INTERNATIONAL BACCALAUREATE
BACCALAURÉAT INTERNATIONAL
BACHILLERATO INTERNACIONAL

N01/430/S(2)

PHYSICS
STANDARD LEVEL
PAPER 2

Monday 19 November 2001 (afternoon)

1 hour

Name

Number

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, indicate the number of the Section B question answered in the box below.

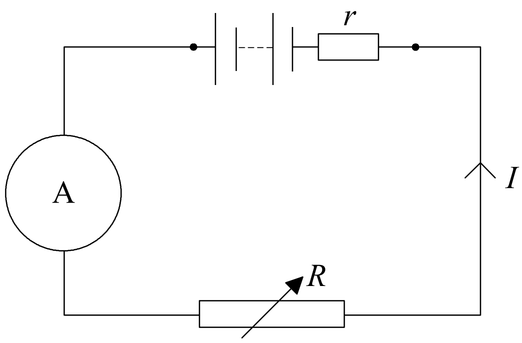
QUESTIONS ANSWERED		EXAMINER	TEAM LEADER	IBCA
SECTION A	ALL	/25	/25	/25
SECTION B	. . . .	/25	/25	/25
		TOTAL /50	TOTAL /50	TOTAL /50

SECTION A

*Candidates must answer **all** questions in the spaces provided.*

A1. This question is about power dissipation in a resistor and the internal resistance of a battery.

In the circuit below the variable resistor can be adjusted to have known values of resistance *R*. The battery has an unknown internal resistance *r*.



The table below shows the recorded value *I* of the current in the circuit for different values of *R*. The last column gives the calculated value of the power *P* dissipated in the resistor.

***R* / Ω**	***I* / A** ±0.01 A	***P* / W**
0	1.50	0
1.0	1.20	1.4
2.0	1.00	2.0
3.0	0.86	2.2
4.0	0.75	2.3
6.0	0.60	2.2
8.0	0.50	2.0
10.0	0.43	

(a) Complete the last line of the table by calculating the power dissipated in the variable resistor when its value is 10.0 Ω. *[2]*

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(This question continues on the following page)

(Question A1 continued)

(b) If each value of R is known to ±10 % determine the **absolute** uncertainty in the value of P when $R = 10.0\ \Omega$. *[3]*

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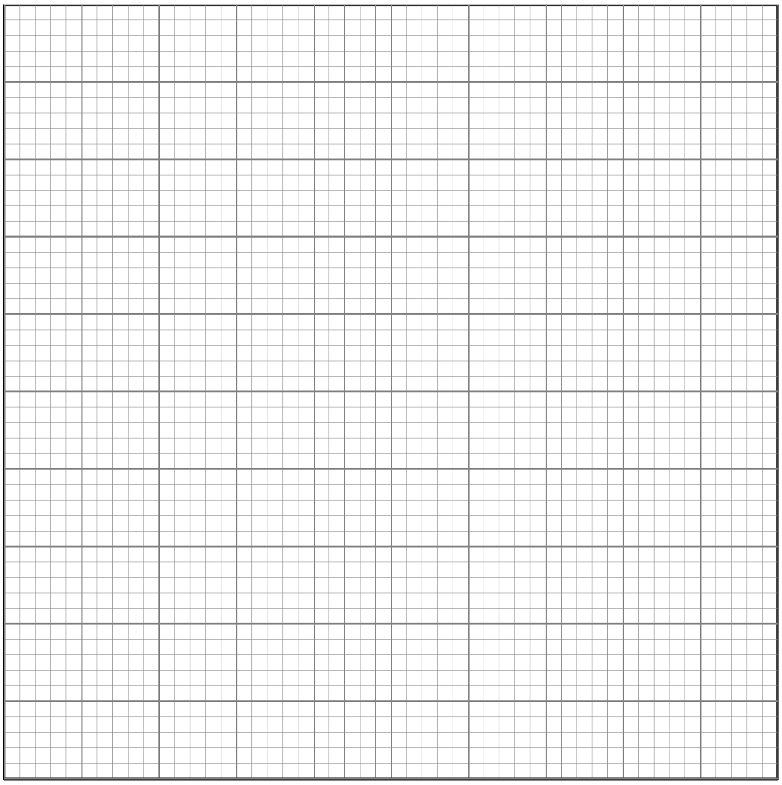
(c) On the grid below plot a graph of power P against resistance R. **(Do not include error bars)**. *[4]*



