Name:..... Centre Number:.....

Candidate Number:..... Set (Please circle): 4P3 4P4

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Winchester College – Physics Mock
D-block
Friday 25th April 2014 - 1400

Time allowed: 135 min

Write your name, candidate number and centre number at the top of this page, and on all work you hand in.
Write in dark blue or black pen, except the multiple choice answer grid, which should be answered in pencil. You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
You may use a calculator.
You may lose marks if you do not show your working or if you do not use appropriate units.
The number of marks at the end of each question or part question.
You are advised to spend 50 minutes on Section A and 80 minutes on Section B.

Section A:
This section has **twenty-six (26)** questions. Answer **all** the questions
For each question there are four possible answers; **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice on the separate answer sheet, following the instructions on that sheet.
Read the instructions on the answer sheet very carefully.
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any working should be done in this booklet. You will not be marked on this.

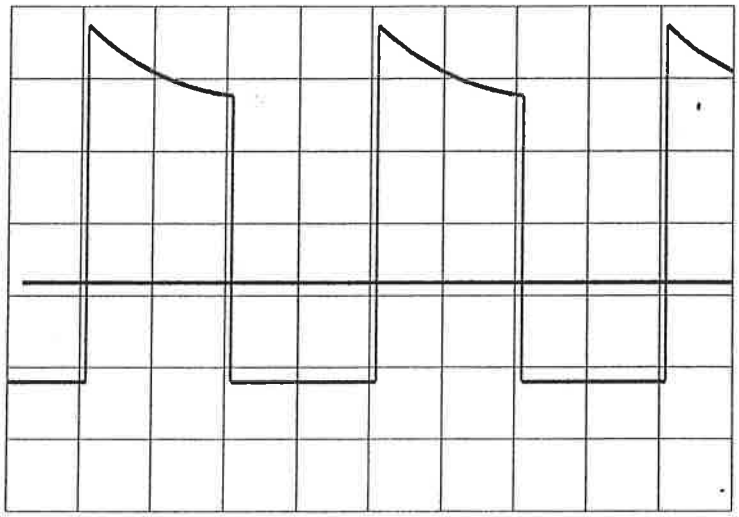
Section B:
This section has six (6) questions. Answer **all** the questions, writing on the question paper.

1. Which formula could be correct for the speed v of ocean waves in terms of the density ρ of sea-water, the acceleration of free fall g, the depth h of the ocean and the wavelength λ?

A $v = \sqrt{g\lambda}$ **B** $v = \sqrt{\frac{g}{h}}$ **C** $v = \sqrt{\rho g h}$ **D** $v = \sqrt{\frac{g}{\rho}}$

2. An oscilloscope display consists of two separate traces, a waveform and a long horizontal line. The horizontal line may be taken as the zero level.

The grid on the screen is calibrated in cm squares, the timebase setting is 2.5 ms cm^{-1}, and the Y-sensitivity is 5 mV cm^{-1}.



What are the period and the peak positive voltage of the waveform in the diagram?

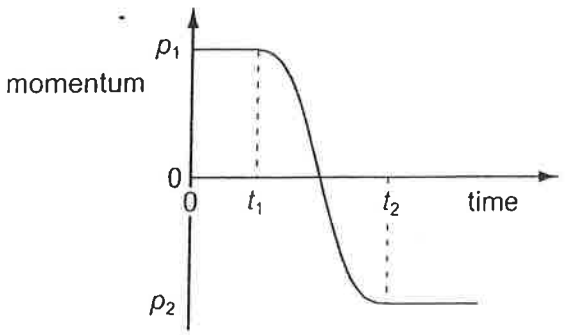
	period / ms	peak positive voltage / mV
A	5	17
B	5	25
C	10	17
D	10	25

3. A stone is dropped from the top of a tower of height 40 m. The stone falls from rest and air resistance is negligible.

What time is taken for the stone to fall the last 10 m to the ground?

A 0.38 s **B** 1.4 s **C** 2.5 s **D** 2.9 s

4. The graph shows the variation with time of the momentum of a ball as it is kicked in a straight line.

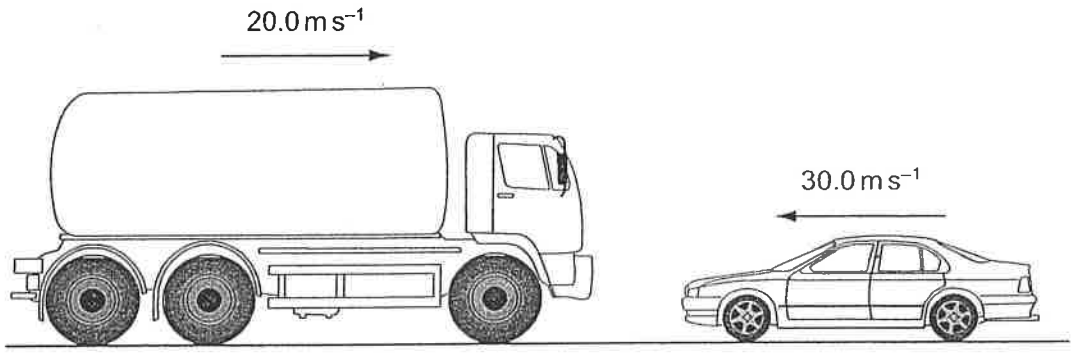


Initially, the momentum is p_1 at time t_1. At time t_2 the momentum is p_2.

