Section A

Answer **all** the questions in this section.

1 Fig. 1.1 shows a 400 g ball falling freely from rest.

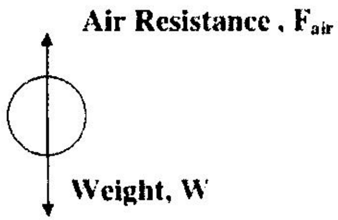

Fig. 1.1

(a) At a certain instant, the ball is accelerating downwards at 6.0 ms^{-2}. Calculate the air resistance acting on the ball.

air resistance = ... [2]

(b) The acceleration of the ball decreases while falling and eventually the ball reaches terminal velocity at t = 10 s. Sketch a velocity - time graph to show the motion of the ball. [2]

(c) Explain, in terms of the forces acting, why the acceleration of the ball decreases and terminal velocity is reached.

....

....

....

....

.... [2]

2 Fig 2.1 (*not drawn to scale*) shows the forces acting on an arrow by the string of a bow just before it is released.

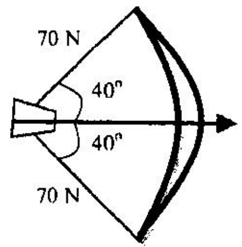

Fig. 2.1

Using a suitable labelled vector diagram, determine the magnitude and the direction of the resultant force exerted by the bowstring on the arrow. [3]

3 (a) Fig. 3.1 shows a piece of glass being lifted by a suction cup. Some air inside the suction cup is removed by a vacuum pump. The atmospheric pressure outside the cup prevents the glass from dropping. The area of the glass covered by the cup is $0.0025\ m^2$. The pressure inside the cup is reduced to 60 kPa. The atmospheric pressure is 100 kPa.

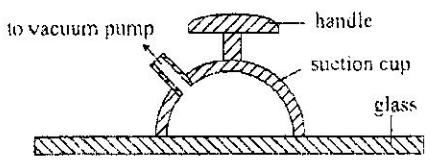

Fig. 3.1

(i) Calculate the maximum weight of a piece of glass that can be lifted with this cup.

Maximum weight = ...[1]

(ii) State one change that would allow the suction cup to lift a heavier piece of glass.

....

....[1]

(b) Fig. 3.2 shows a metal can with a tight fitting lid and the can is heated.

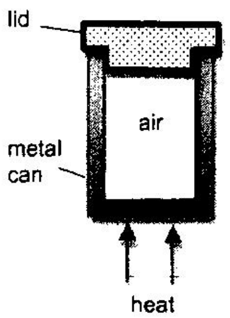

Fig. 3.2

For Examiner's Use

(i) Explain, in terms of the motion of molecules, why the pressure in the metal can increases when the can is heated.

....

....

....

....

....[2]

(ii) If a little water is put in the bottom of the can before heating, explain how this would affect the pressure in the can when the temperature increases.

....

....

....

....[2]

4 (a) Fig. 4.1 shows a filament lamp standing upright in air. The connections to the lamp are not shown. When switched on, the filament lamp loses energy by conduction, convection and radiation.

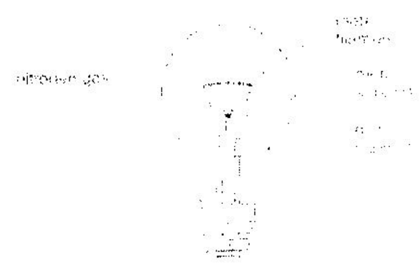

Fig. 4.1

Describe how energy is lost from the metal filament

(i) by conduction,

....

....

....[1]

For Examiner's Use

(II) by convection.

....

....

....

....

....

....[2]

(b) Fig. 4.2 shows an electric bulb painted matt black on one half and silver on the other.

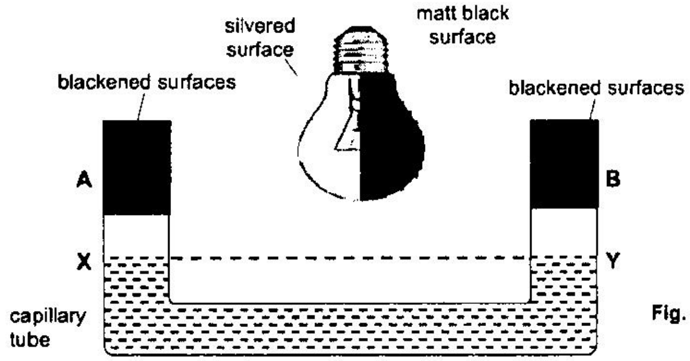

Fig. 4.2

(I) State which method(s) of heat transfer is/are involved in this setup.

....[1]

(II) A capillary tube containing water up to level **XY** is covered with blackened test tubes, **A** and **B**. The bulb is then switched on. Describe and explain what happens to the water level in the capillary tube.

....

....

....

....

....[2]

For Examiner's Use

5 (a) A ray of light is incident on a right-angled prism of refractive index 1.5 as shown in Fig. 5.1.

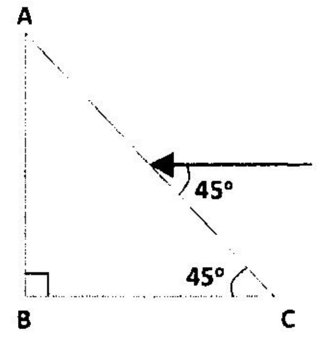

Fig. 5.1

(I) Calculate the angle of refraction of the ray.

angle of refraction = ...[1]

(II) Explain whether this ray within the prism will undergo total internal reflection when it hits the face AB. Show all your workings clearly.

....

....

....[3]

(III) Hence, complete the light ray in the Fig. 5.1 to show how light travels when it strikes on the face AC. [1]

For Examiner's Use

(b) A parallel beam of light making an angle of 30° with the principal axis is incident on the lens as shown in the Fig. 5.2.

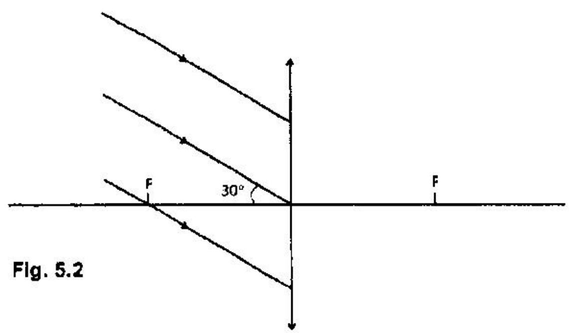

Fig. 5.2

(i) If the rays shown in Fig. 5.2 are from the top of a distant tree, complete the ray diagram to locate the image of the tree. [2]

(ii) Describe the characteristics of the tree image.