(d) It can be shown that the power dissipated in the external resistor is a maximum when the value of its resistance R is equal to the value of the internal resistance r of the battery *i.e.* $R = r$. Use this information and your graph to find the value of r. *[1]*

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(e) The manufacturer of the battery gives the value of its internal resistance as $4.50\ \Omega \pm 0.01\ \Omega$. Is the value of r that you obtained from your graph consistent with the manufacturer's value? Explain. *[2]*

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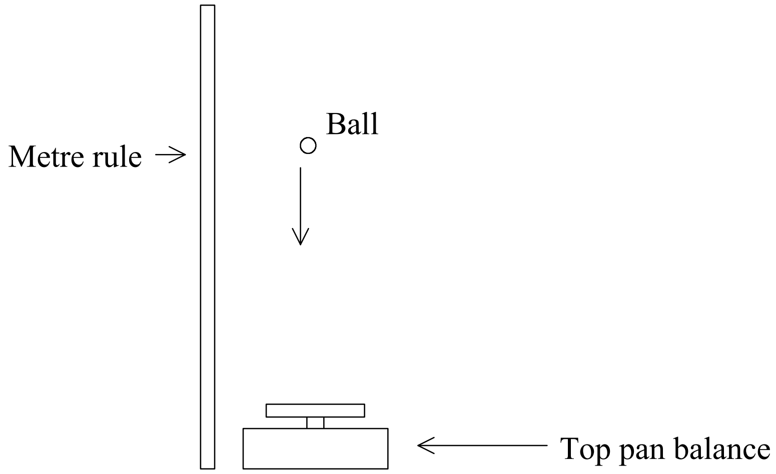
A2. This question is about a bouncing ball and contact time.



Miguel has devised a method to measure how long a bouncing ball is in contact with the surface from which it bounces. The method consists of dropping the ball on to the scale pan of a top pan balance as shown in the diagram above. The balance is calibrated in newtons and Miguel records the maximum reading on the scale, the height from which the ball is dropped and the height to which it bounces.

Miguel obtains the following information.

Height from which the ball is dropped	=	0.80 m
Height to which the ball bounces	=	0.60 m
Maximum reading on the balance scale	=	50.0 N

The mass of the ball is 0.20 kg and the acceleration due to gravity is taken to have a value of $10\ \mathrm{m\,s^{-2}}$.

(a) Calculate

(i) the speed of the ball when it strikes the scale pan. *[1]*

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(ii) the speed of the ball when it leaves the scale pan. *[1]*

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(iii) the total change in momentum of the ball between striking and leaving the scale pan. *[2]*

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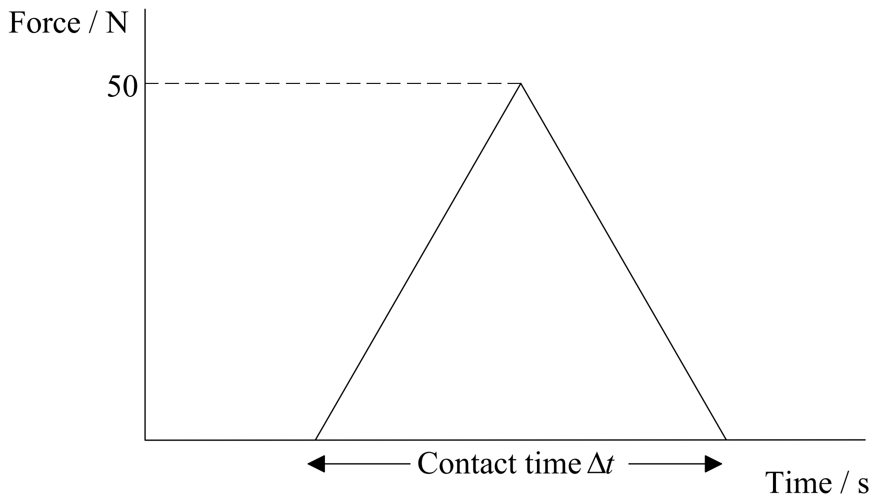
(Question A2 continued)

(b) Miguel assumes that the contact force between the ball and the scale pan varies with time as shown below.



(i) What does the area under the graph represent? *[1]*

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(ii) Calculate the contact time Δt. *[2]*

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(c) Miguel now drops another ball from the same height on to the scale pan. This ball is the same mass as the first ball but is made of a harder material. Sketch, using the same axes as in (b) above, the shape of the graph Miguel might expect to get for this ball. *[2]*

A3. This question is about using the radioactive decay law to determine the age of an ancient campsite.