What is the magnitude of the average force acting on the ball between times t_1 and t_2?

A $\frac{p_1 - p_2}{t_2}$ B $\frac{p_1 - p_2}{t_2 - t_1}$ C $\frac{p_1 + p_2}{t_2}$ D $\frac{p_1 + p_2}{t_2 - t_1}$

5. A lorry of mass 20 000 kg is travelling at 20.0 m s^{-1}. A car of mass 900 kg is travelling at 30.0 m s^{-1} towards the lorry.



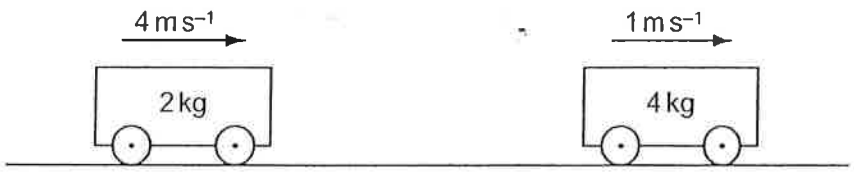
What is the magnitude of the total momentum?

A 209 kN s B 373 kN s C 427 kN s D 1045 kN s

A 750 kg car is moving at a speed of 20.0 ms^{-1} when at a height of 5.0 m above the bottom of a hill when it runs out of fuel. The car coasts down the hill and then continues up the other side until it comes to rest. Ignoring frictional forces and air resistance, what is the value of h, the highest position the car reaches above the bottom of the hill?

A. 6 m B. 15 m C. 25 m D. 45 m

7. The diagram shows the masses and velocities of two trolleys about to collide.

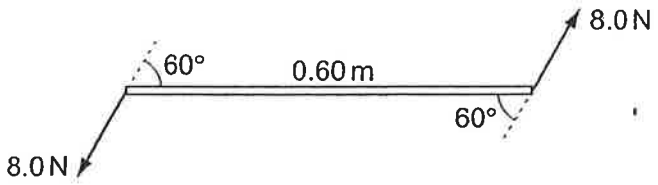


After the impact they move off together.

What is the total kinetic energy of the trolleys after the collision?

A 1.3 J **B** 12 J **C** 18 J **D** 19 J

8. Two 8.0 N forces act at each end of a beam of length 0.60 m. The forces are parallel and act in opposite directions. The angle between the forces and the beam is 60°.



What is the torque of the couple exerted on the beam?

A 2.4 N m **B** 4.2 N m **C** 4.8 N m **D** 9.6 N m

9. Which expression **defines** power?

A force × distance moved in the direction of the force

B force × velocity

C work done ÷ time taken

D work done × time taken

10. The density of mercury is 13.6×10^3 kg m^{-3}.

The pressure difference between the bottom and the top of a column of mercury is 100 kPa.

What is the height of the column?

A 0.75 m **B** 1.3 m **C** 7.4 m **D** 72 m

What gives the value of a body's acceleration?

A the area under its displacement-time graph

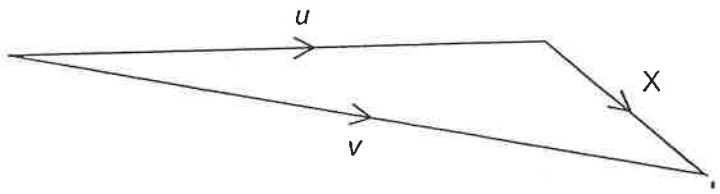
B the area under its velocity-time graph

C the gradient of its displacement-time graph

D the gradient of its velocity-time graph

2. An object has an initial velocity u. It is subjected to a constant force F for t seconds, causing a constant acceleration a. The force is **not** in the same direction as the initial velocity.

A vector diagram is drawn to find the final velocity v.



What is the length of side X of the vector diagram?

A F **B** Ft **C** at **D** $u + at$

Sound wave X has intensity 10^{12} times greater than that of sound wave Y.

By how much is the amplitude of X greater than the amplitude of Y?

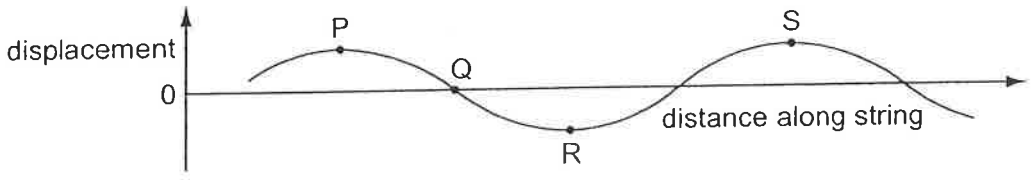
A 10^6 times

B 3.16×10^6 times

C 5×10^{11} times

D 10^{12} times

The graph shows the shape at a particular instant of part of a transverse wave travelling along a string.



Which statement about the motion of points in the string is correct?

