Section A
Answer **all** the questions in this section

1 A flat equilateral triangular cardboard, of side 50.0 cm lies on a flat frictionless surface. A nail is driven through its centre, C, allowing it to turn. This is shown in Fig. 1.1 below.

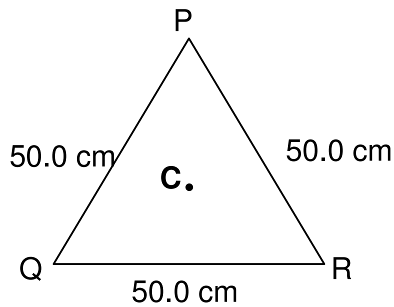

Fig. 1.1

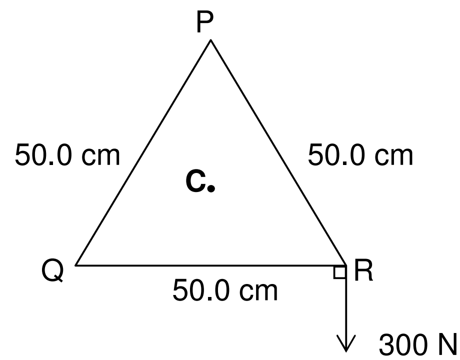

Fig. 1.2

(a) A 300 N force perpendicular to side QR is applied on edge R, as shown in Fig. 1.2.
Calculate the moment about the centre C. [2]

(b) On Fig. 1.2, mark out how another force of 300 N can be applied to edge P so that the cardboard does not turn. Label clearly the angle this 300 N force makes with side PQ. [1]

(c) Calculate the value of the force F perpendicular to side PR, 40.0 cm from edge P as shown in Fig. 1.3 that will also keep the cardboard stationary. [2]

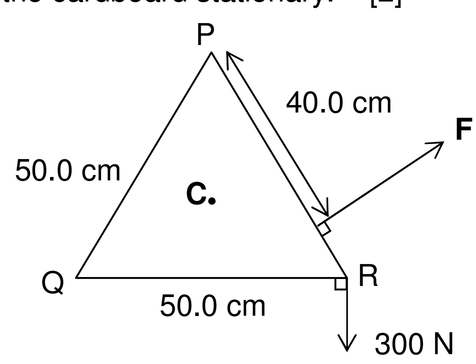

Fig. 1.3

2 A diver dives 30 m below sea level to repair cables at the sea bed. The atmospheric pressure is 100000 Pa, density of sea water = 1000 kg/m^3 and density of mercury = 13600 kg/m^3.

(a) Find the pressure at 30 m below sea level. [2]

(b) The diver released an expandable balloon to lift some of the tools up. Explain in terms of kinetic theory what happens to the balloon as it moves up to the surface. [3]

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(c) Find the volume of the balloon at the water surface if the volume of the balloon at 30 m below the sea level is 1 m^3. Assume that the temperature of the sea water remains unchanged. [2]

3 Fig. 3.1 shows a refrigerator.

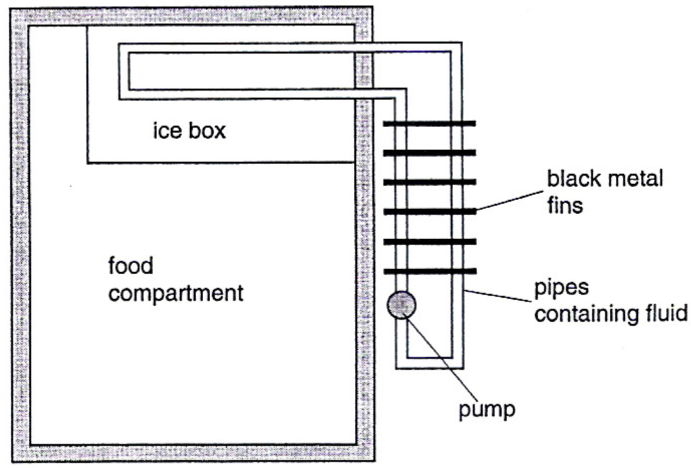

Fig. 3.1

A fluid pumped through the pipes takes thermal energy (heat) out of the ice box. This energy passes into the air at the back of the refrigerator through the black fins.

(a) Explain how the ice box at the top of the refrigerator keeps the whole of the food compartment cool. [2]

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(b) Explain why the fins are black. [1]

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(c) Other than its colour, state two other features that the fins should have, in order to ensure that the rate of passing thermal energy into the air is optimum. [2]

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4 Water waves may be refracted at a boundary.

