INTERNATIONAL BACCALAUREATE
BACCALAURÉAT INTERNATIONAL
BACHILLERATO INTERNACIONAL

M99/430/S(2)

PHYSICS

Standard Level

Friday 14 May 1999 (afternoon)

Paper 2 — 1 hour

A

Candidate name:	Candidate category & number:

This examination paper consists of 2 sections, Section A and Section B.
The maximum mark for Section A is 25.
The maximum mark for Section B is 25.
The maximum mark for this paper is 50.

INSTRUCTIONS TO CANDIDATES

Write your candidate name and number in the boxes above.

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

Section A: Answer ALL of Section A in the spaces provided.

Section B: Answer ONE question from Section B in the spaces provided.

At the end of the examination, complete box B below by stating the question answered from Section B.

B

QUESTIONS ANSWERED
A/ ALL
B/

C

EXAMINER	TEAM LEADER
/25	/25
/25	/25
TOTAL /50	TOTAL /50

D

IBCA
/25
/25
TOTAL /50

EXAMINATION MATERIALS

Required:
Calculator
Physics SL Data Booklet

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

229-236

15 pages

SECTION A

Answer ALL questions in this section.

A1. This question is about determining the acceleration of an aeroplane on a runway.

A jet aeroplane accelerates along the runway before takeoff at night. The regular flashes from the wing light on the moving aeroplane are photographed by a camera. There are also two fixed lights A and B alongside the runway, 30 m apart. The situation is shown in Figure 1.

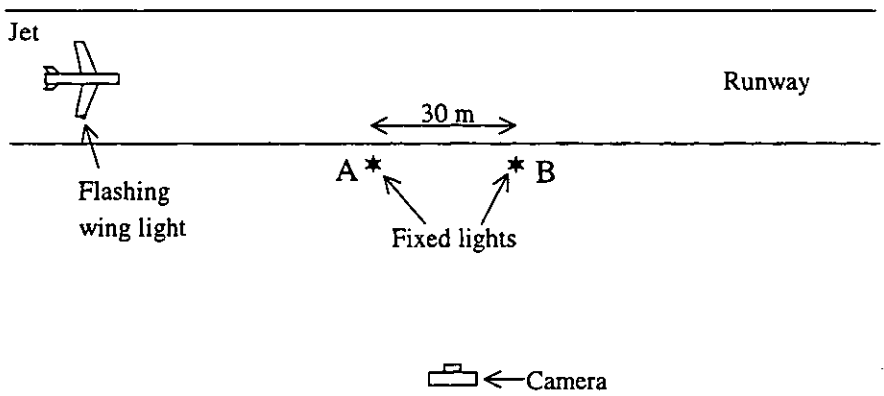


Figure 1: Plan view (not to scale)

The moving wing light appears as a succession of spots R, S, T, U and V on the photographic film, as shown in Figure 2 below. The aeroplane is already moving by the time the first image R is recorded. The wing light flashes every 2.0 seconds. The photograph also records the images of the two fixed lights A and B.

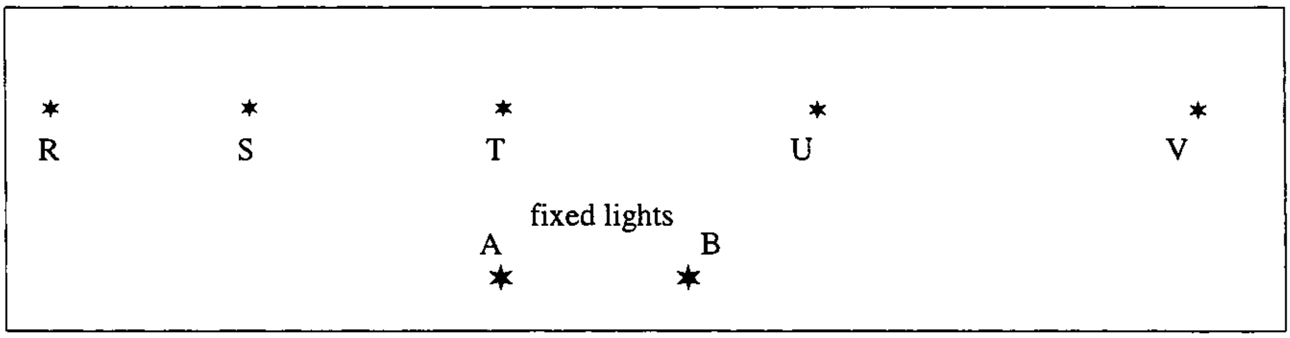


Figure 2: Photographic film record.

By making appropriate measurements on the photograph above, determine:

(a) the distance on the runway represented by 1 mm on the film. *[2]*

. . . .