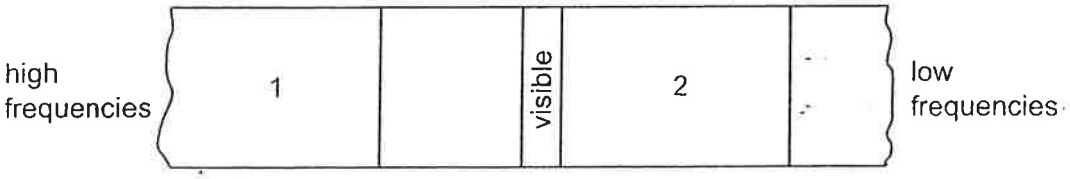
A The speed at point P is a maximum.

B The displacement at point Q is always zero.

C The energy at point R is entirely kinetic.

D The acceleration at point S is a maximum.

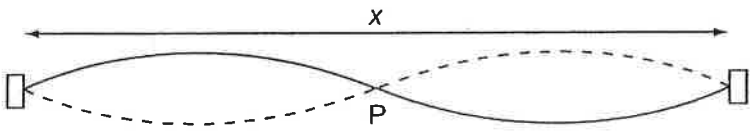
15. The diagram illustrates part of the electromagnetic spectrum.



Which labels are correct for the regions marked 1 and 2?

	1	2
A	infrared	X-rays
B	microwaves	X-rays
C	ultraviolet	microwaves
D	X-rays	infrared

16. The diagram represents a stationary wave on a stretched string.



What is represented by point P and by the length *x*?

	point P	length *x*
A	antinode	one wavelength
B	antinode	two wavelengths
C	node	one wavelength
D	node	two wavelengths

17. A two-slit arrangement is set up to produce interference fringes on a screen. The fringes are too close together for convenient observation when a monochromatic source of violet light is used.

In which way would it be possible to increase the separation of the fringes?

A Decrease the distance between the screen and the slits.

B Increase the distance between the two slits.

C Increase the width of each slit.

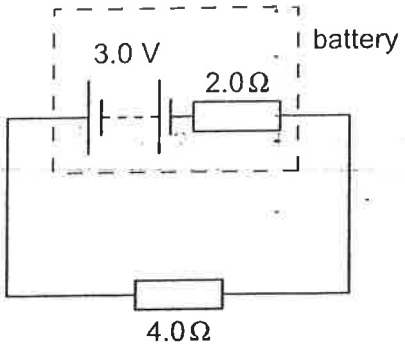
D Use a monochromatic source of red light.

18. The current in a resistor is 8.0 mA.

What charge flows through the resistor in 0.020 s?

A 0.16 mC **B** 1.6 mC **C** 4.0 mC **D** 0.40 C

A battery has an e.m.f. of 3.0 V and an internal resistance of 2.0 Ω.



19. The battery is connected to a load of 4.0 Ω.

What are the terminal potential difference V and output power P?

	V/V	P/W
A	1.0	0.50
B	1.0	1.5
C	2.0	1.0
D	2.0	1.5

20. When four identical resistors are connected as shown in diagram 1, the ammeter reads 1.0 A and the voltmeter reads zero.

diagram 1

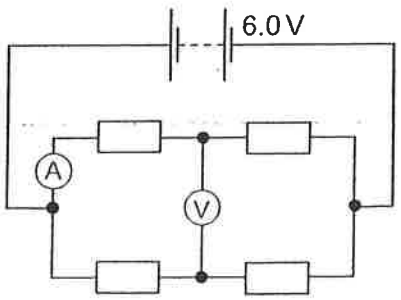
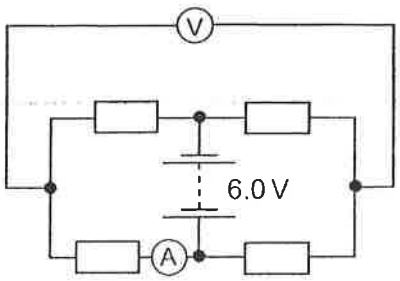


diagram 2



The resistors and meters are reconnected to the supply as shown in diagram 2.

What are the meter readings in diagram 2?

	voltmeter reading/V	ammeter reading/A
A	0	1.0
B	3.0	0.5
C	3.0	1.0
D	6.0	0

21. A mass m has acceleration a. It moves through a distance s in time t. The power used in accelerating the mass is equal to the product of force and velocity. The percentage uncertainties are

0.1 % in m,

1 % in a,

1.5 % in s,

0.5 % in t.

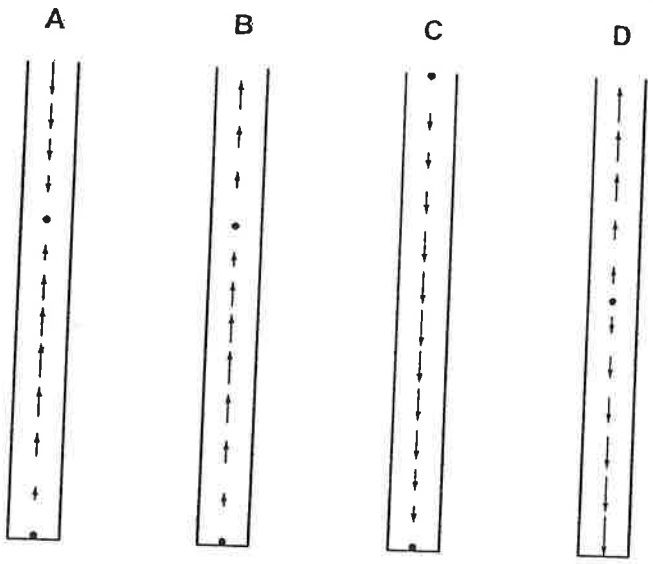
What is the percentage uncertainty in the average power?