....

....[1]

6 Fig 6.1 shows a series of wavefronts of a water wave travelling through regions P and Q.

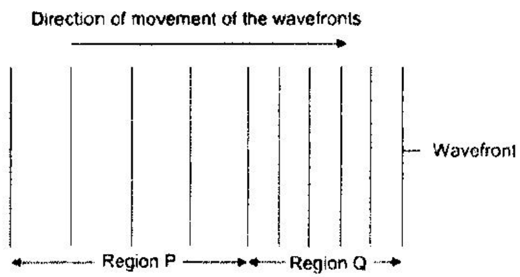

Fig. 6.1

(a) State and explain which region is deeper.

....

....

....[2]

(b) The distance between two successive wavefronts in region Q is 2.0 cm and each wavefront takes 4.0 s to travel through region Q.

(i) Determine the speed of the water wave in region Q.

speed = ...[2]

(ii) Hence, determine the frequency of the wave.

frequency= ....[1]

7 (a) Three uncharged metal spheres **A**, **B** and **C** mounted on insulating supports are positioned so that they touch. A rod carrying positive charge is brought near to them as shown in Fig. 7.1.

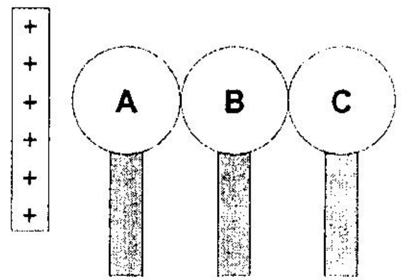

Fig. 7.1

The spheres are now moved slightly apart with the insulating supports and the charged rod is then removed.

(i) On Fig. 7.1, show the resulting charges on the spheres. [2]

(ii) Sphere **A** is moved until it touches sphere **C**. State the movement of the charges that occurs when they touch.

....

....[1]

(b) Fig. 7.2 shows an electric motor which is rated 200 V, 900 W.

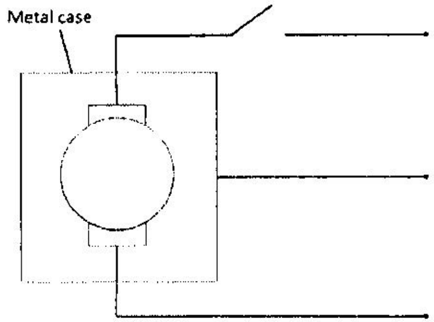

Fig. 7.2

(i) Calculate the current drawn by the motor when it is connected correctly.

current = ...[1]

(ii) Suggest a suitable rating for the fuse to be connected to the circuit.

....

.... [1]

(iii) State and explain which cable (**X**, **Y** or **Z**) should the fuse be placed.

....

....

....[1]

8 A circuit is set up as shown in Fig. 8.1. The variable resistor XY varies between 0 Ω to 1.0 kΩ.

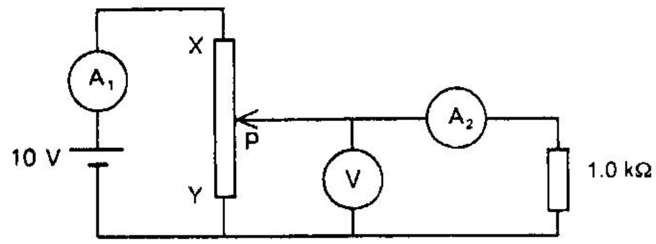

Fig. 8.1

State what happens to the readings of the three meters as P moves from Y to X. Give numerical values where possible.

Voltmeter: ....

....

Ammeter $\mathbf{A_1}$: ....

....

Ammeter $\mathbf{A_2}$: ....

....

[5]

For Examiner's Use

For Examiner's Use

For Examiner's Use

9 Fig. 9.1 shows a simple magnetic relay, together with three contacts X, Y and Z, used to control the operation of two lamps L1 and L2 and a motor of a fan, M.

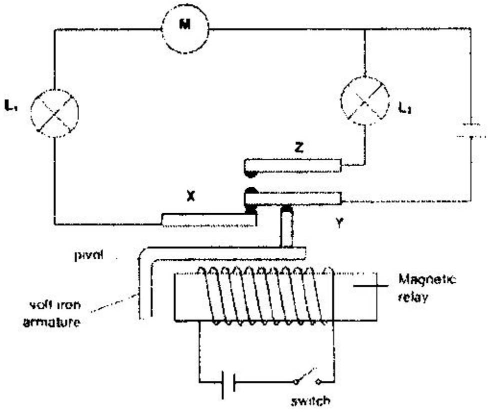

Fig. 9.1

(a) Suggest a suitable material for the magnetic relay. Explain why.

....

....

....[2]

(b) Describe and explain the changes that occur when the switch is closed.

....

....

....

....

....

....[3]

~ End of Section A ~

Section B

This section starts from Question 10.
Answer **all** the questions in this section.
Answer only one of the two alternative questions in **Question 12.**

10 Fig. 10.1 shows the properties of three metals X, Y and Z.

Metal	Density / gcm^{-3}	Specific heat capacity / $Jg^{-1} {}^{\circ}C^{-1}$	Melting point / °C
X	2.7	0.90	700
Y	1.8	0.15	1800
Z	8.0	0.40	1600

Fig. 10.1

Three cooking pots of the same shape are made from the same volume of 800 cm^3 of each of the metals X, Y and Z.

(a) Which pot is the heaviest? Show your working clearly in the space provided.

....

....[3]

(b) Each pot contains equal volume of water and is heated by a hot plate that supplies thermal energy at the same rate. State and explain which pot of water will be the first to boil.

....

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....

....

....[2]

For Examiner's Use

(c) After the water in each of the pots had boiled, the pots are removed from the hot plate and allowed to cool. Heat is lost from the pots at the same rate. After five minutes, state and explain which pot of water will be at the higher temperature.

....

....

....

....

....[2]

(d) State and explain the advantage of using metal **Y** over the other two metals.

....

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....

....

....[3]

11 Fig. 11.1 shows parts of a tall tower crane used on building sires. The trolley used to pick up loads can be moved along an iron jib of uniform density and a length of 80.0 m. The iron jib is pivoted at a point P, which is 20.0 m from one end. A concrete block A of weight 1.5×10^5 N helps to keep the iron jib horizontal at all times.