(a) The radioactive isotope carbon 14 (C-14) is continually being produced in the upper atmosphere by the interaction of neutrons with nitrogen 14.

Complete the nuclear reaction equation below for the formation of C-14.

$$^{14}_{7}\text{N} + \text{n} = {}^{14}_{6}\text{C} +$$ *[1]*

(b) Some of the carbon atoms in a living tree consist of the radioactive isotope C-14. Due to the continual taking in of carbon the amount of C-14 in the living tree remains constant throughout the life of the tree. When the tree dies the taking in of carbon ceases and the amount of C-14 in the tree decreases with time.

(i) Explain why the amount of C-14 decreases with time. *[1]*

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(ii) The half-life of C-14 is 5600 years and the activity of wood from a living tree is 16.8 disintegrations per minute per unit mass.

A piece of burnt wood (charcoal) found at an ancient settlement has an activity of 4.2 disintegrations per minute per unit mass. Estimate the age of the settlement. *[2]*

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SECTION B

This section consists of three questions: B1 (parts 1 and 2), B2 and B3. Answer ***one*** *question in this section.*

B1. This question is in **two** parts. **Part 1** is about change of phase, specific heat capacity and thermal energy transfer and **Part 2** is about the motion of charged particles in electric and magnetic fields.

Part 1. Change of phase, specific heat capacity and thermal energy transfer.

(a) In order to keep a liquid boiling, energy must be continually supplied to it. While the liquid is boiling its temperature remains constant. Explain what must be happening to the kinetic energy and the potential energy of the molecules of the liquid while it is boiling. *[2]*

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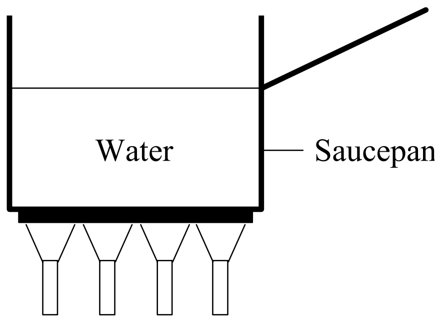
(b) In an attempt to measure the power supplied by a domestic gas burner a measured mass of water in an aluminium saucepan was heated by the burner until boiling. At this point a stopwatch was started and the water boiled for a measured interval of time. After this time interval the saucepan was removed from the burner and the mass of the saucepan plus water was recorded.



The following data is available:

Mass of empty saucepan	= 250 g
Mass of water **plus** saucepan at start	= 1250 g
Mass of water **plus** saucepan after boiling has taken place	= 850 g
Time for which the water is boiled	= 15 min (900 s)
Latent heat of vaporisation of water	= 2.3×10^{6} J kg^{-1}
Specific heat of water	= 4200 J kg^{-1} K^{-1}

(This question continues on the following page)

(Question B1 part 1 continued)

(i) What mass of water is boiled away in 15 min? *[1]*

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(ii) How much energy is required to boil away this mass of water? *[2]*

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(iii) Show that thermal energy is supplied to the saucepan and the water at a rate of 1000 W. *[2]*

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(iv) Explain why the rate at which energy is supplied by the burner will actually be greater than 1000 W. *[1]*

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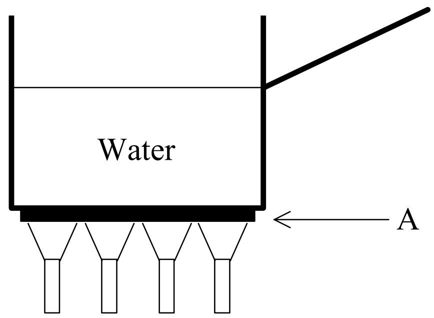
(c) Use the additional data given below to show that the temperature of the lower surface of the base of the saucepan (labelled A in the diagram) is only about $0.6\ ^\circ\mathrm{C}$ higher than that of the temperature of the boiling water.