A 2.1 % **B** 2.6 % **C** 3.1 % **D** 4.1 %

22. A stationary longitudinal wave is set up in a pipe.

In the diagrams below, the length of each arrow represents the amplitude of the motion of the air molecules, and the arrow head shows the direction of motion at a particular instant.

Which diagram shows a stationary wave in which there are two nodes and two antinodes?



23. A narrow beam of monochromatic light is incident normally on a diffraction grating. Third-order diffracted beams are formed at angles of 45° to the original direction.

What is the highest order of diffracted beam produced by this grating?

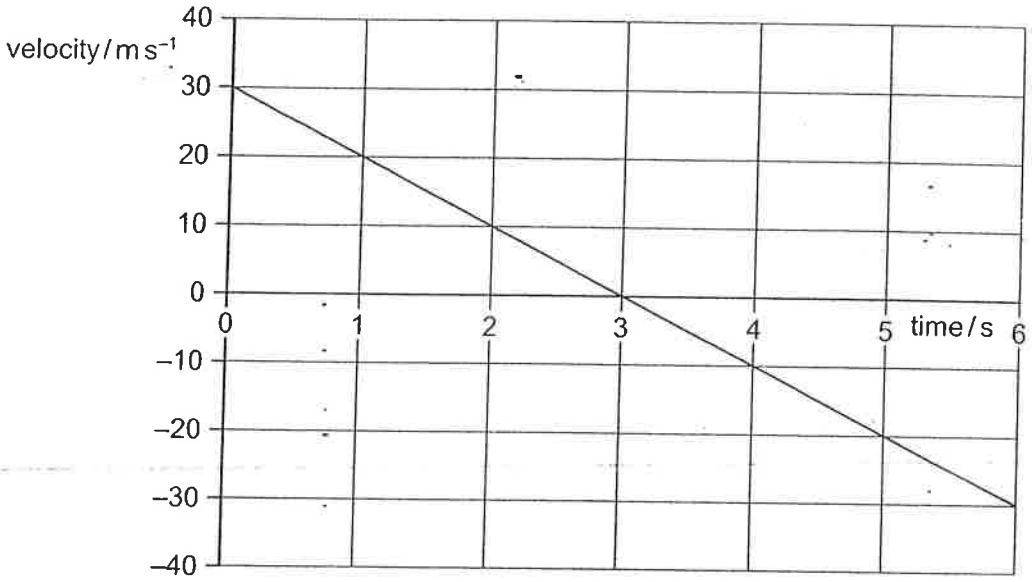
A 3rd **B** 4th **C** 5th **D** 6th

24. Two heating coils X and Y, of resistance R_X and R_Y respectively, deliver the same power when 12 V is applied across X and 6 V is applied across Y.

What is the ratio R_X / R_Y?

A ¼ **B** ½ **C** 2 **D** 4

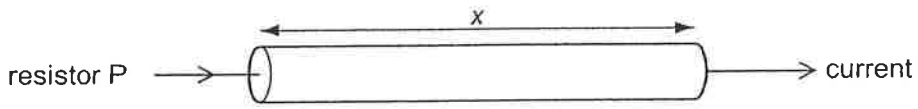
25. A stone is thrown vertically upwards. A student plots the variation with time of its velocity.



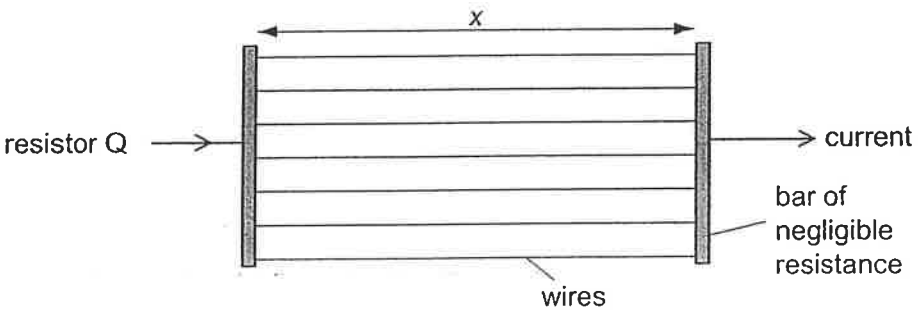
What is the vertical displacement of the stone from its starting point after 5 seconds?

A 20 m **B** 25 m **C** 45 m **D** 65 m

6. A researcher has two pieces of copper of the same volume. All of the first piece is made into a cylindrical resistor P of length *x*.



All of the second piece is made into uniform wires each of the same length *x* which he connects between two bars of negligible resistance to form a resistor Q.



How do the electrical resistances of P and Q compare?

A P has a larger resistance than Q.

B Q has a larger resistance than P.

C P and Q have equal resistance.

D Q may have a larger or smaller resistance than P, depending on the number of wires used.