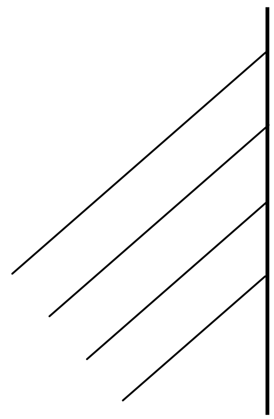

Fig. 4.1

Fig. 4.1 shows four wavefronts of a water wave incident on a boundary.
As the wave crosses the boundary, the wave refracts towards the normal.

(a) Draw in Fig. 4.1 the wavefronts after refraction, to the right of the boundary. [2]

(b) Describe how a ripple tank could be used to produce this refraction. [2]

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(c) State why the water waves refract. [1]

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5 A charged light metal sphere is suspended between two parallel plates. The plates are connected to a d.c. power supply as shown in Fig. 5.1.

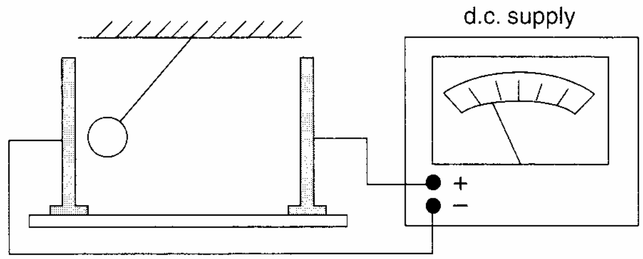

Fig. 5.1

(a) What kind of charge is carried by the sphere? [1]

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(b) Draw the electric field pattern between the plates in Fig. 5.1. [2]

(c) What happens to the deflection of the sphere from the vertical, as

(i) the voltage increases, [1]

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(ii) the a.c. supply with the same voltage is used instead of d.c. supply? [1]

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6 Fig. 6.1 shows a circuit connecting a 8 Ω resistor and 2 identical lamps P and Q. The potential difference across lamp Q is found to be 2 V.

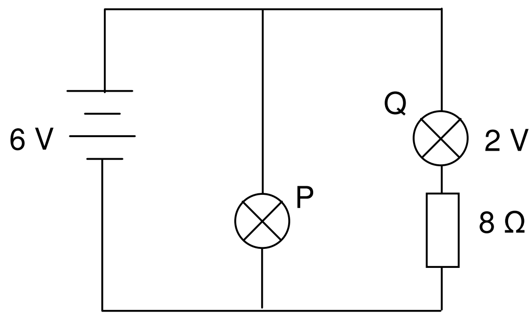

Fig. 6.1

(a) What is the current flowing through the 8 Ω resistor? [2]

(b) Calculate the resistance of lamp Q. [1]

(c) Calculate the current flowing through lamp P. [2]

(d) Calculate the total resistance of the circuit. [2]

7 Fig. 7.1 shows a coil ABCD that can turn between the two poles of a magnet. Bare metal paper clips support and pass current into and out of the coil.

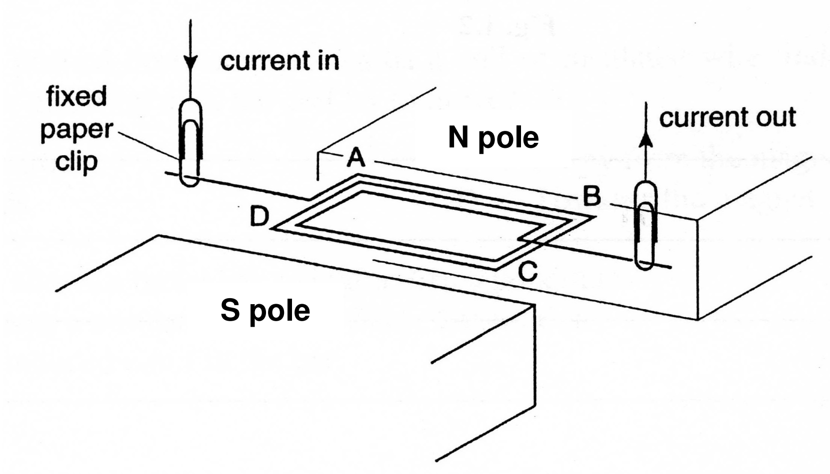

Fig. 7.1

(a) **(i)** State the direction of the force on the side AB. [1]

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....