. . . .

. . . .

(This question continues on the following page)

(Question A1 continued)

(b) the average velocity of the aeroplane between:

(i) points R and S.

. . . .

(ii) points U and V. *[3]*

. . . .

(c) the average acceleration of the aeroplane along the runway. *[3]*

. . . .

. . . .

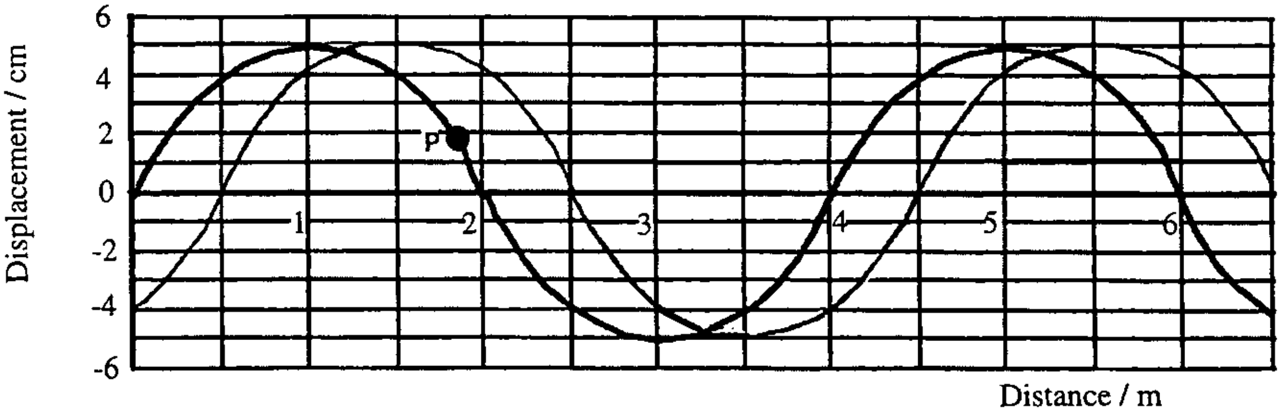
. . . .

. . . .

. . . .

A2. This question is about a transverse wave on a stretched spring.

The thicker line in the figure below shows part of a wave on a spring at time t = 0, while the thinner line shows the wave one tenth of a second later at time t = 0.1 s.



(a) For the wave, determine:

(i) the direction of wave travel. *[1]*

. . . .

(ii) the wavelength. *[1]*

. . . .

(iii) the wave amplitude. *[1]*

. . . .

(iv) the wave speed. *[1]*

. . . .

. . . .

(v) the wave frequency. *[1]*

. . . .

. . . .

(This question continues on the following page)

(Question A2 continued)

(b) Consider the motion of an individual particle of the spring, labelled P on the diagram.

(i) Draw an arrow on the diagram to indicate the direction of motion of particle P at time t = 0. *[1]*

(ii) Determine the average speed of particle P between times t = 0 and t = 0.1 s. *[2]*

. . . .

. . . .

. . . .

. . . .

(iii) What is the period of oscillation of particle P? *[1]*

. . . .

. . . .

A3. Radioactive carbon dating

The carbon in trees is mostly carbon-12, which is stable, but there is also a small proportion of carbon-14, which is radioactive. When a tree is cut down, the carbon-14 present in the wood at that time decays with a half-life of 5800 years.

(a) Carbon-14 decays by beta-minus emission to nitrogen-14. Write the equation for this decay. *[2]*

. . . .

. . . .

(b) For an old wooden bowl from an archaeological site, the average count-rate of beta particles detected per kg of carbon is 13 counts per minute. The corresponding count rate from newly-cut wood is 52 counts per minute.

(i) Explain why the beta activity from the bowl diminishes with time, even though the probability of decay of any individual carbon-14 nucleus is constant. *[3]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(ii) Calculate the approximate age of the wooden bowl. *[3]*

. . . .

. . . .

. . . .

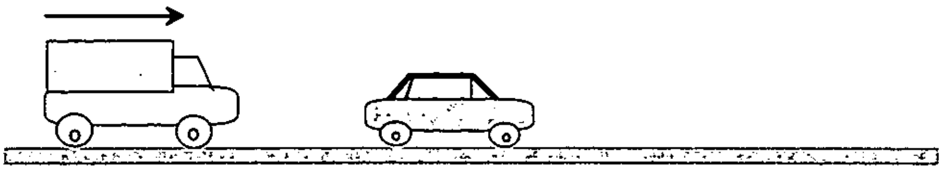
. . . .

SECTION B

This section consists of 3 questions : B1, B2 and B3. Answer any ONE question in this section.

B1. 1. This question is about the application of physics principles to a traffic accident.