For Examiner's Use

A bullet of mass 2.0 g is fired horizontally into a block of wood of mass 600 g. The block is suspended from strings so that it is free to move in a vertical plane.
The bullet buries itself in the block. The block and bullet rise together through a vertical distance of 8.6 cm, as shown in Fig. 3.1.

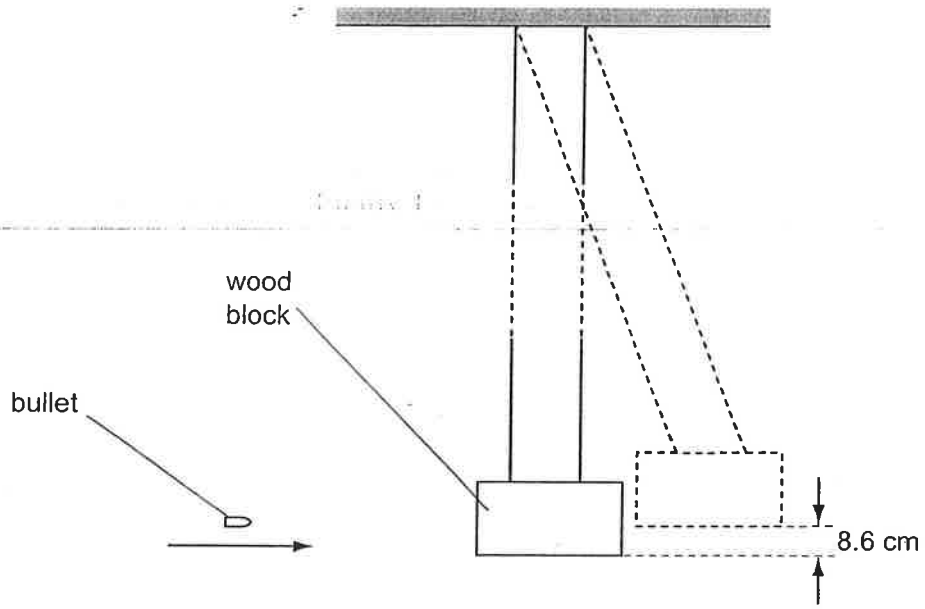


Fig. 3.1

(a) (i) Calculate the change in gravitational potential energy of the block and bullet.

change = ... J [2]

(ii) Show that the initial speed of the block and the bullet, after they began to move off together, was 1.3 m s^{-1}.

[1]

(b) Using the information in (a)(ii) and the principle of conservation of momentum, determine the speed of the bullet before the impact with the block.

For Examiner's Use

speed = ... $m\,s^{-1}$ [2]

(c) (i) Calculate the kinetic energy of the bullet just before impact.

kinetic energy = ... J [2]

(ii) State and explain what can be deduced from your answers to (c)(i) and (a)(i) about the type of collision between the bullet and the block.

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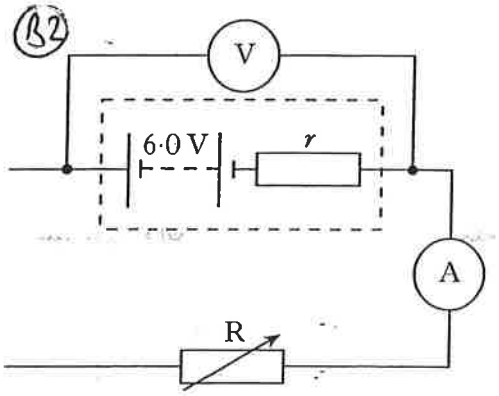
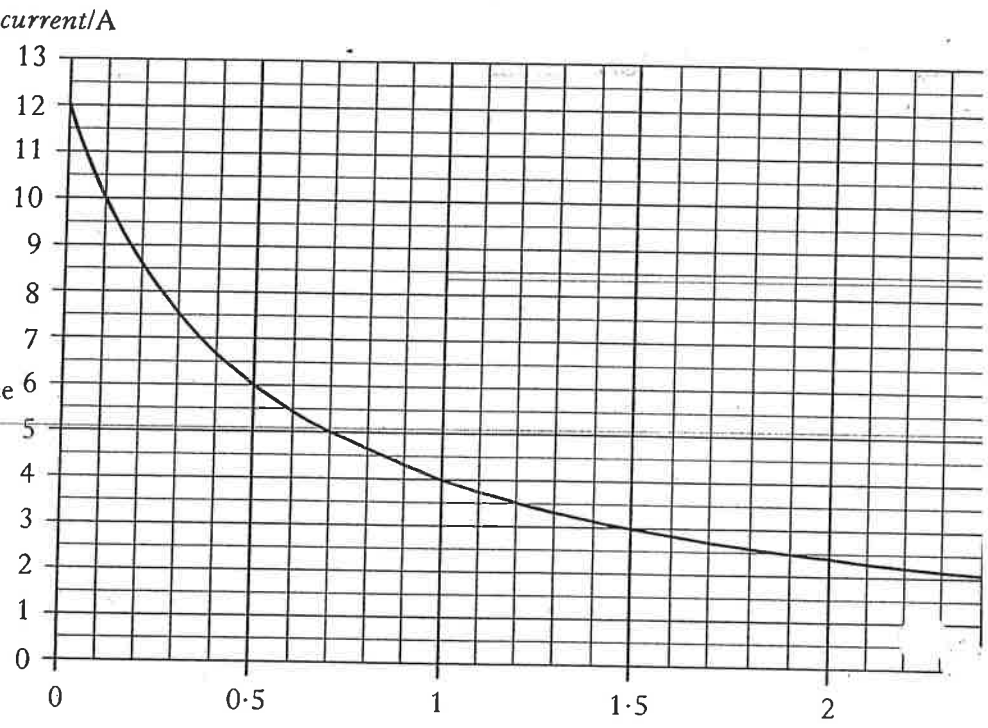
.....[2]