(ii) Explain the reason for your choice of direction. [1]

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(b) A student turns the coil through 180° so that AB is close to the S pole of the magnet.

(i) State the direction of the force on side AB of the coil. [1]

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(ii) The student releases the coil.
Explain why the coil does not rotate continuously. [1]

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(c) With the coil as shown in Fig. 7.1, the top half of the wire from C to the paper clip is coated with an insulator, as shown in Fig. 7.2.
Explain why the coil can now rotate continuously. [2]

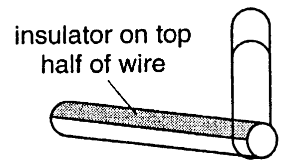

Fig. 7.2

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8 Fig. 8.1 shows a transformer and diode used as a rectifier.

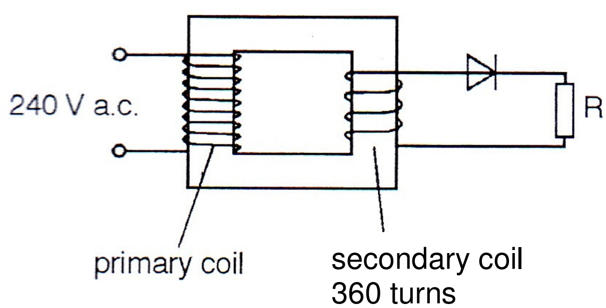

Fig. 8.1

(a) The transformer produces an output voltage of 18.0 V across the secondary coil.
Calculate the number of coils in the primary coil. [2]

(b) State any assumptions that you have made in calculating part **(a)**. [1]

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(c) Fig. 8.2 shows the potential difference across the secondary coil.

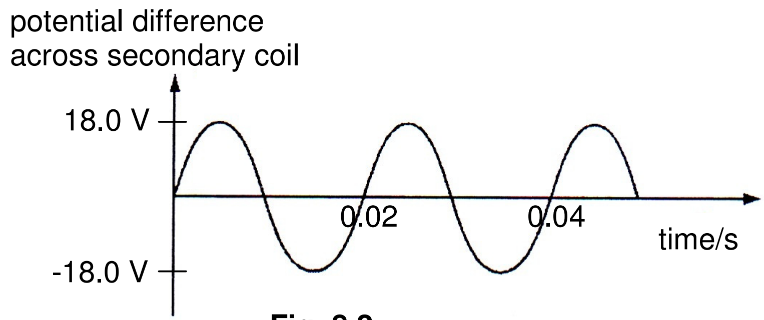

Fig. 8.2

(i) State the period of the waveform shown in Fig. 8.2. [1]

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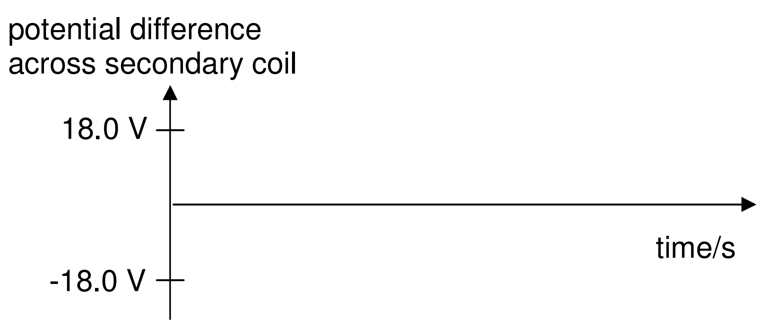
(ii) Calculate the frequency of the alternating current. [2]

(iii) Draw, in the graph below, the potential difference across the resistor R. [2]



(iv) Explain how the circuit converts a.c. into d.c. [2]

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Section B
Answer **all** the questions from this section.
Question 11 has a choice of parts to answer.

9 Diamonds are useful for industrial applications and jewellery. The cut of a diamond affects how light gets transmitted into the eye of the observer when light passes through the diamond. The depth of its pavilion from its crown governs the path light will travel when it enters the diamond from the outside. A diamond that has a good cut is one that allows the most light to exit the top of the crown when light is shone from any angle around it.