Data:

Thermal conductivity of aluminium = $200\ \mathrm{W\ m^{-1}\ K^{-1}}$

Area of the saucepan base = $5.0\times10^{-2}\ \mathrm{m^2}$

Thickness of the saucepan base = 6.0 mm *[3]*

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(This question continues on the following page)

(Question B1 part 1 continued)

(d) The actual temperature of the burner is about 600 °C. Suggest why the lower surface of the base of the saucepan is not at the same temperature as the burner. *[2]*

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(e) Another experiment is now carried out in order to measure the specific heat of aluminium in which a measured mass of cold water is heated in the saucepan to a temperature of 90 °C. Assuming that the burner supplies energy at the rate of 1000 W to the water, use the data below to determine a value for the specific heat of aluminium.

Mass of empty saucepan	= 250 g
Mass of saucepan **plus** water	= 1250 g
Initial temperature of the water	= 20 °C
Final temperature of the water	= 90 °C
Time for the water to reach final temperature	= 315 s
Specific heat of water	= 4200 J kg^{-1} K^{-1}

[4]

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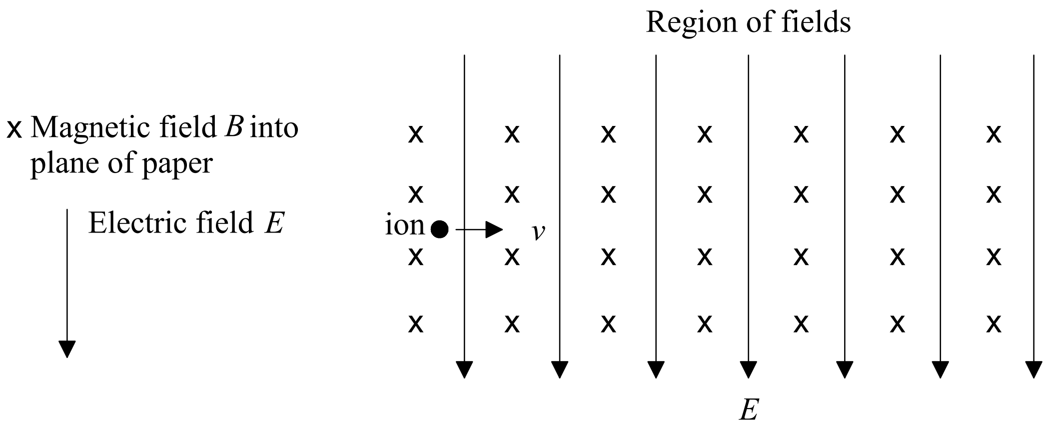
(Question B1 continued)

Part 2. Motion of charged particles in electric and magnetic fields.

In the diagram below a positive ion of charge + q moving with speed v enters a region in which there is a uniform electric field of strength E and a uniform magnetic field of strength B. The magnetic field is directed into the plane of the paper and the electric field is parallel to the plane of the paper as shown below.



(a) Show on the diagram the directions of the electric force and magnetic force acting on the ion. *[2]*

(b) Write down an expression for

(i) the electric force acting on the particle. *[1]*

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(ii) the magnetic force on the particle. *[1]*

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(c) Show that if the particle travels without deflection through the fields then

$$v = \frac{E}{B}$$ *[2]*

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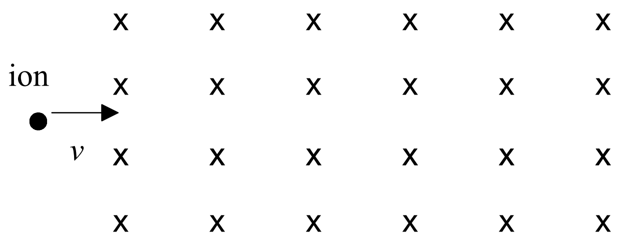
(Question B1 part 2 continued)

(d) The electric field is now switched off and an identical ion travelling with speed v enters the region of magnetic field as shown below.



Explain why the ion will describe a circular path in the region of the magnetic field. *[2]*

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B2. This question is about waves and their various properties.

Diagram 1 below represents a snapshot of some of the wavefronts of a continuous plane wave travelling in the direction shown.

Diagram 2 is a sketch-graph that shows how the displacement of the medium through which the wave is travelling varies with distance along the medium.