(B2)



A battery of e.m.f. 6·0 V and internal resistance, r, is connected to a variable resistor R as shown.

The graph shows how the current in the circuit changes as the resistance R increases.



(*a*) Use information from the graph to calculate:

(i) the lost volts in the circuit when the resistance of R is 1·5 Ω; 2

(ii) the internal resistance, r, of the battery. 2

(*b*) The resistance of R is now increased.

What effect, if any, does this have on the lost volts?

You must justify your answer. 2

(6)

For Examiner's Use

(B3) Fig. 2.1 shows the variation with distance x along a wave of its displacement d at a particular time.

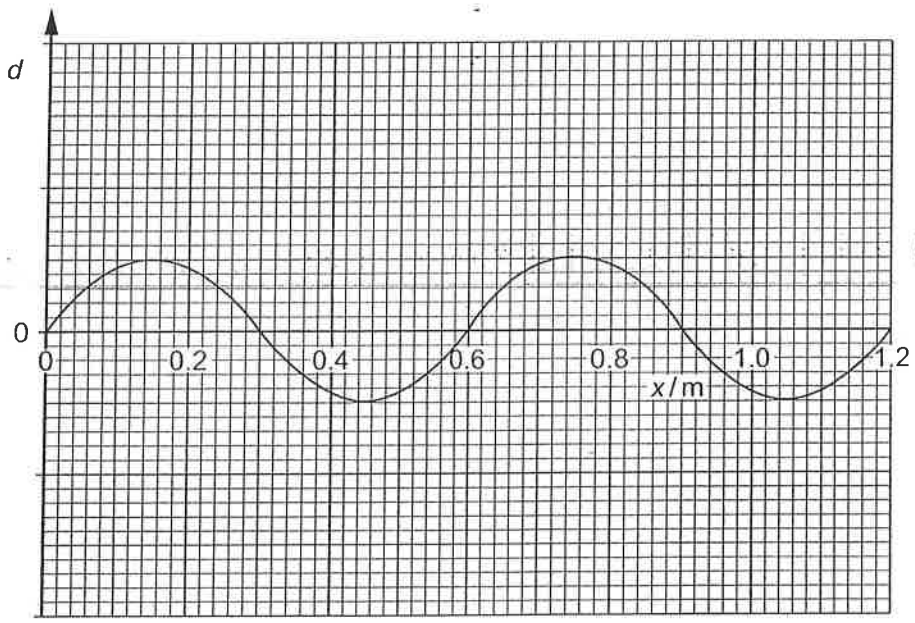


Fig. 2.1

The wave is a progressive wave having a speed of 330 m s^{-1}.

(a) (i) Use Fig. 2.1 to determine the wavelength of the wave.

wavelength = ... m

(ii) Hence calculate the frequency of the wave.

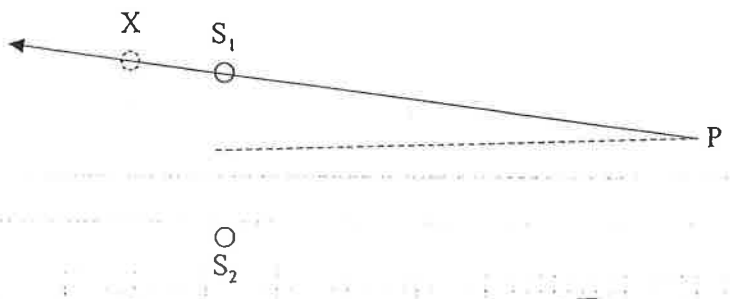
frequency = ... Hz [2]

(b) A second wave has the same frequency and speed as the wave shown in Fig. 2.1 but has double the intensity. The phase difference between the two waves is 180°.

On the axes of Fig. 2.1, sketch a graph to show the variation with distance x of the displacement d of this second wave. [2]

B4

In the diagram below, S_1 and S_2 are two small loudspeakers. They are connected to the same sound source such that they emit sound waves of the same intensity and wavelength. An instrument for detecting sound intensity is placed at point P such that $S_1P = S_2P$.



The speaker S_1 is moved slowly away from P along the line PS_1. As S_1 is moved, the sound detected at P decreases and increases in intensity.

(i) Explain this observation. *[3]*

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(ii) In moving the source from S_1 to point X, the intensity of the sound at P changes from a maximum to a minimum. The distance $S_1X = 0.082\,m$.

Calculate the value of the wavelength of the sound emitted by the sources. *[2]*

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(iii) S_1 remains at the point X and the frequency f of the sound emitted from both S_1 and S_2 is changed until a maximum of sound intensity is detected at P. This occurs when $f = 4100\,Hz$.