Fig. 9.1 shows two diamonds, one of good cut and one of poor cut with a shallower pavilion. Light of wavelength 5.5×10^{-7} m is allowed to enter the surface of the diamond with good cut as shown in Fig. 9.2. The refractive index of diamond is 2.4 and its critical angle is approximately 25°

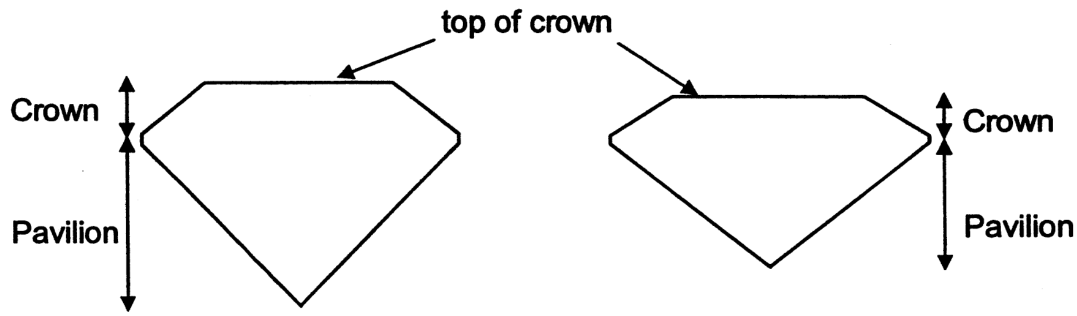

Fig. 9.1

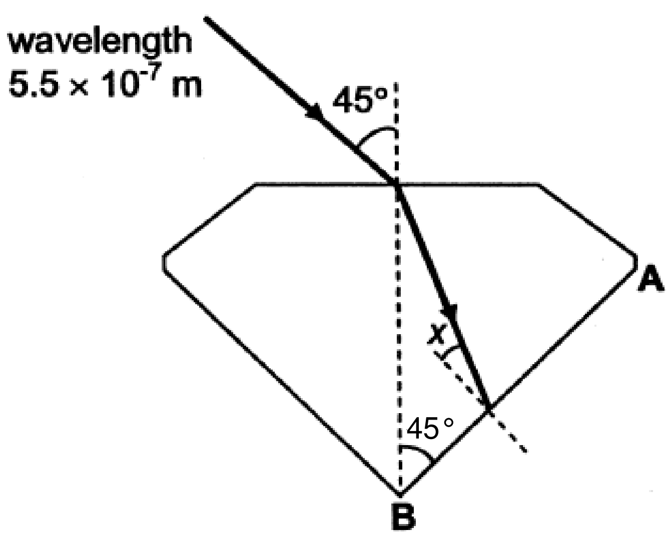

Fig. 9.2

(a) **(i)** Find the speed of light in diamond given the speed of light in air is 3.0×10^8 m/s. [1]

(ii) Find the wavelength of light in diamond. [1]

(b) Given the angle of incidence that light enters the diamond is 45°, find the angle of incidence, x, that the light ray hits surface AB. [2]

(c) Complete the path of the light ray in Fig. 9.2 to show how it exits the top of the diamond. [2]

(d) The depth of the pavilion plays a pivotal role in how light gets reflected internally and thus how bright a diamond sparkles.
Explain how a diamond with a shallower pavilion will not shine as brightly as one with a deeper pavilion. [2]

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(e) Comment on the refractive index of diamond and how it is able to shine more brightly compared to other materials of lower refractive indices. [2]

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10 Fig. 10.1 below shows the front panel of a C.R.O.. Bright spots are seen to move across the screen from left towards right.

