal reflection as shown. [4]

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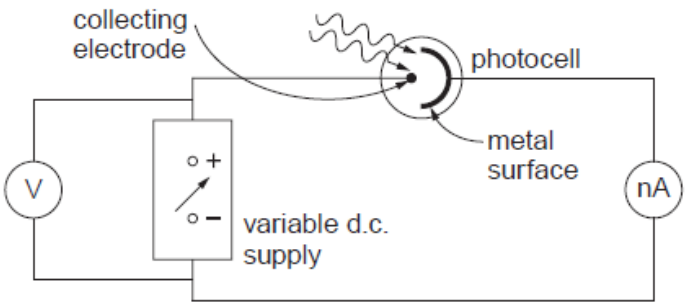
3. Light is incident on a photoelectric cell as shown.



(a) Explain why a current is detected by the ammeter. [3]

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(b) The work function of the metal surface is 2.7 eV and electrons are emitted with a maximum kinetic energy of 1.2 eV.

Calculate the frequency of the incident photons. [3]

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(c) (i) Explain how you would modify and use the circuit opposite to measure the stopping potential. [3]

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(ii) The metal surface of the photocell is radioactive and emits alpha particles some of which arrive at the collecting electrode. Explain briefly what effect this would have on measuring the stopping potential and what could be done to reduce this effect. [3]

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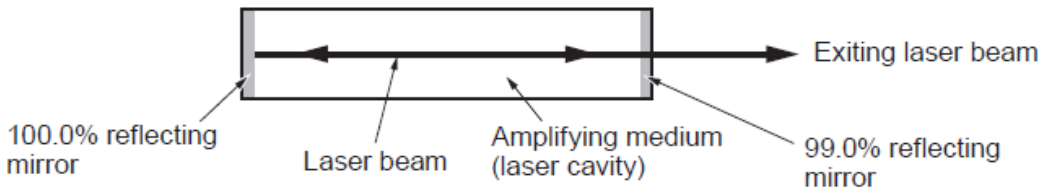
4. A laser has two mirrors either side of the amplifying medium as shown.



(a) Explain the purpose of the 99.0% reflecting mirror and the 100.0% reflecting mirror. [2]

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(b) Explain the purpose of a population inversion in the laser cavity. [3]

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(c) (i) The light intensity inside a powerful laser is 2.0×10^{15} W and its wavelength is 1.05 μm. Show that this corresponds to approximately 1×10^{34} photons per second. [2]

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(ii) Show that the momentum of a 1.05 μm photon is approximately 6×10^{-28} kg m s^{-1}. [1]

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(iii) Show that the force exerted on a 100.0% reflecting mirror by a beam of power 2.0×10^{15} W is approximately 1×10^{7} N. [2]

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(iv) Calculate the strain produced in a laser structure if the power of the beam between the mirrors is 2.0×10^{15} W. You may assume that the structure of the laser cavity has a cross-sectional area of 43 cm^2 and is made of a material with Young modulus 2.8×10^{11} Pa. [3]

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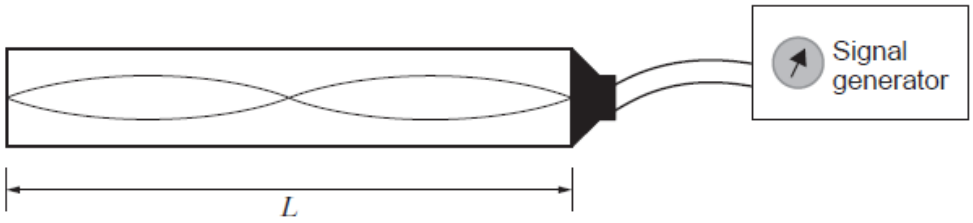
5. An experiment is carried out using stationary waves to measure the speed of sound in air. A loudspeaker is placed at one end of a hollow tube so that both ends are closed. The frequency, f, of the signal generator connected to the loudspeaker is varied and those frequencies corresponding to loud noises recorded.



(a) Describe the differences between a stationary wave and a progressive wave in terms of energy, phase and amplitude. [3]

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(b) Show that the frequencies corresponding to stationary waves are given by:

$$f = \frac{v}{2L} n$$

where n is any whole number (n = 2 in the above diagram). [3]

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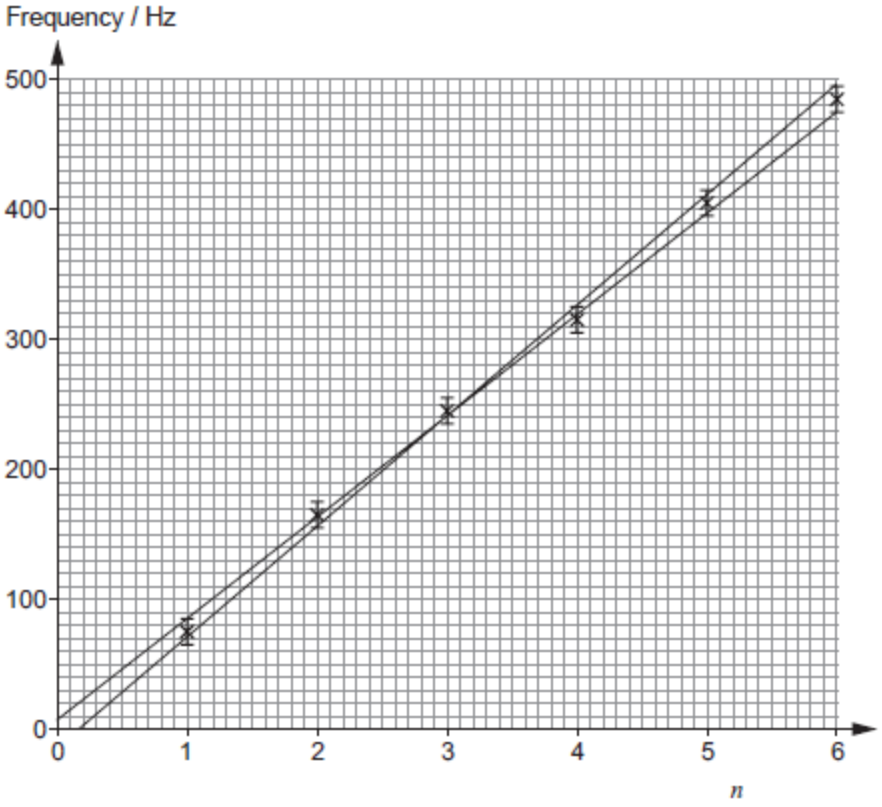
(c) The data obtained are plotted on the grid below.



Explain to what extent the graph agrees with the equation: [3]

$$f = \frac{v}{2L} n$$

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(d) The experiment is repeated with the tube filled with nitrogen dioxide (NO_2), a gas that is 1.5 times denser than air. The speed of sound in a gas is inversely proportional to the square root of the density, ρ:

$$v \propto \frac{1}{\sqrt{\rho}}$$

Explain what effect this will have on the gradient of the graph. [3]

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(e) A car company is fined £15 billion for excessive NO_2 emissions of its diesel engines. However, there is little or no reliable evidence that NO_2 produces any detrimental health effects at the concentration levels present in the atmosphere. Discuss whether or not the car company or pedestrians have been treated unfairly. [3]

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