Estimate a value for the speed of sound. *[2]*

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B5

When liquid nitrogen at a temperature of 77 K or -196°C is poured into a beaker, it is observed to boil continuously as heat enters it from the surroundings. When stored in a full 25 litre Dewar flask (an insulated steel container similar to a thermos flask), it takes 100 days for all of the liquid nitrogen to boil away. The rate at which heat enters the Dewar flask is very low; we can estimate the value using the results of the following experiment.

Fig 1. Liquid nitrogen Dewar

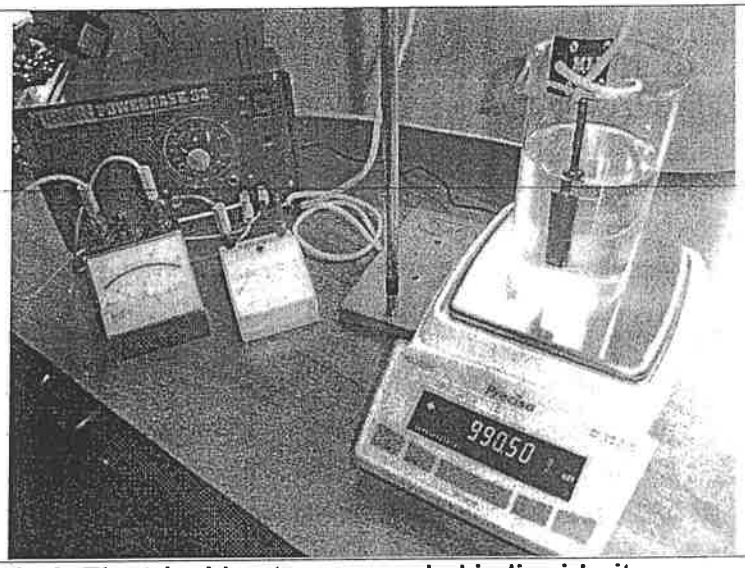
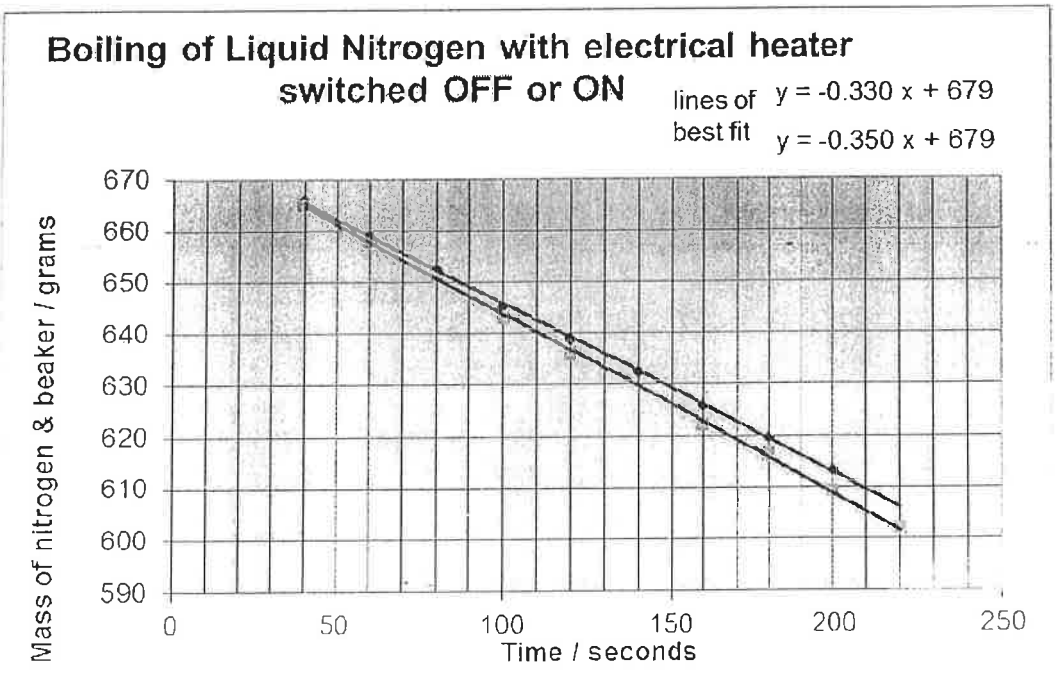


Fig 2. Electrical heater suspended in liquid nitrogen

A beaker of liquid nitrogen is placed on an electronic balance and readings of the mass are taken every twenty seconds. A small electrical heater is suspended in the liquid, and the experiment is carried out twice, once with the heater turned off and then repeated with the heater connected to the electrical supply. A graph is plotted of the two sets of results and the lines of best fit are obtained, along with the equations. The graph is shown below.



a) Calculate the rate of loss of liquid nitrogen in grams per second for each of the two cases, using the data from the graph. The equations for the lines of best fit are given.

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.....(2)

b) The potential difference across the heater is 3.9 V ; the current through it is 1.2 A.

i) Calculate how much energy is required to boil away one gram of liquid nitrogen. Show your working.

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.....(3)

ii) Explain the purpose of this experimental arrangement clearly.

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.....(2)

c) Hence calculate the average power that must enter the full 25 litre Dewar to boil away the nitrogen in 100 days. (Density of liquid nitrogen is 810 kg m^{-3}. 1 m^3 = 1000 litres).

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.....(3)

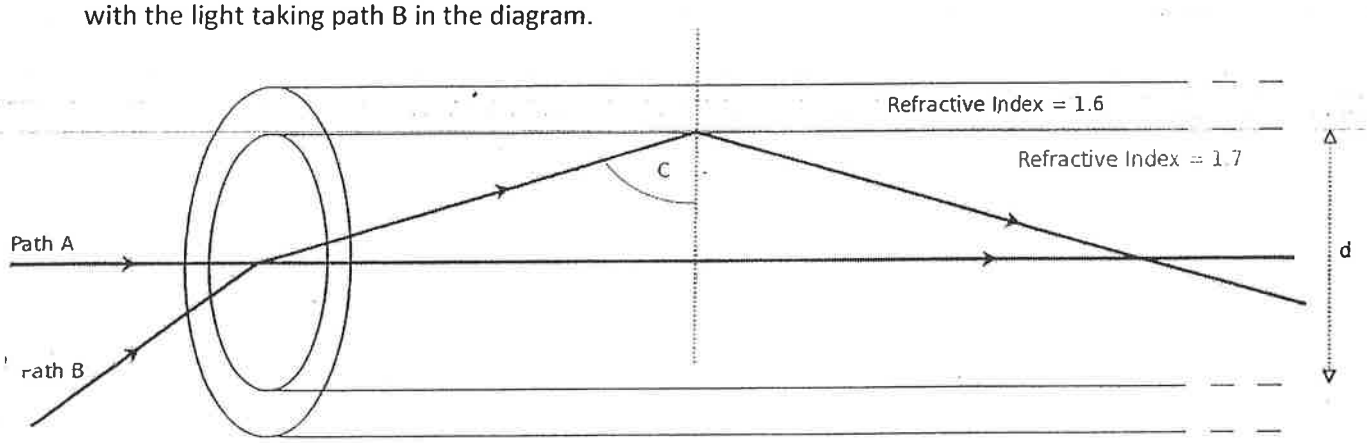
[Total: 10]

Q6. A fibre-optic cable is made from two layers of glass as shown in the diagram below.

The inner core of the fibre has a higher refractive index than the outer layer.

An optical signal can travel directly along the fibre taking path A in the diagram.

Alternatively, the signal can bounce along the inside of the fibre, thus taking a longer path. The longest possible path will occur when the angle of incidence is just greater than the critical angle, with the light taking path B in the diagram.



a. Show that the critical angle (C in the diagram) is about 70°

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.....(2)

b. A certain fibre optic cable is 1.0km long. Calculate how much longer a signal taking path B would take to travel along the cable than a signal taking path A.

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.....(5)

c. State and explain how this time difference would be affected if the refractive index of the outer coating were lower.

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.....(2)

d. Suggest how this time difference might affect high-frequency digital signals passing along the cable.

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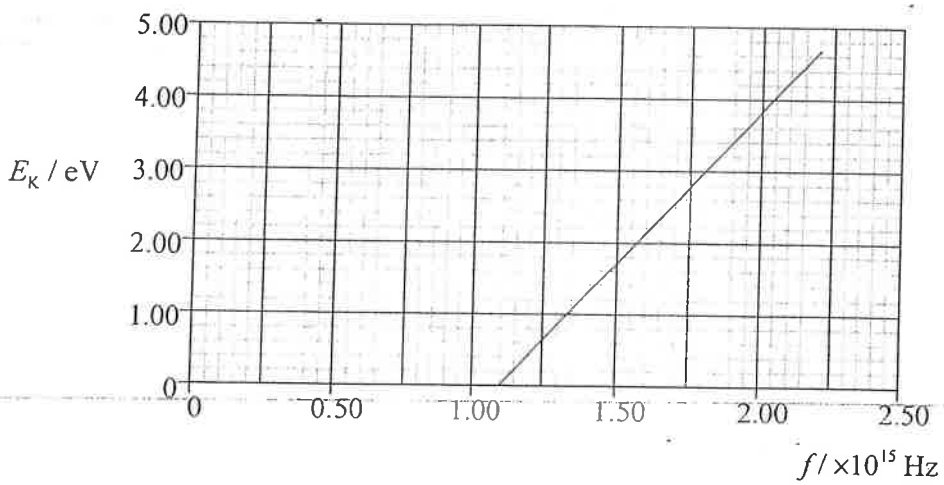
.....(2)

[11]

7. A metal is placed in a vacuum and light of frequency f is incident on its surface. As a result, electrons are emitted from the surface. The graph below shows the variation with frequency f of the maximum kinetic energy E_K of the emitted electrons.



(a) The graph shows that there is a threshold frequency of the incident light below which no electrons are emitted from the surface. With reference to the Planck constant and the photoelectric work function, explain how Einstein's photoelectric theory accounts for this threshold frequency.

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..... [3]

(b) Use the graph to determine the

(i) threshold frequency. [1]

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(ii) Planck constant.

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..... [3]

(iii) work function of the metal.

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..... [2]

[9]