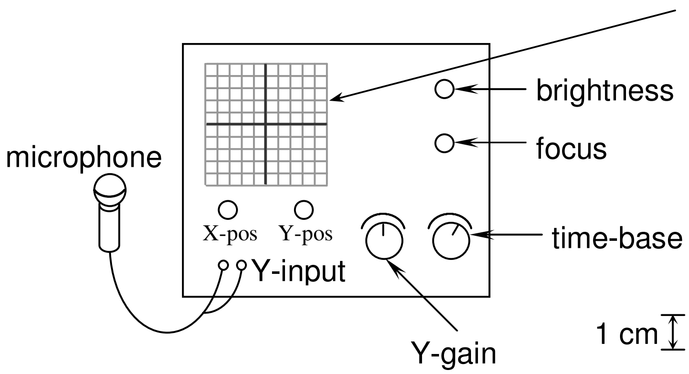

Fig. 10.1

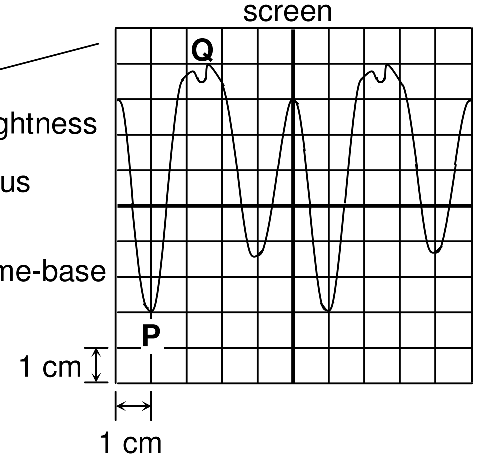

Fig. 10.2

(a) Which knob is used to control the

(i) rate at which electrons strike the screen? [1]

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(ii) sweeping speed of the bright spot across the screen? [1]

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(b) Without changing the settings of the C.R.O., a magnet is brought near the side of the screen as shown in Fig. 10.3.
State what would happen to the display on the screen. [1]

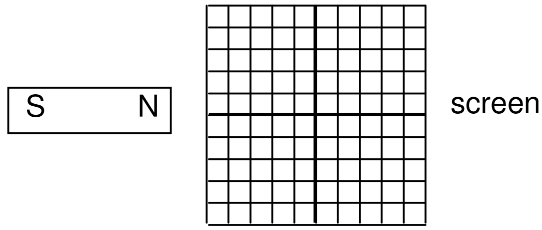

Fig. 10.3

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(c) In one occasion, a musical note is fed into the C.R.O. through a microphone connected to the Y-input. The display is shown in Fig. 10.2.
If the time-base is set at 0.25 ms/cm, what is the frequency of the note? [3]

(d) The Y-gain is set at 4 V/div.
How large is the potential difference between P and Q of the display shown in Fig. 10.2? [2]

(e) Describe the change in the display if

(i) the loudness of the same musical note is decreased. [1]

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(ii) the musical note has a lower pitch but is of the same loudness as before. [1]

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11 Either

(a)

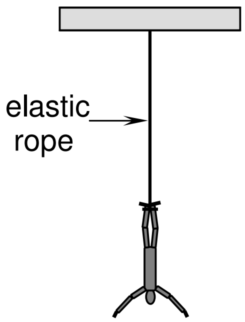

Fig. 11.1

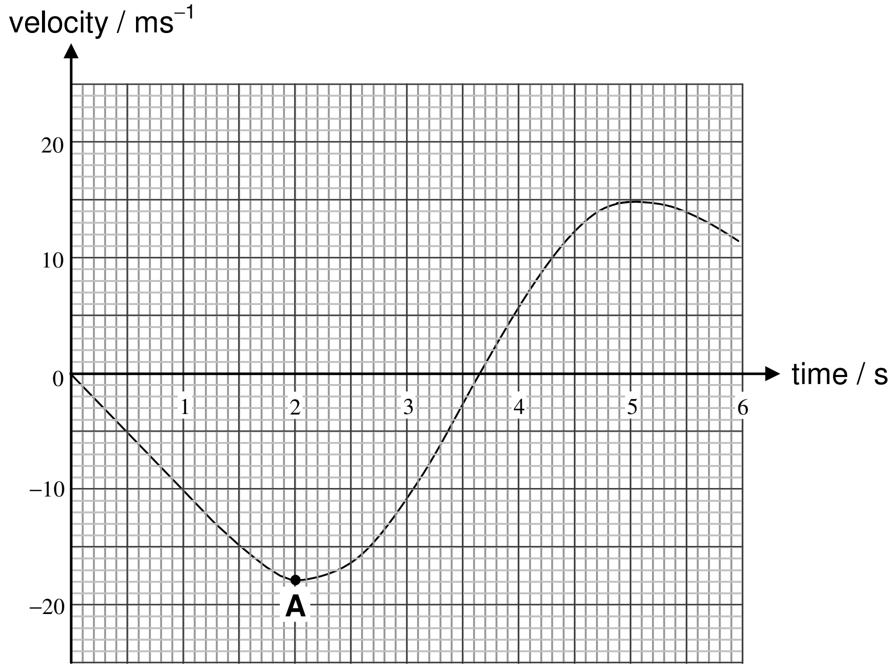

Fig. 11.2

Fig. 11.1 shows a man, tied to a thick elastic rope attached to a high platform, making a bungee jump. The graph in Fig. 11.2 shows how the velocity of the bungee jumper varies with time during the first 6 s of a jump. Upward motion is taken to be positive.
Point A on the graph corresponds to the time when the elastic rope tied to his feet becomes tight. The bungee jumper has a mass of 65 kg.