Diagram 1

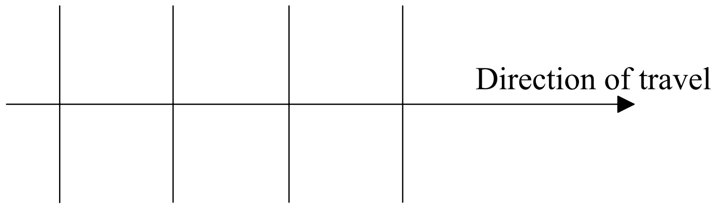
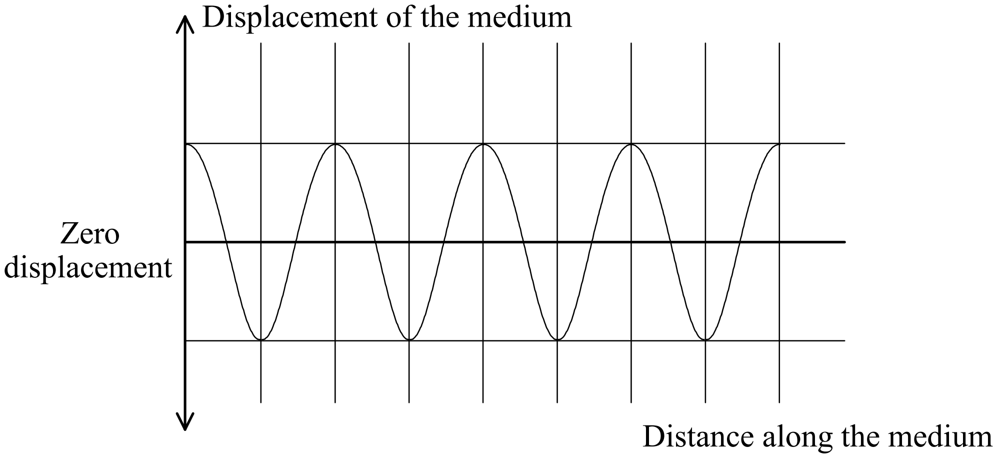


Diagram 2



The frequency of the source producing the waves is 10 Hz and the speed of the waves is $30\ \text{cm s}^{-1}$.

(a) On Diagram 1 mark the wavelength of the waves. *[1]*

(b) Calculate the value of the wavelength of the waves. *[1]*

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(c) Another snapshot of the wave is taken 0.05 s later.

(i) Determine how far the wavefronts have moved in this time. *[2]*

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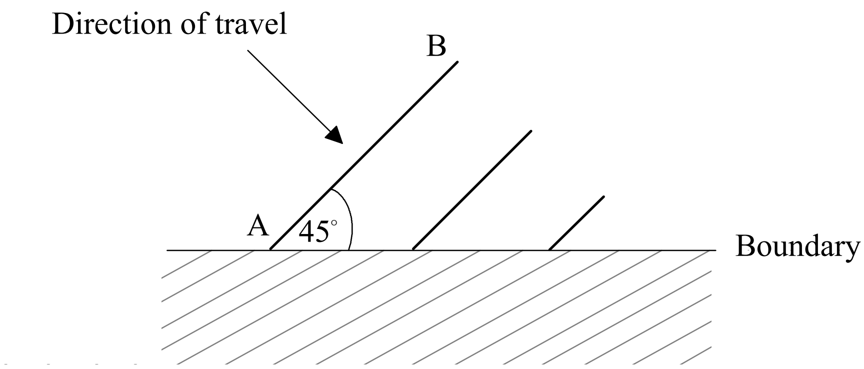
(ii) On Diagram 2 sketch another graph to show how the displacement of the medium now varies with distance along the medium. *[1]*

(This question continues on the following page)

(Question B2 continued)

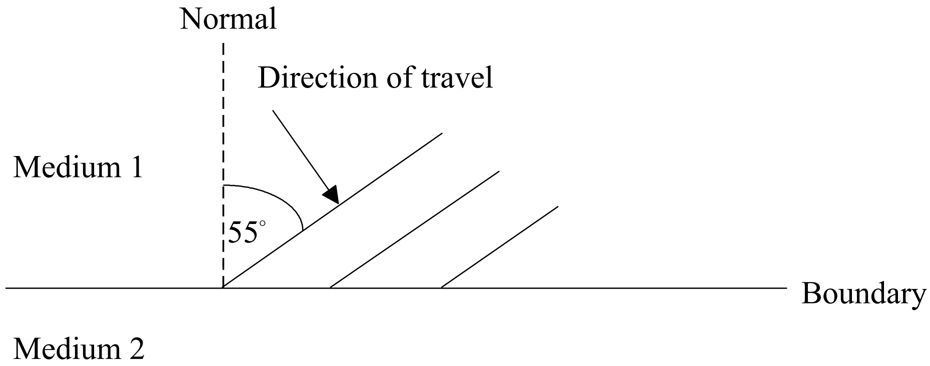
Parts (d) and (e) deal with the reflection and refraction of waves.