In the accident, a moving van ran into the back of a car which was stationary with its handbrake on. The vehicles then moved straight onwards, remaining in contact, but came to rest after a certain distance.



Suppose you are brought in as a scientific consultant to determine the speed at which the van must have been travelling when it hit the car. You gather the following information.

- There are skid marks on the road, 15 m long, made by the car's rear tyres after the collision, but no skid marks for the van.
- The car's handbrake acts only on the rear wheels.
- The frictional force on the car's skidding rear tyres is 30% of the car's weight.
- The masses of the van and car are 1200 kg and 800 kg respectively.

(a) Using this information and principles of physics, determine the speed of the van just before it hit the car. You may take $g = 10 \text{ m s}^{-2} = 10 \text{ N kg}^{-1}$. *[12]*

(Hint: there are two stages to consider, namely the collision and skidding to a halt after the collision.)

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(This question continues on the following page)

(Question B1 continued)

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(b) The driver sitting in the car was wearing a safety belt and had a headrest behind her head. Explain whether or not the safety belt and/or headrest could serve a protective function in this particular accident. Refer to the sequence of events and to principles of physics in your answers.

Safety belt: *[3]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

Headrest: *[3]*

. . . .

. . . .

. . . .

. . . .

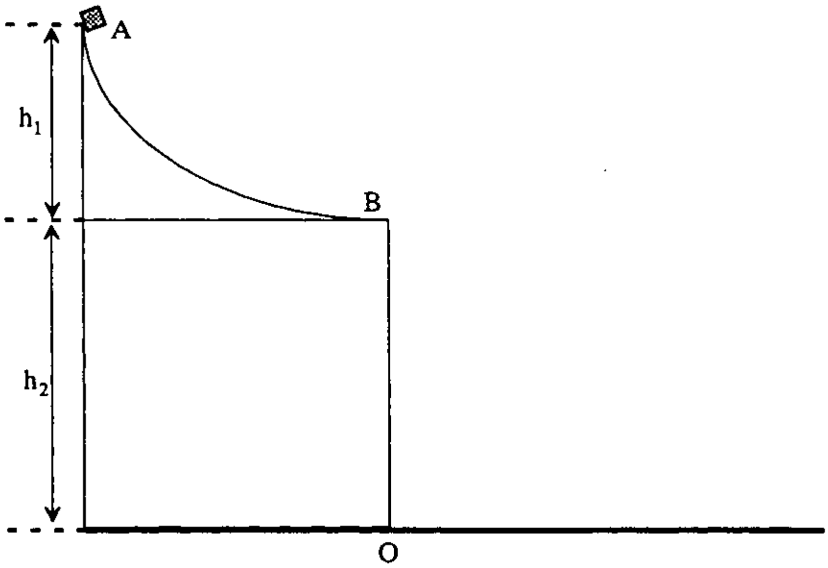
. . . .

. . . .

. . . .

. . . .

B1. 2. A body slides with negligible friction from point A down a smooth curved ramp, starting from rest. The end of the ramp is horizontal at point B. The end of the ramp is a height h_1 below A and a height h_2 above the floor, as shown in the diagram.



(a) On the diagram above sketch in the shape of the path taken by the body after it leaves the ramp. *[1]*

(b) Show that the body will hit the floor at a distance d from point O given by $d = 2\sqrt{h_1 h_2}$ *[6]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

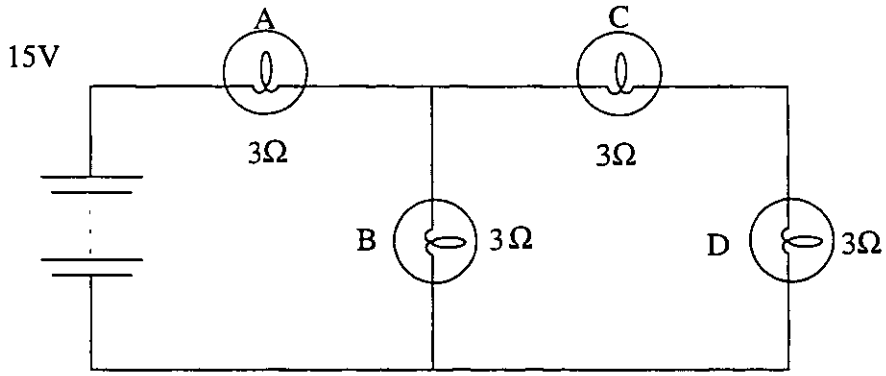
. . . .

. . . .

. . . .

B2. Four bulb circuit

Four identical light bulbs and a 15 V battery are connected in the circuit shown below. The battery has negligible internal resistance. Assume initially that the bulbs are *ohmic* and each has resistance 3Ω.



