INTERNATIONAL BACCALAURÉAT BACHILLERATO
BACCALAUREATE INTERNATIONAL INTERNACIONAL

M99/430/S(3)

PHYSICS

Standard Level

Monday 17 May 1999 (morning)

Paper 3 — 1 hour

A

Candidate name:	Candidate category & number:

This examination paper consists of 8 options.
The maximum mark for each option is 20.
The maximum mark for this paper is 40.

INSTRUCTIONS TO CANDIDATES

Write your candidate name and number in the boxes above.

Do NOT open this examination paper until instructed to do so.

Answer all of the questions from TWO of the options in the spaces provided.

At the end of the examination, complete box B below with the letters of the options answered.

B

OPTIONS ANSWERED

C

EXAMINER	TEAM LEADER
/20	/20
/20	/20
TOTAL /40	TOTAL /40

D

IBCA
/20
/20
TOTAL /40

EXAMINATION MATERIALS

Required:
Calculator
Physics SL Data Booklet

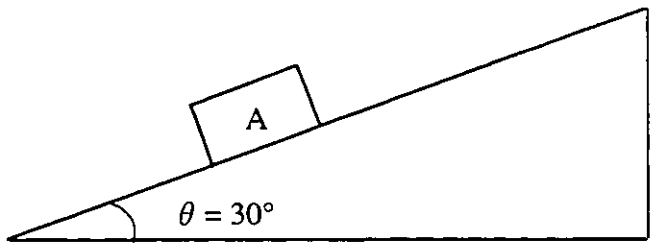
Allowed:
A simple translating dictionary for candidates not working in their own language

OPTION A—MECHANICS

Answer ALL the questions in this option.

A1. This question is about coefficient of static friction and Newton's Second Law.

(a) A wooden block of weight 4.0 N rests on a inclined plane as shown in the diagram below. The plane is tilted and when the angle $\theta = 30°$ is reached the block is just about to slip.



(i) Draw and label the forces acting on the block. *[3]*

(ii) Show that the coefficient of friction between the block and the plane is 0.60. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) The block is now held on the plane whilst the angle θ is increased to 60°. It is then released. Calculate the initial acceleration of the block down the plane. (Take g = 10 ms^{-2}) *[4]*

. . . . . .

. . . . . .

. . . . . .

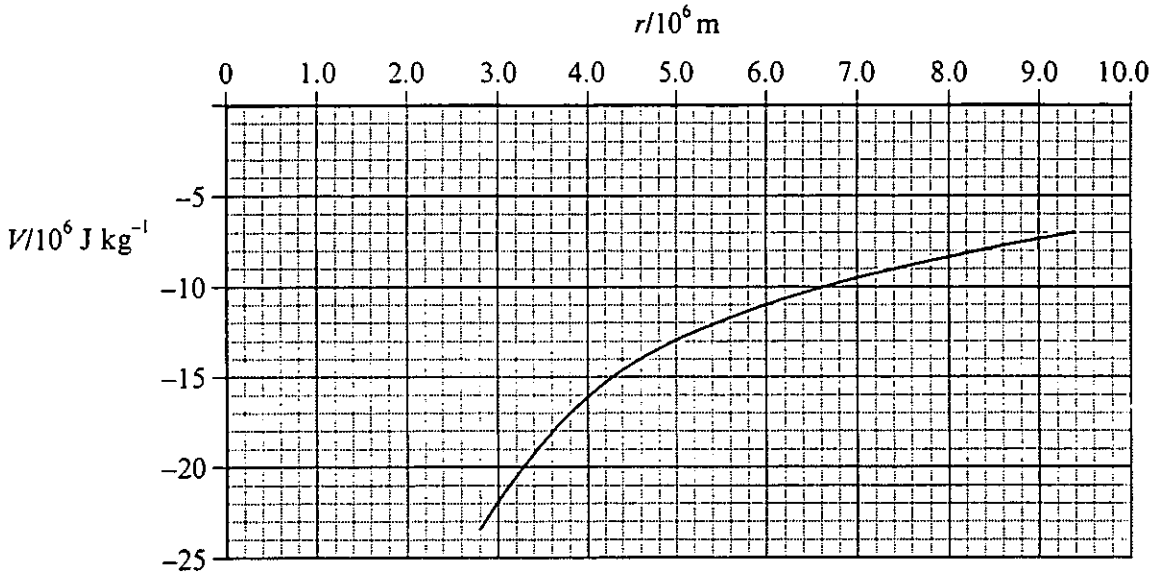
. . . . . .

. . . . . .

. . . . . .

. . . . . .

A2. This question is about gravitational potentials.



This graph shows how the gravitational potential V varies with distance r from the centre of a planet.

The mean radius of the planet is 2.8×10^6m and r is the distance measured from the centre of the planet.

(a) What is the gravitational potential at the surface of the planet? *[1]*

. . . . . .

. . . . . .

(b) Determine the energy required to move a mass of 1 kg from the surface of the planet to a distance of 3.8×10^6m from the centre of the planet. *[2]*

. . . . . .

. . . . . .

. . . . . .

(c) What kind of energy will the mass have when it has been moved to this point? *[1]*

. . . . . .

. . . . . .

(d) How much energy is required to move a mass of 1 kg from the surface of the planet to an infinite distance away? *[1]*

. . . . . .

. . . . . .

(e) Calculate the escape velocity from the surface of the planet. *[2]*

. . . . . .

. . . . . .

A3. This question is about circular motion.

A car travels round a bend in the road at a constant speed of 20 ms^{-1}.

The bend is an arc of a circle of radius 100 m.

(a) Calculate the acceleration of the car. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) In what direction is the car accelerating? *[1]*

. . . . . .

. . . . . .

(c) What is the origin of the force which causes the car to accelerate? *[1]*

. . . . . .

. . . . . .

OPTION B—ATOMIC AND NUCLEAR PHYSICS

Answer ALL the questions in this option.

B1. This question is about neutrons.

(a) Why was the existence of the neutron postulated? *[1]*

. . . . . .

. . . . . .

(b) (i) When Chadwick bombarded polonium with alpha particles he discovered that another radiation is produced. What **two** facts about this radiation led Chadwick to believe that the radiation did not carry an electric charge and might therefore consist of neutrons? *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(ii) On what **two** principles of physics was the measurement of the neutron's mass based? *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) A free neutron will decay with a half life of ten minutes. Write the equation for its decay and name the particles into which it decays. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

B2. This question is about nuclear reactions.

Consider the following nuclear reaction.

$$^{2}H + {}^{2}H = {}^{3}He + {}^{1}_{0}n$$

(a) In this reaction there is a mass change of 0.0035 u.

Calculate the energy in joules released in the reaction. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) In what form does this energy appear? *[1]*

. . . . . .

. . . . . .

. . . . . .

(c) In any sample of pure water about $10^{-2}\%$ of the hydrogen nuclei will be the isotope deuterium (^{2}H). If all these nuclei could be used to produce energy show that 1 kg of water could fuel a household with an average power consumption of 4 kW for nearly 60 hours. (The molecular weight of water is 18). *[5]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

B3. This question is about evidence for the wave-particle nature of radiation.

In the photoelectric effect it is observed that:

- no matter how low the intensity of the incident light the ejection of the first electrons from the metal surface is always instantaneous.
- there exists a frequency of the incident light below which no electrons are ejected no matter how intense the incident light nor for how long the surface is exposed to the light.

Explain how these observations are inconsistent with the wave theory of light and provide support for the particle model. *[5]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

OPTION C—ENERGY EXTENSION

Answer ALL questions in this option.

C1. This question is about energy sources.

(a) Give **one** example of a renewable energy source and **one** example of a non-renewable energy source and explain why they are classified as such. *[4]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) A wind farm produces 35 000 MWh of energy in a year. If there are ten wind turbines on the farm show that the average power output of **one** turbine is about 400 kW. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) State **two** disadvantages of using wind power to generate electrical power. *[2]*

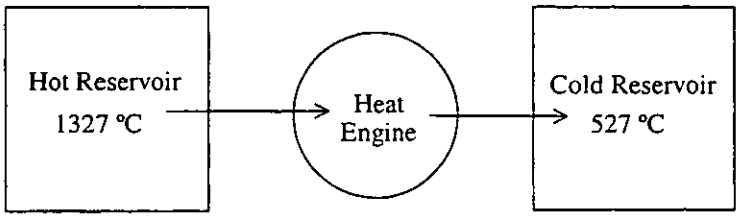
. . . . . .

. . . . . .

. . . . . .

. . . . . .

C2. This question is about heat engines and the Laws of Thermodynamics.



The diagram above shows a heat engine operating between two reservoirs one at a temperature of 1327 °C and the other at a temperature of 527 °C.

(a) Explain why, even if all the friction in the moving parts of the heat engines could be eliminated, the engine can never be 100% efficient. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Calculate the maximum theoretical efficiency of the engine shown in the diagram. *[2]*

. . . . . .

. . . . . .

. . . . . .

(c) The actual efficiency of the engine is 20%. If its power absorption from the hot reservoir is 140 kW, how much energy will it transfer to the cold reservoir in one hour? *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(d) In an isothermal expansion of a gas the energy absorbed by the gas is completely converted to work. Explain how this process can still be consistent with the Kelvin Statement of the Second Law of Thermodynamics. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

OPTION D—MEDICAL PHYSICS

Answer ALL questions in this option.

D1. This question is about blood flow.

(a) Explain why the blood pressure at various points in the human body will depend on whether a person is standing vertically or lying down horizontally. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Two parallel arteries in the body, A and B, are of the same length and have the same pressure difference between their ends.

Artery A has a diameter of 0.60 mm and artery B has a diameter of 0.30 mm.

Calculate the ratios in A and B of the

(i) mean velocity of blood flow. *[1]*

. . . . . .

. . . . . .

. . . . . .

(ii) fluid flow resistance. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(iii) A and B supply blood to the muscles in the body. Explain any changes that might take place to the arteries during a period of intense exercise and why. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

D2. This question is about scaling in mammals.

(a) Explain, by making suitable estimates, why, under the same external conditions, a baby is at a much greater risk of dying from exposure to cold than an adult. *[4]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) State **one** assumption that you have made in the above explanation. *[1]*

. . . . . .

. . . . . .

D3. This question is about human hearing.

(a) Explain what is meant by *conductive* hearing loss. *[1]*

. . . . . .

. . . . . .

(b) A person with conductive hearing loss who uses an effective hearing aid will suffer little loss of hearing when taking part in a conversation.

However, explain why such a person should be advised **not** to spend a lot of money on a 'Hi Fi' music system. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) A person has hearing loss of 40 dB at a frequency of 1000 Hz. Estimate the least intensity of sound that the person can detect at this frequency. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

OPTION E—HISTORICAL PHYSICS

Answer ALL questions in this option.

E1. This question is about models of the solar system.

(a) The word for 'planet' comes from the Greek word for 'wanderer'. Explain briefly why the planets should be known as the 'wanderers'. *[2]*

. . . . . .

. . . . . .

. . . . . .

(b) In what ways did Copernicus' model of the solar system differ from that of Ptolemy's model? *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

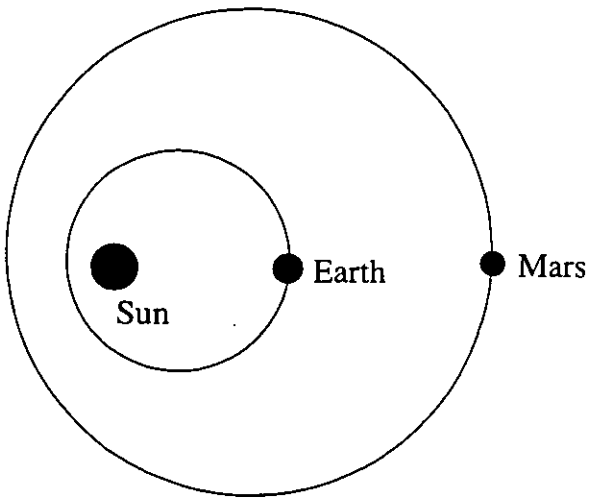
. . . . . .

. . . . . .

(This question continues on the following page)

(Question E1 continued)

(c) The diagram below shows a section of the orbits of Earth and Mars about the Sun. Explain, with the aid of this diagram, or with the aid of your own diagram, how the Copernican model accounts for Mars being know as a 'wanderer'. *[4]*



Explanation:

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Space for your own diagram

Explanation:

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

E2. This question is about Newton and Newtonian Mechanics.

(a) Suggest why, although Newton was English, his *Principia Mathematica* was written in Latin. *[1]*

. . . . . .

. . . . . .

(b) In his *Principia* Newton refers to *'the quantity of matter'* of a body. What is the modern term for this? *[1]*

. . . . . .

. . . . . .

(c) In the 1930s an editorial appeared in the New York Times which stated that interplanetary rocket travel was impossible since in space a rocket would have no air against which to push and so therefore would not be able to move. Explain, with reference to Newton's laws of motion, why this reasoning is incorrect. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

E3. This question is about the wave nature of matter.

(a) Derive an expression for the momentum of a photon in terms of its associated wavelength and state how this expression is related to the de Broglie hypothesis. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) In 1926 Davisson and Germer carried out an experiment in which they measured the de Broglie wavelength of electrons scattered from a nickel crystal.

By considering the momentum of electrons which have been accelerated through a potential difference of 1000 V show why Davisson and Germer elected to use a crystal to measure the wavelength of electrons. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

OPTION F—ASTROPHYSICS

Answer ALL questions in this option.

F1. This question is about stars and their spectra.

(a) State **three** pieces of information about a star that may be obtained from its spectrum. *[3]*

. . . . . .

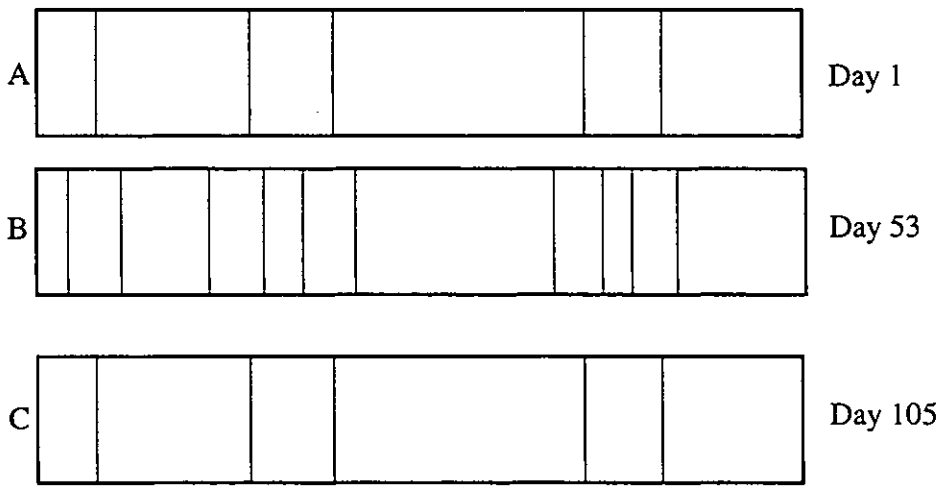
. . . . . .

. . . . . .

. . . . . .

(b) The system, β-Aurigae (Capella) is observed to have a spectrum which changes over time.

The diagram below shows the spectrum at three different times.



For every line in spectrum A there are two lines in spectrum B, one at a slightly higher frequency and one at slightly lower frequency than in A. Spectrum C is the same as Spectrum A.

(This question continues on the following page)

(Question F1 continued)

(i) Describe what type of system would give rise to this observed spectral sequence. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(ii) Explain with the aid of diagram(s) how the system accounts for the observed spectral sequence. *[6]*

Diagram:

Explanation:

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

F2. This question is about models of the universe.

(a) One model of the universe **postulates** that it is ***infinite*** and ***static*** and that the ***stars are uniformly distributed*** throughout the universe.

It is a known **fact** that the apparent brightness of a star decreases with the inverse square of distance from the star.

Show that the **postulates** and the **fact** lead to the prediction that the 'sky', as seen from Earth, would always be uniformly bright. *[5]*

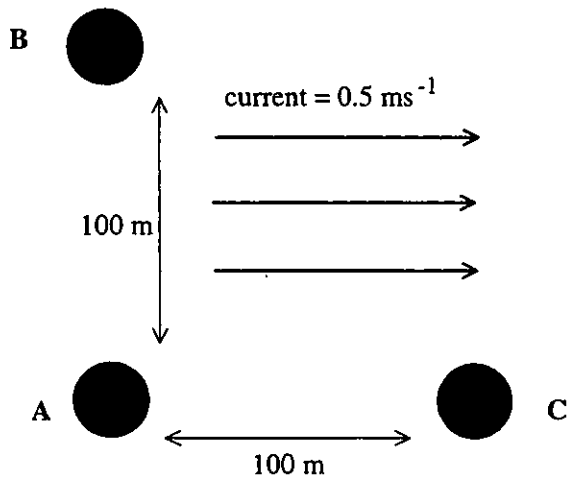
(b) It is a **fact** the night sky is dark. What alternative **postulates** can be made regarding a model of the universe to explain this **fact**? *[3]*

OPTION G—RELATIVITY

Answer ALL questions in this option.

G1. This question is about an analogy of the Michelson-Morley experiment.

The diagram below shows a river in which three buoys A, B and C are moored. The distances AB and AC are 100 m. The current in the river flows with a speed of 0.5 ms^{-1} relative to the bank in the direction shown.



(a) (i) Calculate the time t_{AC} it takes a swimmer to go from A to C if he swims at a steady speed of 1.0 ms^{-1} relative to the water. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(ii) It takes a time t_{AB} = 230 s, for the swimmer to go from A to B and back swimming at a steady speed of 1.0 ms^{-1} relative to the water. Calculate the ratio t_{AB}: t_{AC} . *[1]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question G1 continued)

(b) If this situation is thought of as analogous to the Michelson-Morley experiment then to what in the Michelson-Morley experiment is:

(i) the current analogous? *[1]*

. . . . . .

. . . . . .

(ii) the swimmer analogous? *[1]*

. . . . . .

. . . . . .

(c) In the Michelson-Morley experiment what assumption was made about the concept analogous to the current? *[1]*

. . . . . .

. . . . . .

. . . . . .

(d) What value did Michelson and Morley obtain for the ratio t_{AB}: t_{AC} and what was the significance of this result? *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

G2. This question is about time and the concept of simultaneity in Special Relativity.

(a) A person X observes two events which take place at the same position in her frame of reference. She measures one event taking place 1.00×10^{-7}s after the other.

Another person Y observes the same two events but he measures them as taking place 1.01×10^{-7}s after each other.

Calculate the relative velocity of X and Y. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) X now observes two events which take place at different locations. She observes the two events to take place simultaneously.

Explain, why observer Y will not observe these two events to be simultaneous. You may illustrate your answer by means of a suitable diagram. *[3]*

Diagram:

Explanation:

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

G3. This question is about gravity and gravitational redshift in General Relativity.

(a) Newton postulated that a force of attraction, the so-called gravitational force, exists between all objects. How did Einstein account for the gravitational attraction between bodies? *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Explain what is meant by 'gravitational redshift'. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

OPTION H—OPTICS

Answer ALL questions in this option.

H1. This question is about the formation of images in mirrors.

(a) A student asks, "How can an image formed by a plane mirror be virtual if I can see it?"

Using suitable diagrams to illustrate your answer, explain to the student how he is able to see a virtual image. *[3]*

(This question continues on the following page)

(Question H1 continued)

(b) (i) Explain why convex mirrors, rather than plane mirrors, are placed in shops in order to detect shoplifting. *[1]*

. . . . . .

. . . . . .

(ii) State a disadvantage of convex mirrors as opposed to plane mirrors used in this way. *[1]*

. . . . . .

. . . . . .

(iii) A customer of height 1.8 m stands 2.5 m away from the convex mirror of radius of curvature 1.0 m. Find, either by scale drawing or calculation, the position and size of the image of the customer. *[4]*

Calculation:

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(iv) State whether the image is real or virtual. *[1]*

. . . . . .

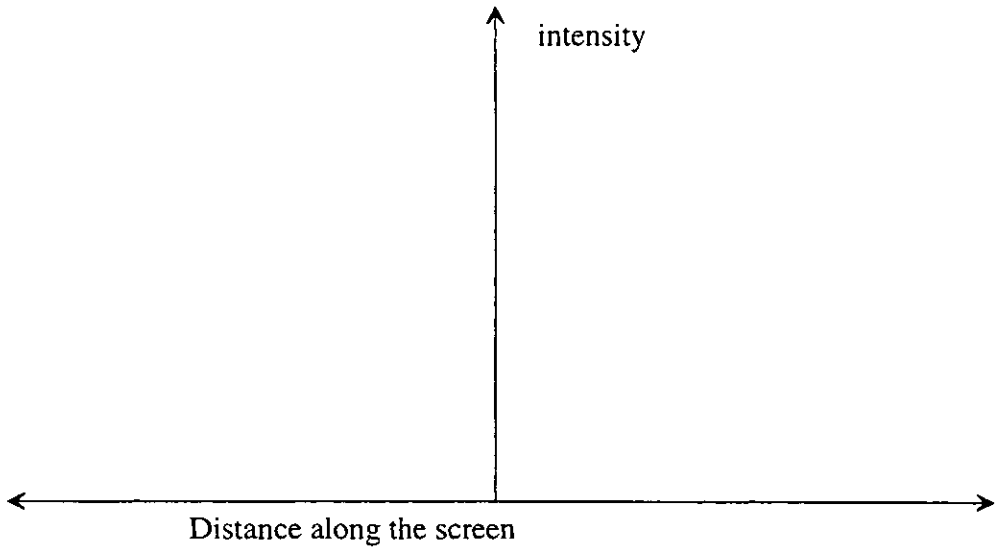
. . . . . .

H2. This question is about the interference of light.

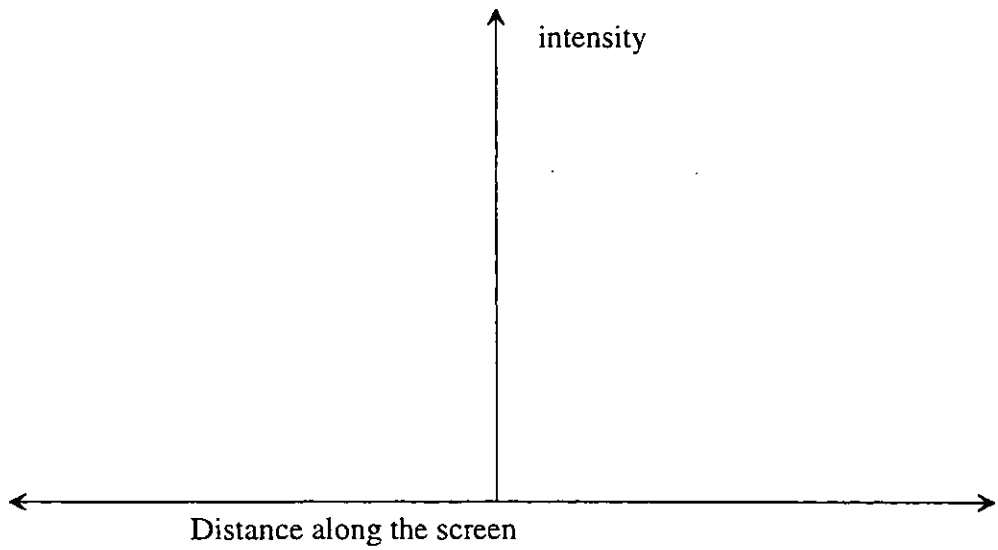
An experiment is set up in which light from a coherent source passes through two narrow slits to produce an interference pattern on a screen.

Sketch a diagram on the axes below to show the intensity distribution of the interference pattern on the screen when

(a) the slits are narrow compared to their separation. *[2]*



(b) the slit width is comparable to their separation. *[2]*



(This question continues on the following page)

(Question H2 continued)

(c) Explain briefly why the two intensity distributions that you have drawn are different. *[2]*

. . . . . .

. . . . . .

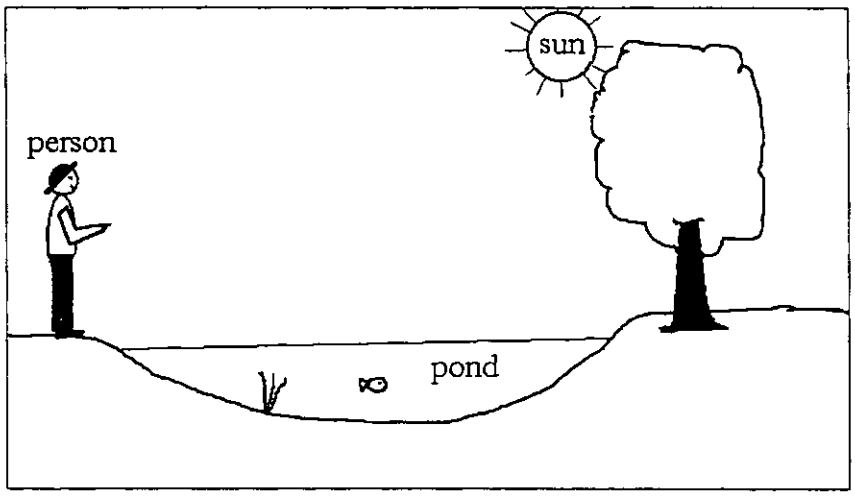
. . . . . .

. . . . . .

. . . . . .

H3. This question is about the polarisation of light.

A person looks into a pond on a bright sunny day as shown in the diagram below.



(a) Explain why the person will get a clearer view of the bottom of the pond if he wears Polaroid sunglasses than if he were to wear ordinary sunglasses. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) At what angle to the normal should the person look in order to see the bottom of the pond most clearly? (Refractive index of water = 1.3) *[1]*

. . . . . .

. . . . . .