(d) The same wavefronts as in Diagram 1 are now incident at an angle of 45° to a boundary from which they are reflected. On the diagram below sketch the position of the wavefront labelled AB when the point B on the wavefront has just reached the boundary. *[1]*



(e) The same waves now travel across a boundary between two different media. The diagram below shows wavefronts incident on this boundary such that they make an angle of 55° with the normal. The speed of the waves in medium 1 is $30\,\text{cm s}^{-1}$ and in medium 2 is $45\,\text{cm s}^{-1}$.

(iii)



(i) What is the frequency of the waves in medium 2? *[1]*

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(ii) What is the wavelength of the waves in medium 2? *[2]*

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(iii) On the diagram sketch the position of the wavefront labelled AB when the point B on the wavefront has just reached the boundary. *[2]*

(This question continues on the following page)

(Question B2 continued)

(iv) Calculate the value of the angle that the wavefronts in medium 2 make with the normal. *[4]*

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(v) Explain what will happen to waves in medium 1 that are incident at an angle of 45° to the normal and justify your explanation by means of a calculation. *[4]*

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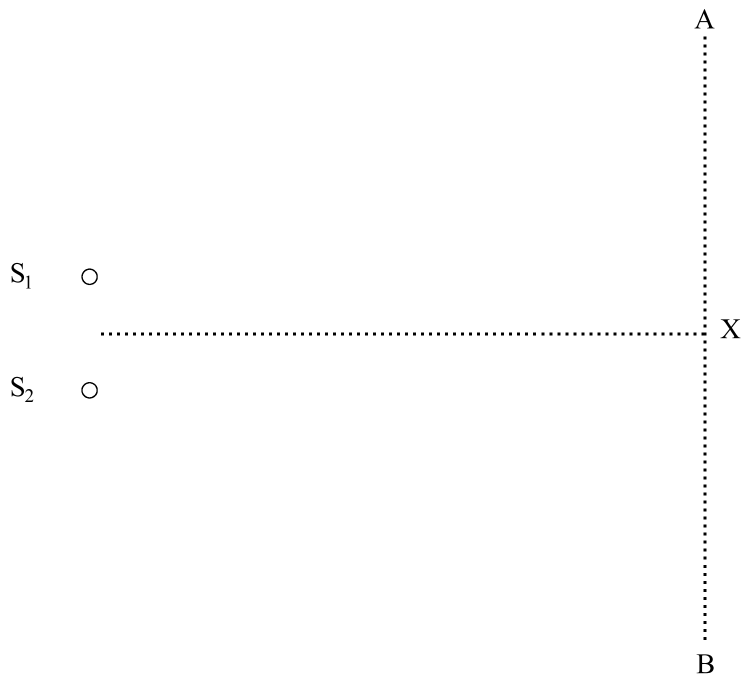
Part (f) deals with the interference of waves.

(f) In the diagram below S_1 and S_2 are two continuous harmonic sound sources that emit sounds of identical frequency. The distance $S_1X = S_2X$. An instrument that detects sound intensity is moved along the line AB.



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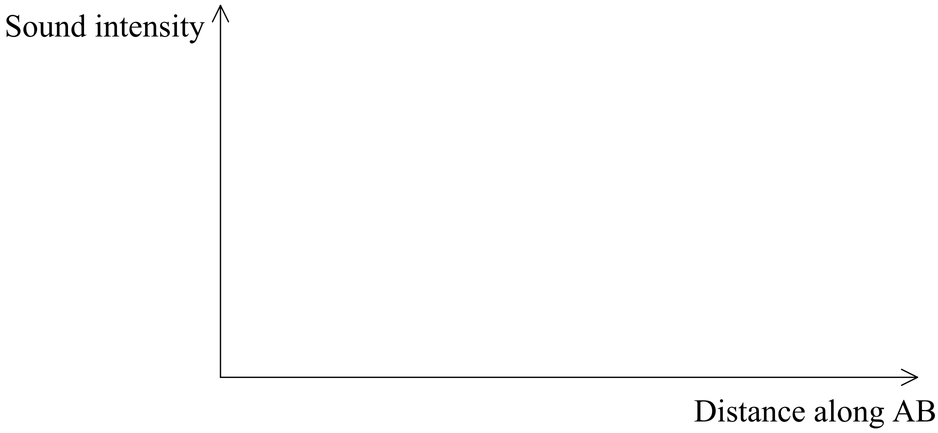
(Question B2 continued)