(a) Find the average acceleration of the jumper during the first second. Deduce the tension in the bungee rope during this time interval. [2]

(b) **(i)** What is the acceleration of the jumper at point A of the graph? [1]

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(ii) Find the tension in the bungee rope at point A of the graph. [1]

(c) Using information from the graph, state the time at which the bungee rope is at its maximum length. [1]

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(d) State the energy changes from the time when the rope first becomes tight to the time when it reaches the maximum length. [3]

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(e) Explain, in terms of the force of the rope acting on the bungee jumper, why an elastic rope is used rather than a rope that cannot be stretched very much. [2]

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OR

Adapted from Ultrasonic Transducers for Chemical and Process Plant
(R.C. Asher Physics Technology, vol14)

Ultrasound techniques are used in the chemical engineering industry for measuring and detecting the levels of liquid in closed vessels. In one such method, the Pulse Echo method, pulses of ultrasound are passed through the liquid under test. By timing the echo of a reflected pulse it is possible to calculate the depth of liquid in the vessel.

The apparatus is shown in Fig. 11.3.

The source of ultrasound is a transducer. Separate pulses of ultrasound are created using a thin disc of material which is made to oscillate rapidly at a frequency of 6 MHz. Each pulse contains just a few cycles of the oscillation, with the amplitude rapidly decreasing with time.

The ultrasound passes into the metal of the vessel but, at the metal/liquid boundary, only about 12% of the ultrasound passes into the liquid, the other 88% is reflected. The pulse is highly directional and does not spread out.

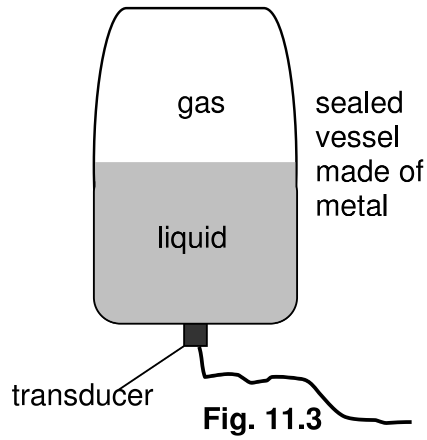

Fig. 11.3

At the boundary between the liquid and the gas in the vessel very nearly 100% of the ultrasound is reflected.

The reflected signals are picked up by another transducer similar to the one that generated it; indeed it is usually convenient to use the same transducer for emitting and receiving the ultrasound.

The time taken for the sound to travel through the liquid is measured and the position of the liquid surface can be calculated.

(a) Calculate the time taken for one oscillation of the disc in the transducer. [2]

(b) On the axes below sketch a graph to show how the displacement of the material of the disc varies with time as one pulse is created. Add values to the x-axis to indicate the time involved. [2]

(c) Explain why, when each pulse is sent out into the metal,

(i) a large pulse returns almost immediately, [1]

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(ii) then a much smaller pulse (about 1.4% of that initially passing into the metal) returns. [2]

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(d) Calculate how long the ultrasound will take to return to the transducer given that the thickness of the metal is 0.5 cm and the depth of the liquid is 25.0 cm. (speed of ultrasound in the metal is 5600 m/s and in the liquid is 1500 m/s) [3]

END OF PAPER

Answers to 2009 Sec 4 Preliminary Examination Pure Physics Paper 2

1a Moment = 300 x 25 [1]
= 7500 N cm or 75 N m [1]

1b 300 N force perpendicular to either PR or PQ, generating an anticlockwise moment.
Example:

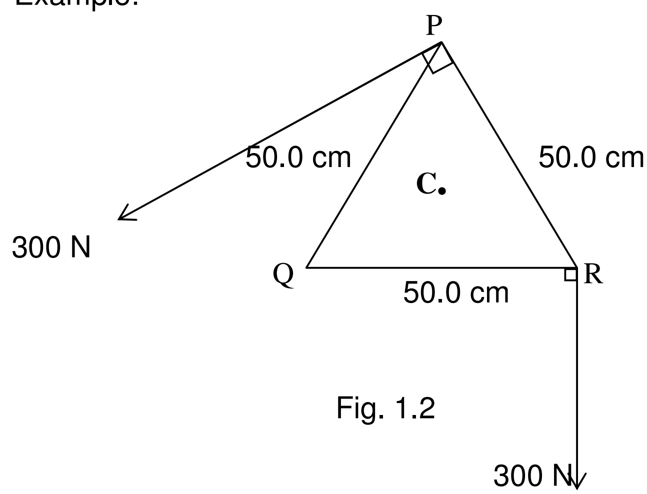


Fig. 1.2

1c Using Principle of moments, taking pivot about C,
Sum of Anticlockwise moment = Sum of Clockwise moment
F x 15 = 7500 N cm [1]
F = 500 N [1]

2a Pressure Difference = hpg = 30 x 1000 x 10 = 300 000 Pa [1]
Absolute Pressure = 300000 + atmospheric pressure = 400000Pa [1]

2b As the balloon moves up, the <u>frequency of bombardment</u> of the water molecules on the walls of the balloon <u>decreases</u>.[1]
The air molecules in the balloon adjust by also reducing the frequency of bombardment by <u>increasing the inter-molecular distance [1]</u>.
This causes the balloon to expand in volume [1].

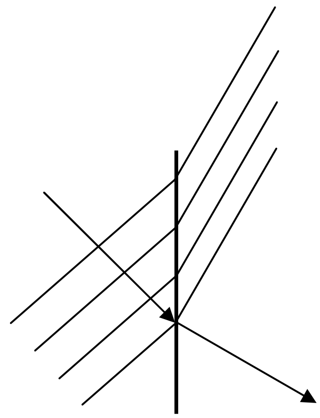
2c $P_1V_1 = P_2V_2$
400 000 x 1 = 100 000 x V_2 [1]
V_2 = 4 m^3 [1]

3a The air round the ice box would be **cooled** and undergoes contraction; as a result it **becomes denser and sinks**. **Warmer air** from other regions of the food compartment, being less dense, would then rise and **takes its place** and **be cooled in turn**.[1]
This creates **a convection current** that would **cool the food compartment efficiently**. [1]

3b The fins are black to optimise heat transfer to the air as **black surfaces are the best emitters of** thermal **radiation**. [1]

3c They should have **a large surface area** [1] and a **dull** / **rough surface.** [1] or be a good conductor/metal.

4a



Direction of wave is refracted towards the normal. [1]
Refracted waves are drawn with smaller wavelengths. [1]

4b A plastic (transparent) plate is placed in the ripple tank on the right side of the boundary [1]
so that the water in the right side of the boundary is shallower. [1]

4c The water waves refracts towards the normal because the speed of water waves in deeper region (left of boundary) is faster than that in the shallower region (right of boundary). [1]

5a Positive charge [1]

5b Straight, parallel lines to the horizontal with even spacing between two plates.[1]
Arrows from positive plate to negative plate [1]

5ci The deflection of the sphere would become greater. [1]

5cii The sphere would oscillate between deflection towards the left and right plate. [1]

6a p.d. across 8Ω resistor = 6 – 2 = 4 V [1]
I through 8Ω resistor = V/R = 4/8 = 0.5 A [1]

6b $R_Q = V / I_Q = 2 / 0.5 = 4\ \Omega$ [1]

6c $I_P = V / R_P = 6 / 4$ [1]
$= 1.5$ A [1]

6d $1 / R_T = 1/4 + 1/(4 + 8)$ [1]
$R_T = 3\ \Omega$ [1]

Or $V_T = I_T R_T$
$6 = (1.5 + 0.5) R_T$ [1]
$R_T = 3\ \Omega$ [1]

7ai The force acts downward, perpendicular to side AB. [1]

7aii Using Fleming's left hand rule, the direction of the force is indicated by the thumb which points downward. [1]

7bi The force acts downward, perpendicular to side AB. [1]

7bii When the coil makes half a turn, a counter moment that opposes the original rotation is produced in the coil. [1]
This prevents the coil from rotating continuously.

7c The insulation prevents current flow during the half turns. [1]
Thus the moment that oppose the original rotation would not be produced at every half turn. [1]

8a $$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

$$\frac{240}{18} = \frac{N_p}{360} \quad [1]$$

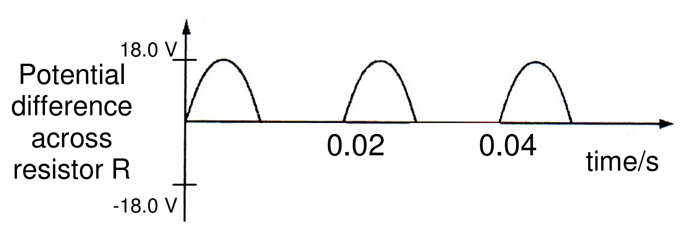
$N_P = 4800$ turns [1]

8b The assumption made is that it is an ideal transformer and thus there is no energy lost in the step-down process. [1]

8ci Period = 0.02 s [1]

8cii f = 1 / T
f = 1 / 0.02 = 50 Hz [1]

8ciii



8civ The diode only conducts when it is forward-biased. [1]
When it is reversed-biased, which it is for half of every cycle, it will have a every high resistance that effectively stop any current from flowing through it. [1]

Section B

9ai n = c / v

$2.4 = 3 \times 10^8 / v$

Speed of light in diamond = 1.25×10^8 m/s [1]

9aii frequency remains unchanged [1]

Using v = f λ,

$V_{air} / \lambda_{air} = v_{diamond} / \lambda_{diamond}$

$\lambda_{diamond} = (1.25 \times 10^8 / 3 \times 10^8) \times 5.5 \times 10^{-7}$ m

$= 2.29 \times 10^{-7}$ m [1]

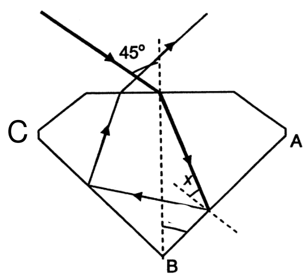
9b n = sin i / sin r

r = 17° [1]

x = (180 – 17 – 45 – 90)°

= 28° [1]

9c



Total internal reflection at surface AB. [1]

Total internal reflection at surface BC. [1]

9d A shallower pavilion means when light rays hit one of the faces of the pavilion, the angle of incidence on that face will be smaller than the critical angle. [1] Instead of being totally internally reflected and exiting from the crown, it will get refracted and exit the diamond from the pavilion. [1]

9e The large refractive index of diamond enables its critical angle to be relatively small. [1] This allows a large degree of freedom / more chance for light to undergo total internal reflection within the diamond. [1]

10ai Brightness knob [1]

10aii Time-base knob [1]

10b The spot would be deflected downwards [1]

10c Period, T = 5 x 0.25 = 1.25 ms [1]

Frequency, $f = 1 / T$

$= 1 / (1.25 \times 10^{-3})$ [1]

= 800 Hz [1]

10d $V_{PQ} = 7 \times 4$ [1]

= 28 V [1]

10ei Amplitude of the waveform decreases. [1]

10eii Less waves are displayed (or the waves are wider). [1]

11 Either

11a Average acceleration in the first second = 10 m/s^2 downwards [1]
Tension = 0 N [1]

11bi Acceleration at A = 0 m/s^2 [1]

11bii Tension of rope at A = weight of jumper = 65 x 10 = 650 N [1]

11c Time at which the rope is at maximum length = 3.65 s [1]

11d The kinetic energy and gravitational potential energy [1] of the rope and jumper are gradually changed to elastic potential energy [1] in the rope as it stretches.
At the maximum length of the rope, all the kinetic energy and gravitational potential energy become zero and the elastic potential energy in the rope is maximum. [1]

11e With an elastic rope, the tension increases gradually as it stretches. The deceleration and hence the upward resultant force acting on the jumper increases gradually [1] and would not hurt him.
If the rope used is less elastic, the deceleration of the jumper would be greater and hence the upward resultant force is much larger which may hurt [1] the jumper.

11 OR

11a $T = 1/f = 1/(6 \times 10^6)$ [1]
$= 1.67 \times 10^{-7}$ s [1]

11b Sine/ cosine curve [1] with decreasing amplitude [1]

11ci 88% of the ultrasound is reflected back immediately at the metal/liquid boundary. [1]

11cii 12% of the original ultrasound gets reflected at the liquid/ gas boundary and returns back to the liquid/ metal boundary.[1]

At this liquid/metal boundary, only $\frac{12}{100} \times 12\% = 1.44\%$ passes through the metal back into the transducer. [1]

11d $t = t_{metal} + t_{liquid}$
$= [2(0.005) / 5600]$ [1] + $[2(0.25)/ 1500]$ [1]
$= 3.35 \times 10^{-4}$ s [1]

End of Answer