(a) What is meant by *ohmic* behaviour for a conductor? *[1]*

. . . .

. . . .

. . . .

(b) How will the brightnesses of the four bulbs compare with each other? Give qualitative physical reasoning without any calculations. *[3]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(c) Calculate the equivalent resistance of the circuit. *[3]*

. . . .

. . . .

. . . .

(This question continues on the following page)

(Question B2 continued)

(d) For bulb D calculate:

(i) the current
(ii) the potential difference
(iii) the power. *[4]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(e) Because the bulb filaments get hot, the bulbs will *not* in fact have ohmic behaviour as assumed above. In terms of a simple microscopic model of electric conduction in a metal, explain why light bulb filaments become hot when electric current flows through them. *[3]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(This question continues on the following page)

(Question B2 continued)

(f) A consequence of non-ohmic behaviour is that the resistances of the bulbs will no longer be identical when used in this circuit. **Explain** which bulb(s) will have the greatest resistance when used in the circuit above, and which bulb(s) the least. *[4]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(g) Explain how this will affect the potential difference across **bulb D**, compared to the ohmic case. *[3]*

. . . .

. . . .

. . . .

. . . .

. . . .

(h) Sketch in on the original diagram how an ammeter and voltmeter should be connected in order to measure the actual current and potential difference for bulb D. *[2]*

(i) Suppose bulb D burns out (its filament breaks) while the voltmeter is connected across its socket. Will the voltmeter reading become zero, increase, decrease or remain unchanged? Explain. *[2]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

B3. 1. This question is about determining the specific latent heat of fusion of ice.

A student determines the specific latent heat of fusion of ice at home as follows. She takes some ice from the freezer, measures its mass and mixes it with a known mass of water in an insulating jug. She stirs until all the ice has melted and measures the final temperature of the mixture. She also measured the temperature in the freezer and the initial temperature of the water.

She records her measurements as follows:

Mass of ice used	m_i	0.12 kg
Initial temperature of ice	T_i	-12 °C
Initial mass of water	m_w	0.40 kg
Initial temperature of water	T_w	22 °C
Final temperature of mixture	T_f	15 °C

The heat capacities of water and ice are $c_w = 4.2$ kJ kg^{-1} °C^{-1} and $c_i = 2.1$ kJ kg^{-1} °C^{-1} respectively.

(a) Set up the appropriate equation, representing energy transfers during the process of coming to thermal equilibrium, that will enable them to solve for the specific latent heat L_i of ice. Insert values into the equation from the data above, **but do not solve the equation.** *[5]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(This question continues on the following page)

(Question B3 continued)

(b) Explain the physical meaning of each *energy transfer term* in your equation (but not each symbol). *[4]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(c) State an assumption you have made about the experiment, in setting up your equation in (a). *[1]*

. . . .

. . . .

. . . .

(d) Why should she take the temperature of the mixture *immediately* after all the ice has melted? *[1]*

. . . .

. . . .

. . . .

. . . .

(e) Explain from the microscopic point of view, in terms of molecular behaviour, why the temperature of the ice does not increase while it is melting. *[4]*

. . . .

. . . .

. . . .

. . . .

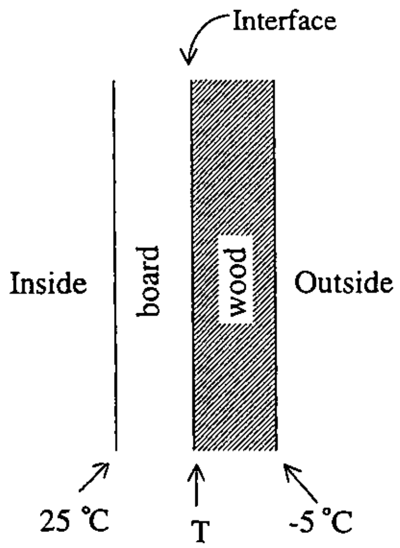
. . . .

. . . .

. . . .

B3. **2.** Two-layer cottage wall

The wall of a heated cottage is made of two layers of **equal thickness**, insulating board on the inside and wood on the outside, as shown below. The thermal conductivity of the board is **half** that of wood. In the steady state, with energy flowing steadily from inside to outside, the inside surface temperature of the board is 25 °C and the outside surface temperature of the wood is -5 °C.



(a) Will the rate of energy transfer be greatest through the wood layer, the board layer, or the same for both? Explain your reasoning. *[2]*

. . . .

. . . .

. . . .

. . . .

(b) Would you expect the **temperature difference** across the wood layer to be greater than, less than or equal to that across the board layer? Explain. *[3]*

. . . .

. . . .

. . . .

. . . .

(c) Calculate the temperature T at the interface between board and wood. *[5]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .