INTERNATIONAL BACCALAUREATE
BACCALAURÉAT INTERNATIONAL
BACHILLERATO INTERNACIONAL

M99/430/H(3)

PHYSICS

Higher Level

Monday 17 May 1999 (morning)

Paper 3 — 1 hour 15 minutes

A

Candidate name:	Candidate category & number:

This examination paper consists of 5 options.
The maximum mark for each option is 30.
The maximum mark for this paper is 60.

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
/30	/30
/30	/30
TOTAL /60	TOTAL /60

D

IBCA
/30
/30
TOTAL /60

EXAMINATION MATERIALS

Required:
Calculator
Physics HL Data Booklet

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

229-228

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]*

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(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]*

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

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(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]*

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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]*

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

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D3. This question is about human hearing.

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

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(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]*

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(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]*

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D4. This question is about x-rays.

(a) Name **two** methods by which x-rays are attenuated when they interact with matter. *[2]*

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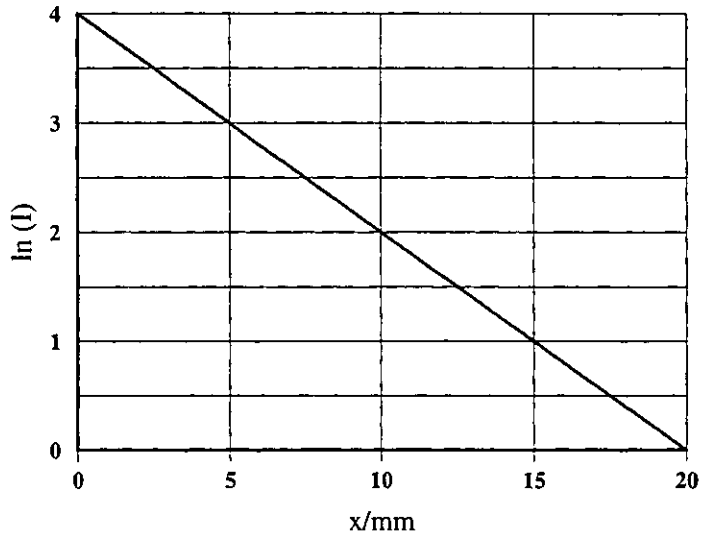
(b) The graph below shows how the logarithm of the intensity of x-rays varies with the distance travelled in a certain metal.



Calculate values for:

(i) the linear attenuation coefficient. *[2]*

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(ii) the half-value thickness. *[2]*

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(This question continues on the following page)

(Question D4 continued)

(c) (i) Explain how x-rays can cause damage to living tissues. *[3]*

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(ii) Give an example of the sort of damage that they might cause. *[1]*

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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]*

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

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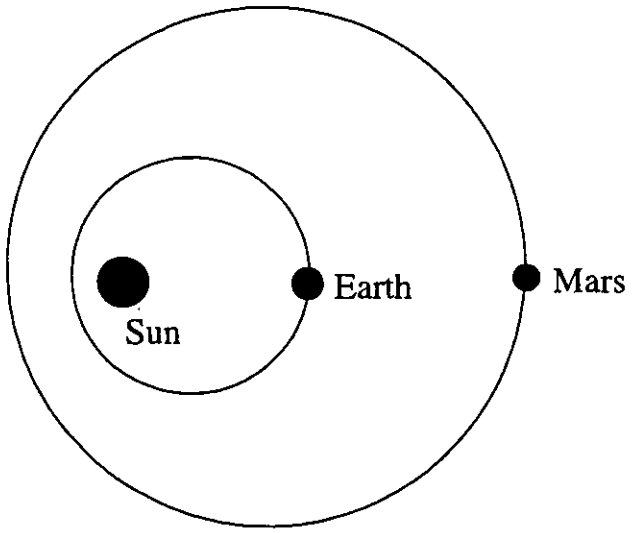
(This question continues on the following page)

(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 known as a 'wanderer'. *[4]*



Explanation:

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Space for your own diagram

Explanation:

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E2. This question is about Newton and Newtonian Mechanics.

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

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

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(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]*

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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]*

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(This question continues on the following page)

(Question E3 continued)

(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]*

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E4. This question is about the concept of entropy.

(a) In what specific way did Lord Kelvin's interpretation of entropy differ from that of Boltzmann? *[2]*

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(b) Based on Boltzmann's interpretation of entropy, Maxwell proposed his famous 'demon' thought experiment.

(i) Describe this experiment. *[2]*

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(ii) What does the experiment attempt to demonstrate? *[1]*

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(iii) Why does it not demonstrate what it attempted to demonstrate? *[1]*

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E5. This question is about conservation laws.