(i) On the axes below sketch a graph to show how the intensity of sound varies with distance along AB. Mark the position of X on your graph. *[2]*



(ii) Explain what is meant by the **principle of superposition** as applied to waves and describe how this principle accounts for the variation of the sound intensity along the line AB. *[4]*

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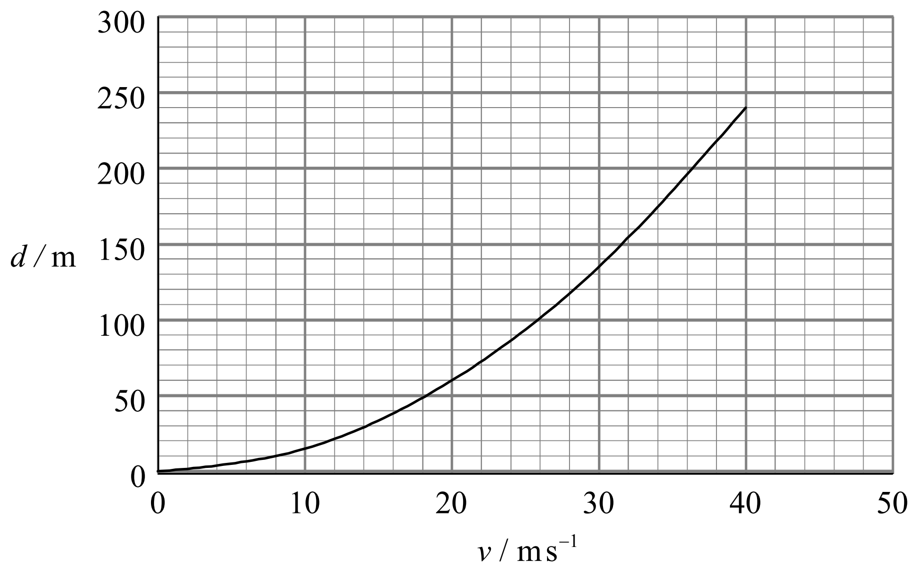
B3. This question is about the braking distance of a car and the power developed by the car engine.

The **minimum braking distance** is the shortest distance a car travels without skidding from the moment the brakes are applied until the moment the car comes to rest

The graph below shows how the minimum braking distance *d* varies with the initial speed *v* of a car travelling along a straight, horizontal road.



(a) By choosing **two** data points show that the graph suggests that the minimum braking distance depends on the square of the initial speed. *[4]*

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(b) Explain why, if the braking force is constant, you would expect theoretically the braking distance to depend on the square of the speed. *[3]*

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(This question continues on the following page)

(Question B3 continued)

(c) The car has a mass of 1500 kg and is moving with an initial speed of $20\,\mathrm{m\,s^{-1}}$ when the brakes are applied. Calculate

(i) the time that it takes the car to come to rest. *[3]*

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(ii) the average braking force acting on the car. *[3]*

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(d) The **stopping distance** of a car is the distance that the car travels in coming to rest from the moment that the driver decides to apply the brakes. The **stopping distance** is greater than the **minimum braking distance**. Explain why you think that this is so. *[2]*

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(e) Using the same axes as for the graph given at the start of the question sketch a graph to show how the stopping distance varies with initial speed. Explain the shape of the graph that you have drawn. *[3]*

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(This question continues on the following page)

(Question B3 continued)

(f) If the car were travelling down an incline would you expect the minimum braking distance for a given initial speed to be greater than or less than the braking distance on the level for the same road conditions? Explain. *[2]*

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The next part of the question looks at the power developed by the car engine.

(g) Travelling at a constant speed of $40\ \mathrm{m\,s^{-1}}$ the car engine uses 1 litre of fuel for every 12 km travelled. At what rate does the engine use fuel? *[2]*

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(h) The combustion of 1 litre of fuel releases 35 MJ of energy and at a speed of $40\ \mathrm{m\,s^{-1}}$ the car engine is 25 % efficient. Determine the power output of the car engine at this speed? *[2]*

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(i) Use your answer to (h) above to estimate the average drag force acting on the car when travelling at a constant speed of $40\ \mathrm{m\,s^{-1}}$. *[1]*

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