(a) In the table below put a tick mark against the quantities that must always be conserved in any interaction between particles. *[2]*

electric charge	
strangeness	
energy	
mass	
baryon number	

(b) Explain briefly why conservation laws are so useful when considering interactions between particles. *[2]*

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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]*

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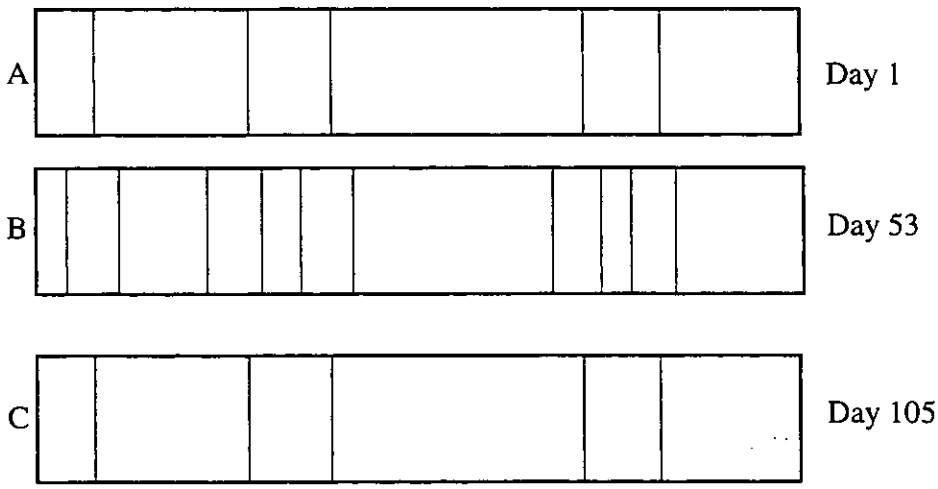
(b) The system, β-Aurigae (Capella) is observed to have a spectrum which changes over time.

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]*

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

Diagram:

Explanation:

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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]*

F3. This question is about Stellar Evolution.

The supernova, SN1987A, which is in the Magellanic Cloud, was first observed in February 1987.

(a) (i) What type of star would have produced the supernova? *[1]*

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(ii) Would the star that produced the supernova have been less or more massive than our Sun? *[1]*

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(b) Some matter is ejected by the supernova.

(i) Explain what might happen to matter that is not ejected. *[2]*

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(ii) What property of the supernova determines its final fate? *[1]*

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F4. This question is about Hubble's law and redshift.

(a) A star is 1.65×10^6 light years from Earth. Show that the recession speed of the star is about 25 km s^{-1}.
(Hubble's constant = 50 km s^{-1} Mpc^{-1}) *[2]*

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(b) The star emits light of wavelength 5.00×10^{-9}m. Calculate the value of this wavelength as measured by an observer on Earth. *[3]*

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OPTION G—RELATIVITY

Answer ALL questions in this option.

G1. This question is about time and the concept of simultaneity on 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]*

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

(i) 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]*

Explanation:

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(This question continues on the following page)

(Question G1 continued)

(ii) Explain whether or not it is possible to determine if the two events do actually take place simultaneously. *[2]*

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G2. 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]*

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

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(c) Describe briefly one piece of experimental evidence for the existence of gravitational redshift. *[2]*

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(d) The **wavelength** of light from a certain source is measured to be 300 nm in a laboratory on the ground floor of a building. The source is now moved to a laboratory on the top floor 90 m above the ground floor. By how much is the **frequency** shifted as measured by an observer on the ground floor? Comment on your answer. *[3]*

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G3. This question is about relativistic dynamics.

(a) Electrons are accelerated from rest through a potential difference of 1.8×10^5 V. Calculate, as measured in the laboratory reference frame, the

(i) electron mass. *[3]*

(ii) electron velocity. *[3]*

(iii) total energy of an electron. *[2]*

(iv) final momentum of an electron. *[2]*

(b) If another beam of electrons were to be accelerated through the same potential but in the opposite direction to the first beam what would be the relative velocity of an electron in one beam with respect to an electron in the other beam? *[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]*

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

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A customer of height 1.8 m stands 2.5 m away from the convex mirror of radius of curvature 1.0 m.

(iii) Find, either by scale drawing or calculation, the position and size of the image of the customer. *[4]*

Scale drawing:

Calculation:

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

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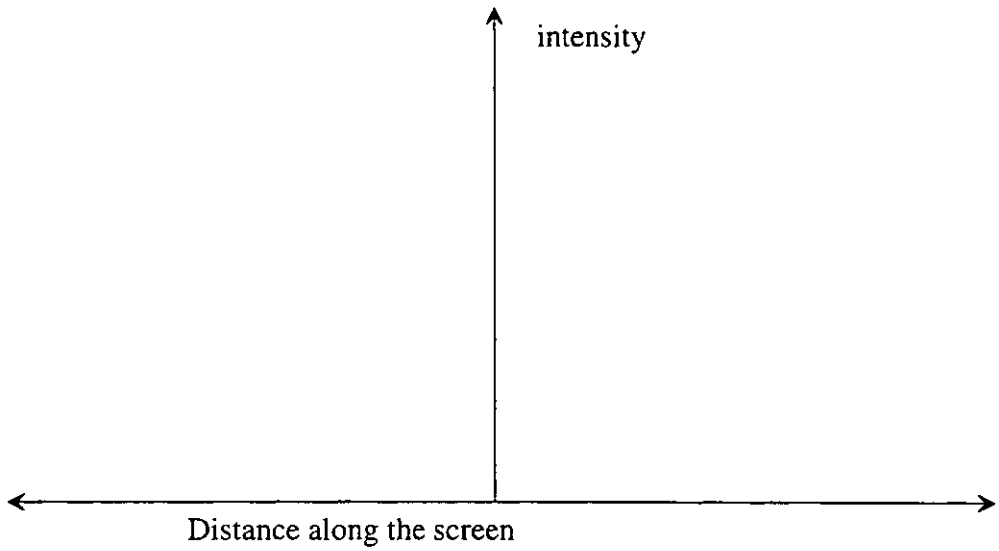
H2. This question is about the interference of light.

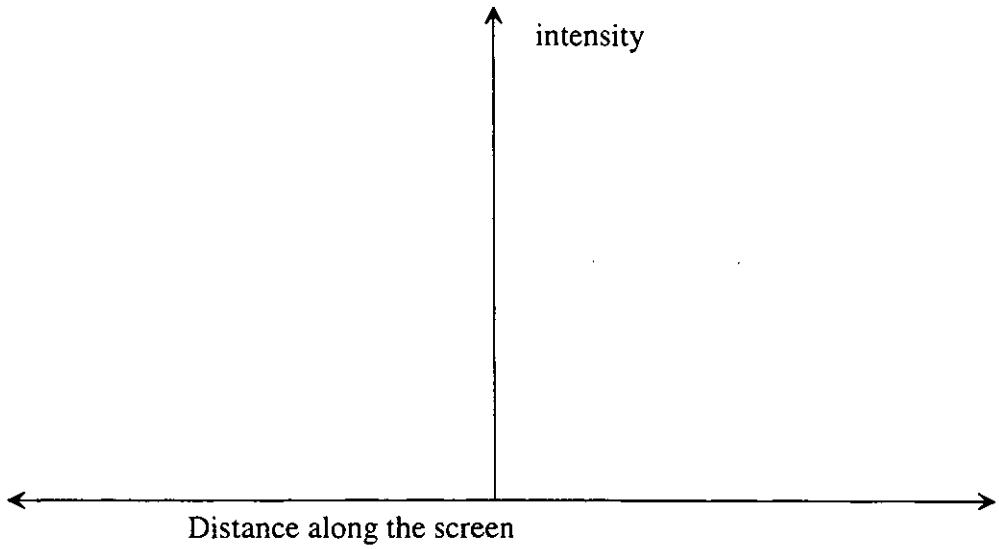
An experiment is set up in which light from a coherent source passes through two narrow slits to produce an interference pattern on a screen.

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

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



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



(This question continues on the following page)

(Question H2 continued)

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

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H3. This question is about optical resolution.

(a) A person is walking along the side of a long straight road at night. In the distance she sees the lights of an approaching car.

(i) Explain why the two headlights of the approaching car appear to be a single source but as the car gets nearer the lights are seen as two separate sources. *[4]*

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In answering the next question you will be asked to make sensible estimates of certain quantities in order to obtain the required answer.

(ii) Estimate the distance that the car will be from the person when she first sees the headlights as two separate light sources.

Estimates: *[3]*

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Calculation: *[3]*

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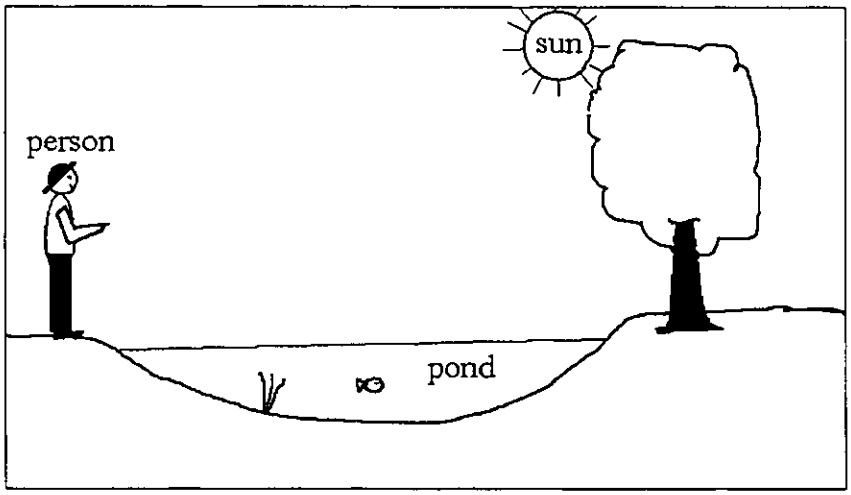
H4. This question is about the polarisation of light.

A person looks into a pond on a bright 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]*

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(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]*

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