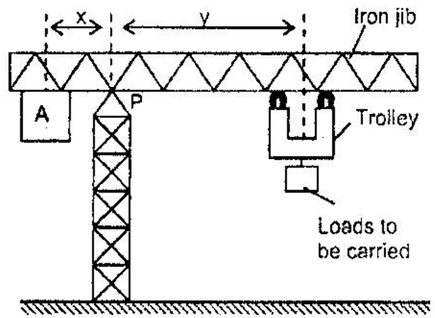

Fig. 11.1

For Examiner's Use

(a) (i) When the crane is used to lift a load of 4.0×10^4 N, the distance x and y must be kept at 6.0 m and 15.0 m respectively to ensure the iron jib does not topple. Keeping the distance x at 6.0 m, determine the load in which the crane can carry without toppling if the trolley is moved till y = 30.0 m.

load = ...[3]

(ii) With y kept at 30.0 m, if the trolley is to lift a load heavier than the value calculated in (i), suggest and explain what changes must be made to the parts of the crane.

....

....

....[2]

For Examiner's Use

(b) The tower crane can be modified to carry a load of fixed mass and the distance y can be varied without causing the iron jib to topple. This is done by attaching a cable as shown in Fig. 11.2.

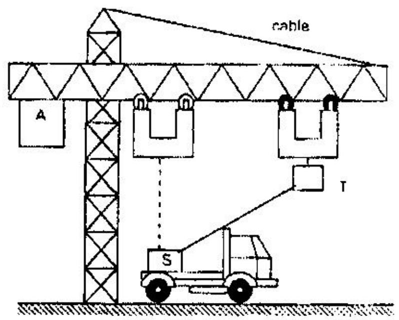

Fig. 11.2

The crane is used to lift a load of 1.5×10^5 N from a height of 1.0 m at S to a height of 25.0 m at T along the diagonal path ST in a time of 30.0 s.

(i) Calculate the gain in gravitational potential energy by the load as it lifted from S to T.

gain in gravitational potential energy = ...[1]

(ii) If the electrical energy is supplied to the crane at a rate of 5.3×10^5 W, calculate the efficiency of the crane motor.

efficiency = ...[2]

For Examiner's Use

(iii) At position T, the crane stops lifting the load. If the load is dropped from this height, calculate the speed of the load before it hits the ground.

For Examiner's Use

speed = ... [2]

12 EITHER

For Examiner's Use

(a) Describe an experiment to determine the speed of sound in air.
In your account
- list all the apparatus you would use,
- describe the procedure of the experiment with the aid of a diagram,
- state one way you would take to improve the accuracy of this experiment.

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[5]

(b) Fig.12.1 shows an experiment carried out by Naomi to measure the wind speed.

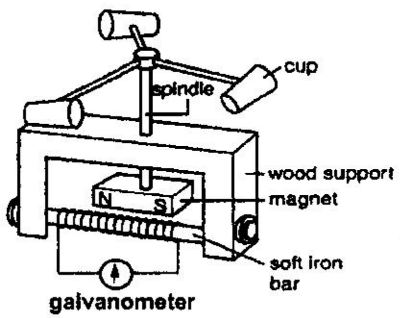

Fig. 12.1

(i) Explain how the wind causes the galvanometer to give a reading.

....

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....

....

....[2]

(ii) Why does the galvanometer reading increase as the wind speed increases?

....

....

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....

....[2]

(iii) The design shown in Fig. 12.1 is not sensitive enough to measure smaller winds. Give two ways that Naomi can modify the design to make the gauge more sensitive.

....

....[1]

For Examiner's Use

12 OR

(a) Ultrasound may be used to measure the depth of the sea. Fig. 12.2 shows a pulse of ultrasound sent down to the sea bed and the reflected pulse returning to the ship.

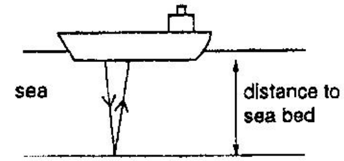

Fig. 12.2

(i) Describe what is meant by ultrasound.

....

....[1]

(ii) Fig. 12.3 is a cathode-ray oscilloscope (c.r.o.) trace of the pulses of ultrasound sent from the ship and the reflected pulses.

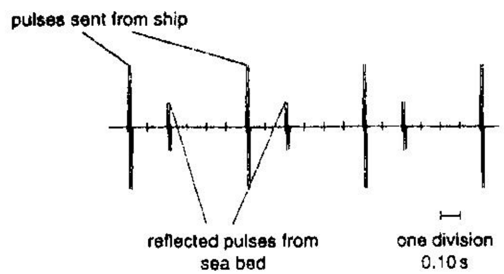

Fig. 12.3

The speed of ultrasound in water is 1500 m/s and the wavelength of the ultrasound wave is 0.030 m. The time-base setting for the x-axis on the c.r.o. is 0.10 s/division. Calculate the distance to the sea bed.

distance = ...[2]

For Examiner's Use

(iii) The ship moves to a place where the sea is deeper. State and explain two changes that would occur to the reflected pulses on the c.r.o. trace.

....

....

....

....

....

....[2]

For Examiner's Use

(b) Fig. 12.4 shows two insulated copper coils, P and Q mounted close together on a wooden rod. Coil P is connected to switch S and a battery. Coil Q is connected to a sensitive voltmeter V.

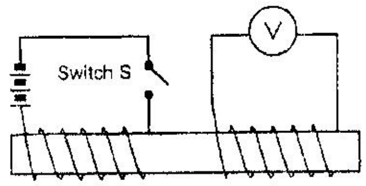

Fig. 12.4

When the switch S is closed, a deflection is seen on the voltmeter. This deflection lasts for a very short time.

(i) Explain whether the current flows through the meter from left to right or from right to left.

....

....

....

....

....

....[2]

For

(ii) Explain briefly how this effect is made use of in a transformer. Include in your answer a labelled diagram to illustrate the structure of a transformer.

Examiner's Use

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....

....[3]

~ End of Section B ~

Section A

Answer **all** the questions in this section.

1 Fig. 1.1 shows a 400 g ball falling freely from rest.

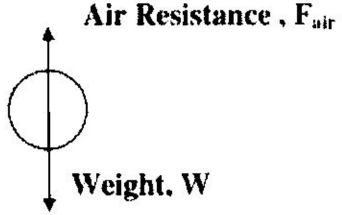
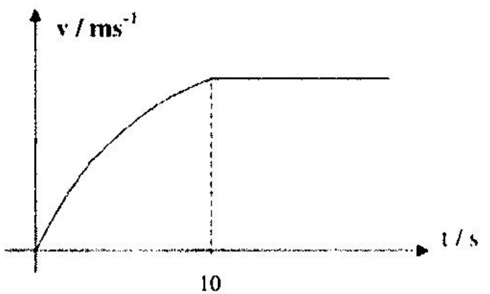


Fig. 1.1

(a) At a certain instant, the ball is accelerating downwards at 6.0 ms^{-2}. Calculate the air resistance acting on the ball. [2]

$F = ma$
$W - F_{air} = 0.400 \text{ kg} \times 6.0 \text{ms}^{-2}$
$F_{air} = (0.400 \times 10) - 2.4$
$F_{air} = 1.6 \text{ N}$

(b) The acceleration of the ball decreases while falling and eventually the ball reaches terminal velocity at t = 10 s. Sketch a velocity - time graph to show the motion of the ball. [2]



[1/2] label both axis
[1/2] dotted line and label t = 10s
[1/2] curve until t = 10 s
[1/2] horizontal straight line after t

(c) Explain, in terms of the forces acting, why the acceleration of the ball decreases and terminal velocity is reached. [2]

As the **velocity increases, upwards air resistance** (acting on the ball) **increases. Downwards resultant force acting on the ball decreases** as F = ma, therefore acceleration decreases as the ball is falling.
As acceleration decreases, upwards air resistance increases until **downwards weight is equal to upwards air resistance.** Therefore **resultant/ <u>net force acting on the ball is zero</u>** and F = ma, **<u>acceleration is zero</u>** so it moves with terminal velocity.

2 Fig 2.1 (*not drawn to scale*) shows the forces acting on an arrow by the string of a bow just before it is released.

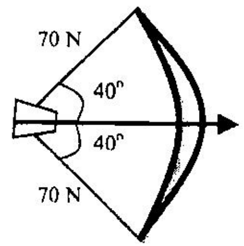
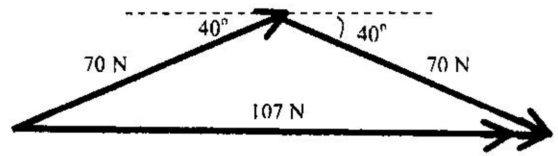


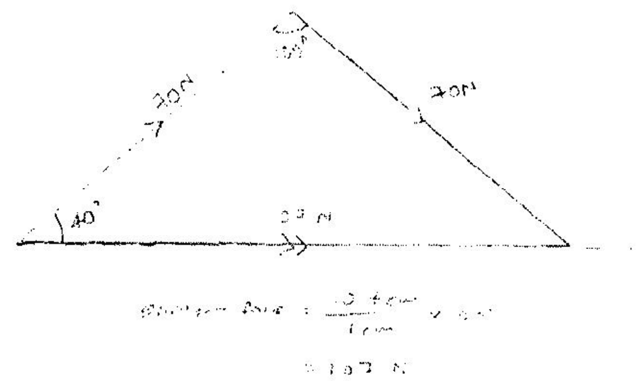
Fig. 2.1

Using a suitable labelled vector diagram, determine the magnitude and the direction of the resultant force exerted by the bowstring on the arrow. [3]



[1/2] appropriate scale: 1 cm rep10 N
[1/2] correct orientation
[1/2] correct diagram with labelled forces
[1/2] correct arrow direction, resultant force double arrows

Magnitude of the resultant force = 107 N (± 2 N) [1/2]
Direction of the resultant force = **horizontal to the right** or 40° to/from the 70 N force [½]



3 (a) Fig. 3.1 shows a piece of glass being lifted by a suction cup. Some air inside the suction cup is removed by a vacuum pump. The atmospheric pressure outside the cup prevents the glass from dropping. The area of the glass covered by the cup is 0.0025 m^2. The pressure inside the cup is reduced to 60 kPa. The atmospheric pressure is 100 kPa.

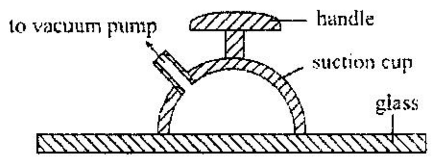


Fig. 3.1

(i) Calculate the maximum weight of a piece of glass that can be lifted with this cup. [1]

Pressure difference that prevents the glass from slipping = (100 – 60) kPa
= 40 kPa

P = F/A
F = 40 000 Pa × 0.0025 m^2
F = **100 N**

(ii) State one change that would allow the suction cup to lift a heavier piece of glass. [1]

Any one of the answers:

1) Suck out more air from inside of suction cup to increase the pressure difference.

2) Increase the surface area of the suction cup with the glass

(b) Fig. 3.2 shows a metal can with a tight fitting lid and the can is heated.

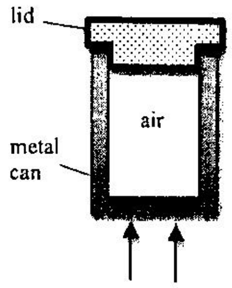


Fig. 3.2

(i) Explain, in terms of the motion of molecules, why the pressure in the metal can increases when the can is heated. [2]

As the temperature increases, the **average kinetic energy of the air molecules increases and air molecules move faster**. The **rate / frequency of collision of the air molecules with the walls of can increases.** The air molecules also collide with the walls of the can with **greater average force. Pressure is force per unit area (P = F/A)**.This causes the pressure to increase.

(ii) If a little water is put in the bottom of the can before heating, explain how this would affect the pressure in the can when the temperature increases. [2]

There will be **greater increase in pressure** as there will be **more (air) molecules due the vaporisation of water in the metal can**. Therefore, **frequency of collisions per unit area of the walls will increase**.

4 (a) Fig. 4.1 shows a filament lamp standing upright in air. The connections to the lamp are not shown. When switched on, the filament lamp loses energy by conduction, convection and radiation.

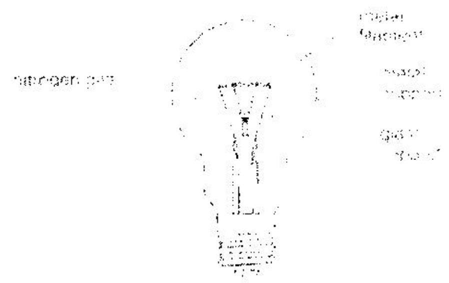


Fig. 4.1

Describe how energy is lost from the metal filament

(i) by conduction, [1]

Thermal energy is conducted down the **metal support** through the **glass support** and lost through the base of the filament lamp.

(ii) by convection. [2]

The metal filament **heated up the nitrogen gas near to the filament** and the gas expands, becomes less dense and rises. **(Minimal)**

The cooler gas being denser sinks. The **heated nitrogen gas transfers thermal energy to the surrounding air around the lamp by radiation or conduction.** The **air around the filament lamp is heated up expands, becomes less dense and rises.** The denser cooler surrounding air sinks. **Difference in densities set up convection current in the nitrogen gas inside the glass bulb and the air around the filament lamp** causing thermal energy to be lost to the surroundings.

(b) Fig. 4.2 shows an electric bulb painted matt black on one half and silver on the other.

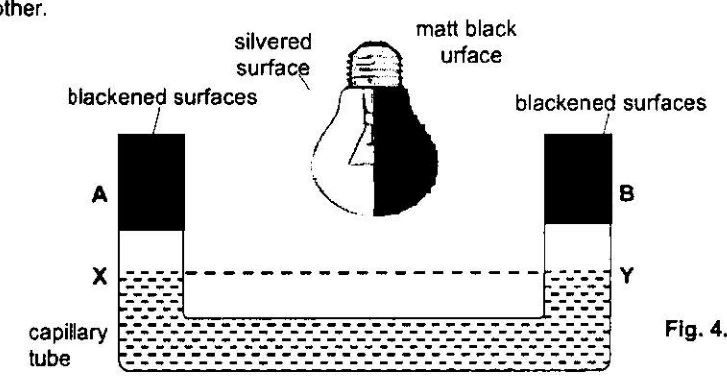


Fig. 4.2

(i) State which method(s) of heat transfer is/are involved in this setup. [1]

Radiation

(ii) A capillary tube containing water up to level **XY** is covered with blackened test tubes, **A** and **B**. The bulb is then switched on. Describe and explain what happens to the water level in the capillary tube. [2]

Black is a **good/better emitter of radiant heat** so rate of emission from the black surface of the bulb is greater.
Black is also a **good / better absorber of radiant heat**. Thus, the **rate of heat absorption** in blackened **test tube B will be greater** than A.
When heated, the **(air molecules in B will move faster)** and the pressure exerted **on water surface at Y will be greater**.
Thus, **X will have a higher water level than Y**.

5 (a) A ray of light is incident on a right-angled prism of refractive index 1.5 as shown in Fig. 5.1.

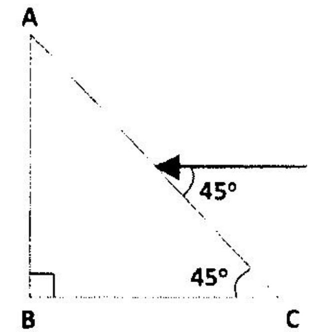


Fig. 5.1

(i) Calculate the angle of refraction of the ray. [1]

Let r be the angle of refraction,

$$n = \frac{\sin i}{\sin r}$$

$$1.5 = \frac{\sin 45^\circ}{\sin r}$$

$$r = 28^\circ$$

(ii) Explain whether this ray within the prism will undergo total internal reflection when it hits the face AB. Show all your workings clearly. [3]

Let c be the critical angle for the glass,

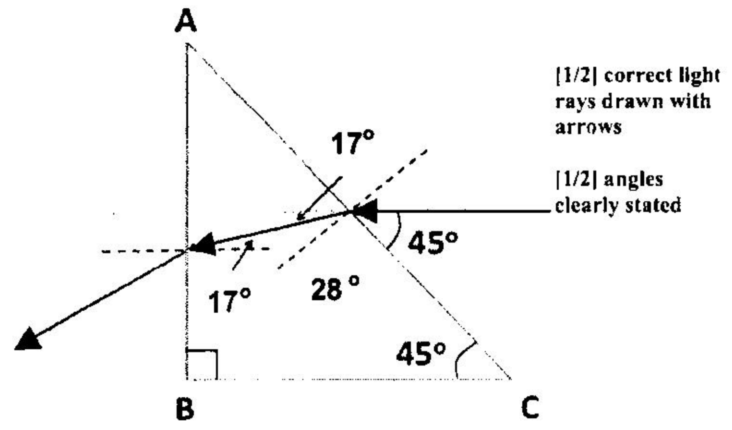
$$n = \frac{1}{\sin c}$$

$$1.5 = \frac{1}{\sin c}$$

$$c = 42^\circ$$

Using Geometry,
Angle of incidence of light ray at face AB, $i = 17^\circ$
The ray within the prism **will not undergo total internal reflection** since the **angle of incidence at face AB [1/2] is smaller than the critical angle**.

(iii) Hence, complete the light ray in the Fig. 5.1 to show how light travels when it strikes on the face AC. [1]



(b) A parallel beam of light making an angle of 30° with the principal axis is incident on the lens as shown in the Fig. 5.2.

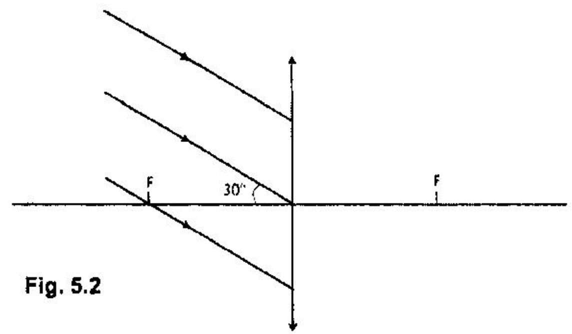
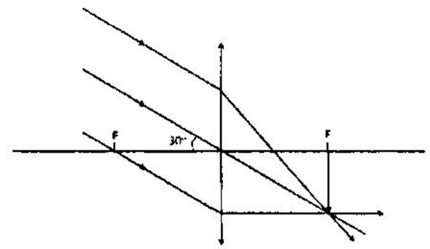


Fig. 5.2

(i) If the rays shown in Fig. 5.2 are from the top of a distant tree, complete the ray diagram to locate the image of the tree. [2]



½ mark for each correct ray drawn and ½ for the image drawn.

(ii) Describe the characteristics of the tree image. [1]

The tree image is real, inverted and diminished.

[1 marks for all 3 correct characteristics; 0.5 marks for 2; 0 mark for 1 and 0 for none.]

6 Fig 6.1 shows a series of wavefronts of a water wave travelling through regions P and Q.

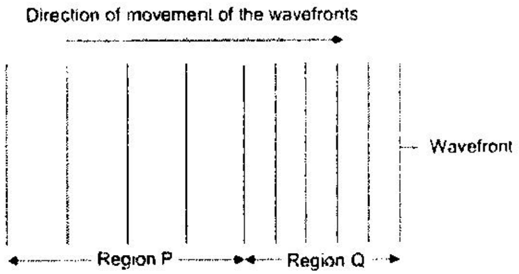


Fig. 6.1

(a) State and explain which region is deeper. [2]

Region P is deeper. It is because the **wavelength of P is longer than Q**, so **speed of the water wave is greater in region P** while **frequency of the wave remains unchanged**.

(b) The distance between two successive wavefronts in region Q is 2.0 cm and each wavefront takes 4.0 s to travel through region Q.

(i) Determine the speed of the water wave in region Q. [2]

Distance of region Q = 5 x 2.0 cm

= 10 cm

Distance = speed x time

Speed = 10 cm / 4.0 s

= 2.5 cm/s

(ii) Hence, determine the frequency of the wave. [1]

$v = f\lambda$

f = 0.025 ms^{-1} / 0.020 m [1/2] with formula (accept if units in cm/s & cm)

= 1.25 Hz

7 (a) Three uncharged metal spheres **A**, **B** and **C** mounted on insulating supports are positioned so that they touch. A rod carrying positive charge is brought near to them as shown in Fig. 7.1.

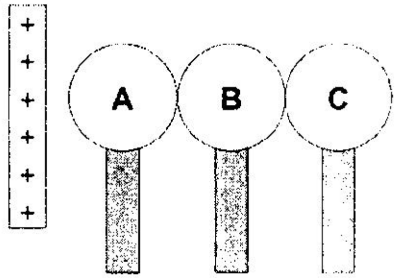
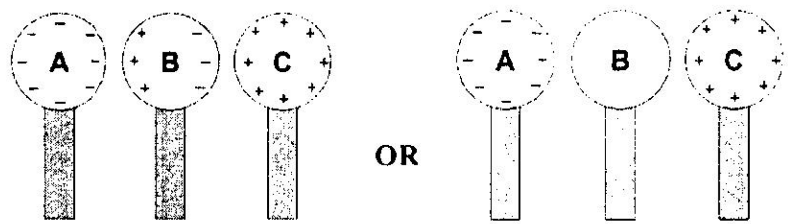


Fig. 7.1

The spheres are now moved slightly apart with the insulating supports and the charged rod is then removed.

(i) On Fig. 7.1, show the resulting charges on the spheres. [2]



[1] for showing the negative charges in sphere **A**

[1] for showing the positive charges in sphere **C**.

(ii) Sphere **A** is moved until it touches sphere **C**. State the movement of the charges that occurs when they touch. [1]

The negative charges in sphere **A** flows into sphere **C**.

(b) Fig. 7.2 shows an electric motor which is rated 200 V, 900 W.

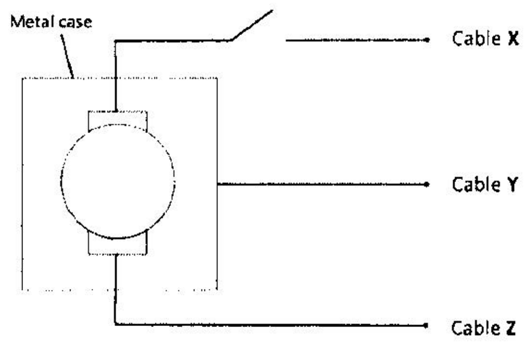


Fig. 7.2

(i) Calculate the current drawn by the motor when it is connected correctly. [1]

$I = P / V$

$= 900 / 200$

$= 4.5$ A

(ii) Suggest a suitable rating for the fuse to be connected to the circuit. [1]

5 A (accept 6 A or 7 A) or

Any value slightly greater than the answer in part (a) [e.c.f]

(iii) State and explain which cable (**X**, **Y** or **Z**) should the fuse be placed. [1]

The fuse should be placed along cable **X** as cable **X** is the live wire where switch is placed on the **live wire to disconnect the appliance from high voltage source**.

8 A circuit is set up as shown in Fig. 8.1. The variable resistor XY varies between 0 Ω to 1.0 kΩ.

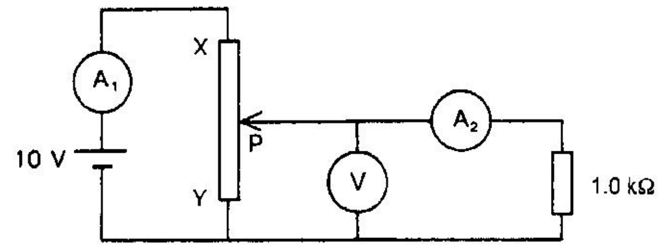


Fig. 8.1

State what happens to the readings of the three meters as P moves from Y to X. Give numerical values where possible. [5]

Voltmeter: The voltmeter reading will **increase** from **0 V to 10 V**.

Ammeter A_1: The ammeter reading will **increase** from **0.01 A** to **0.02 A**.

Ammeter A_2: The ammeter reading will **increase** from **0 A** to **0.01 A**.

9 Fig. 9.1 shows a simple magnetic relay, together with three contacts X, Y and Z, used to control the operation of two lamps L_1 and L_2 and a motor of a fan, M.

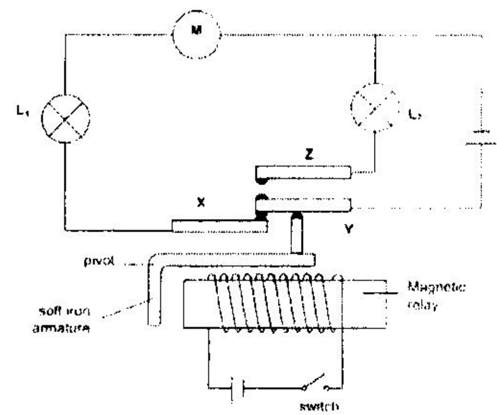


Fig. 9.1

(a) Suggest a suitable material for the magnetic relay. Explain why. [2]

(Soft) Iron.

Iron is a **soft magnetic material** which is **magnetised easily**, but it also **loses its magnetism easily**.

(b) Describe and explain the changes that occur when the switch is closed. [3]

When the switch is closed, **current flows through the solenoid** and magnetic field is produced at the solenoid. **Magnetic relay becomes magnetised / an electromagnet** and **attracts the soft iron armature** pushing the **contact Y upwards to be in contact with Z**. Therefore, **L_2 lights up** but **L_1 and motor of a fan are switched off.**

Section B

Answer **all** the questions in this section.
Answer only one of the two alternative questions in **Question 12.**

10 Fig. 10.1 shows the properties of three metals X, Y and Z.

Metal	Density / gcm^{-3}	Specific heat capacity / $Jg^{-1}{}^{\circ}C^{-1}$	Melting point / °C
X	2.7	0.90	700
Y	1.8	0.15	1800
Z	8.0	0.40	1600

Fig. 10.1

Three cooking pots of the same shape are made from the same volume of 800 cm^3 of each of the metals X, Y and Z.

(a) Which pot is the heaviest? Show your working clearly in the space provided. [3]

Mass = Density × Volume
Mass for metal X = (2.7 × 800) g = 2160 g
Mass for metal Y = (1.8 × 800) g = 1440 g
Mass for metal Z = (8.0 × 800) g = 6400 g

Pot made of metal Z is the heaviest because the mass of metal Z is the largest.

(b) Each pot contains equal volume of water and is heated by a hot plate that supplies thermal energy at the same rate. State and explain which pot of water will be the first to boil. [2]

Water in pot Y will be the first to boil because the **heat capacity of metal Y (216 $J^{\circ}C^{-1}$) is the lowest** which means that the **amount of thermal energy required to raise the temperature of metal Y by 1 °C is the smallest as compared to metal X (1944 $J^{\circ}C^{-1}$) and Z (2560 $J^{\circ}C^{-1}$)** and with the same amount of thermal energy supplied by the hot plate, water in the pot Y will be heated up faster.

(c) After the water in each of the pots had boiled, the pots are removed from the hot plate and allowed to cool. Heat is lost from the pots at the same rate. After five minutes, state and explain which pot of water will be at the higher temperature. [2]

Water in pot X will be the at the higher temperature as compared to water in pot Y because it has the **higher heat capacity (1944 $J^{\circ}C^{-1}$ > 216 $J^{\circ}C^{-1}$)** so **more thermal energy will be needed for the temperature of metal X to drop 1 °C.**

Another acceptable answer (OR)

Water in pot Z will be the at the highest temperature because it has the **highest heat capacity** (2560 $J^{\circ}C^{-1}$ > 1944 $J^{\circ}C^{-1}$ & 216 $J^{\circ}C^{-1}$) so the **thermal energy needed for the temperature of metal Z to drop 1 °C is the highest.**

(d) State and explain the advantage of using metal **Y** over the other two metals. [3]

Metal Y is the **lightest** as its **mass (1440 g) is the smallest** among the metals. Metal has the **lowest specific heat capacity**, which required the **least amount of thermal energy to raise the temperature of 1 g by 1°C**. It has also the **highest melting point** among the metals.

11 Fig. 11.1 shows parts of a tall tower crane used on building sires. The trolley used to pick up loads can be moved along an iron jib of uniform density and a length of 80.0 m. The iron jib is pivoted at a point P, which is 20.0 m from one end. A concrete block A of weight 1.5×10^5 N helps to keep the iron jib horizontal at all times.

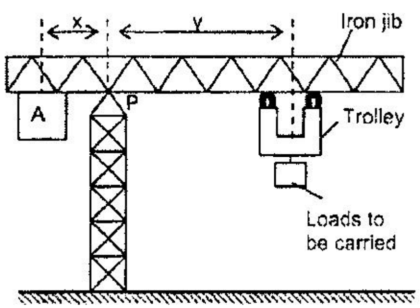


Fig. 11.1

(a) (i) When the crane is used to lift a load of 4.0×10^4 N, the distance x and y must be kept at 6.0 m and 15.0 m respectively to ensure the iron jib does not topple. Keeping the distance x at 6.0 m, determine the load in which the crane can carry without toppling if the trolley is moved till y = 30.0 m. [3]

Let W be the weight of iron jib.

For body to be equilibrium, taking moment about pivot P,

Sum of clockwise moments = Sum of anticlockwise moments

$(4.0 \times 10^4 \text{ N})(15.0 \text{ m}) + (W \times 20.0 \text{ m}) = (1.5 \times 10^5 \text{ N})(6.0 \text{ m})$

W = 15 000 N

Let L be the new load the crane can carry.

For body to be equilibrium, taking moment about pivot P,

Sum of clockwise moments = Sum of anticlockwise moments

$L \times 30.0 \text{ m} + (15\,000 \text{ N} \times 20.0 \text{ m}) = (1.5 \times 10^5 \text{ N})(6.0 \text{ m})$

L = 20 000 N or 2.0×10^4 N

(ii) With y kept at 30.0 m, if the trolley is to lift a load heavier than the value calculated in (i), suggest and explain what changes must be made to the parts of the crane. [2]

Move the pivot nearer to the trolley / increase the distance x / use a heavier block A to increase the anticlockwise moment to balance the increased clockwise moment caused by the heavier load.

OR
Use a smaller mass of iron jib to **reduce the clockwise moments** to balance the **constant anticlockwise moment.**

(b) The tower crane can be modified to carry a load of fixed mass and the distance y can be varied without causing the iron jib to topple. This is done by attaching a cable as shown in Fig. 11.2.

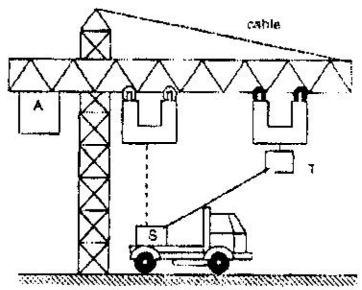


Fig. 11.2

The crane is used to lift a load of 1.5×10^5 N from a height of 1.0 m at S to a height of 25.0 m at T along the diagonal path ST in a time of 30.0 s.

(i) Calculate the gain in gravitational potential energy by the load as it lifted from S to T. [1]

Gain in G.P.E = mgh

$= 1.5 \times 10^5 \text{ N} \times 24.0 \text{ m}$

= 3 600 000 J or 3.6×10^6 J

(ii) If the electrical energy is supplied to the crane at a rate of 5.3×10^5 W, calculate the efficiency of the crane motor. [2]

Output power = E / t

= 3 600 000 J / 30.0 s

= 120 000 W or 1.2×10^5 W

Efficiency = (Output Power / Input Power) x 100%

$= (1.2 \times 10^5 \text{ W} / 5.3 \times 10^5 \text{ W}) \times 100\%$

= 22.6% or 23%

(iii) At position T, the crane stops lifting the load. If the load is dropped from this height, calculate the speed of the load before it hits the ground. [2]
By Principle of Conservation of Energy,

Loss in G.P.E. = Gain in K.E.

$mgh = \frac{1}{2} mv^2$

$v^2 = 2 \times 10 \text{ ms}^{-2} \times 25.0 \text{ m}$

$\mathbf{v = 22.4 \text{ ms}^{-1}}$ **or** $\mathbf{22 \text{ ms}^{-1}}$

12 EITHER

(a) Describe an experiment to determine the speed of sound in air.

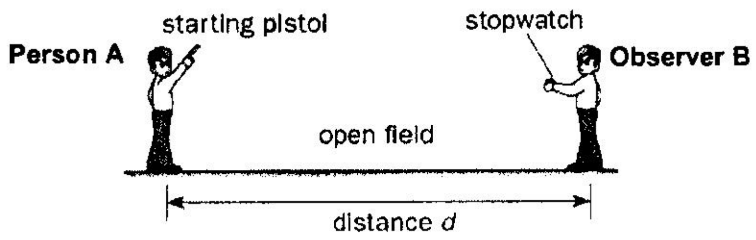
In your account

- list all the apparatus you would use,
- describe the procedure of the experiment with the aid of a diagram,
- state one way you would take to improve the accuracy of this experiment.

[5]

Apparatus: a pistol, a stopwatch, a measuring device such as measuring tape [1/2]

Diagram: [1/2] for drawing + [1/2] for labelling



Procedure:

The experiment is carried out with <u>two people are positioned at a known distance, d apart e.g. 1km in an open space</u>. When <u>person A holding the pistol fires the pistol</u>, observer B upon <u>seeing the smoke/flash from the pistol starts the stopwatch</u> and <u>stops timing on hearing the sound of the shot</u>. <u>The speed of the sound can be calculated using the distance, d divided by the time interval</u> **recorded on the stopwatch.**

Ways to reduce SOEs: (either one)

The experiment is repeated with person B firing and person A recording the time. An average time interval can then be calculated. This will reduce error due to the effect of wind.

The experiment can be repeated several / 2 or 3 times and an average timing is taken. This reduces the error due to human reaction time.

(b) Fig.12.1 shows an experiment carried out by Naomi to measure the wind speed.

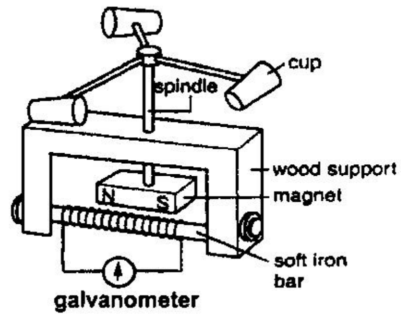


Fig. 12.1

(i) Explain how the wind causes the galvanometer to give a reading. [2]

The wind causes the plastic cups to turn. This causes the spindle and the <u>**magnet to rotate**</u>. The rotating magnet produces <u>**changing magnetic field linking the coil / solenoid**</u>. This <u>**causes an e.m.f. / current to be induced across the coil / solenoid**</u> and thus the galvanometer gives a reading.

(ii) Why does the galvanometer reading increase as the wind speed increases? [2]

As the <u>**wind speed increases, the magnet rotates faster.**</u> This <u>**increases the rate at which its magnetic field lines linking the coil / greater rate of change of magnetic field lines linking the coil**</u>. Thus the <u>**induced e.m.f. / current increases.**</u>

(iii) The design shown in Fig. 12.1 is not sensitive enough to measure smaller winds. Give two ways that Naomi can modify the design to make the gauge more sensitive. [1]

Any two of the following (:

- increase the number of turns of coil,
- use a stronger magnet,
- use larger cups,
- use more cups.
- use lighter cup

12 OR

(a) Ultrasound may be used to measure the depth of the sea. Fig. 12.2 shows a pulse of ultrasound sent down to the sea bed and the reflected pulse returning to the ship.

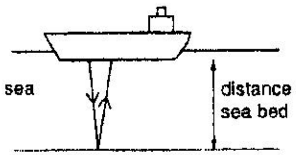


Fig. 12.2

(i) Describe what is meant by ultrasound. [1]

Ultrasound is **sound waves with frequency greater than 20 kHz**. It is beyond human audible range of hearing.

(ii) Fig. 12.3 is a cathode-ray oscilloscope (c.r.o.) trace of the pulses of ultrasound sent from the ship and the reflected pulses.

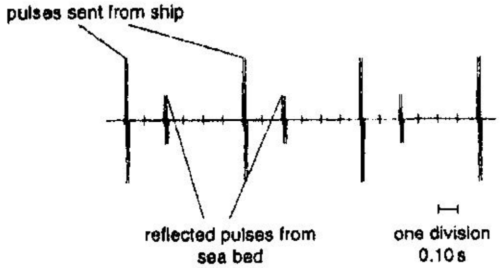


Fig. 12.3

The speed of ultrasound in water is 1500 m/s and the wavelength of the ultrasound wave is 0.030 m. The time-base setting for the x-axis on the c.r.o. is 0.10 s/division. Calculate the distance to the sea bed. [2]

Time for ultrasound pulse to reach sea bed = 0.10 s

Distance = speed × time

= 1500 m/s × 0.10 s

= 150 m

(iii) The ship moves to a place where the sea is deeper. State and explain two changes that would occur to the reflected pulses on the c.r.o. trace. [2]

With the same rate of transmission of the pulses sent from the ship, the number of cycles of waves displayed on the c.r.o. will be the same. **The horizontal separation between the transmitted pulse and the reflected pulse will be further in the c.r.o. as it will take a longer time for the reflected pulse to travel from sea bed to the ship.**

The **amplitude of the reflected pulses will be smaller as there is more energy loss** in a larger time interval. Some energy is absorbed by sea bed during reflection and surrounding water when sound waves propagate through the water.

(b) Fig. 12.4 shows two insulated copper coils, P and Q mounted close together on a wooden rod. Coil P is connected to switch S and a battery. Coil Q is connected to a sensitive voltmeter V.

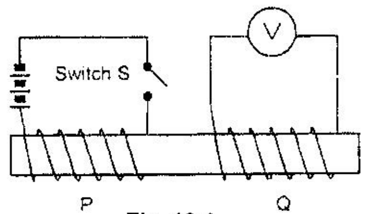


Fig. 12.4

When the switch S is closed, a deflection is seen on the voltmeter. This deflection lasts for a very short time.

(i) Explain whether the current flows through the meter from left to right or from right to left. [2]

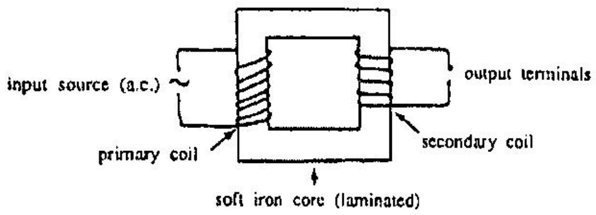
The **current flows through the meter from left to right**. According to **Lenz's Law of electromagnetic induction states that the direction of induced emf hence induced current is always such that its magnetic effect opposes the motion or change producing it**. Since the **current flows from the positive terminal and back to negative terminal of battery in coil P**, the **induced current flows in coil Q in the opposite direction** to oppose the increase in the magnetic flux linkage in coil P.

OR

The **current flows through the meter from left to right**. According to Lenz's **Law of electromagnetic induction states that the direction of induced emf hence induced current is always such that its magnetic effect opposes the change producing it**. Since **coil P magnetized with North pole facing coil Q**, it **induces North pole on the left of coil Q** and using right-hand grip rule, **an induced current flowing in the opposite direction** to oppose the change in the magnetic flux linkage in coil P.

(ii) Explain briefly how this effect is made use of in a transformer. Include in your answer a labelled diagram to illustrate the structure of a transformer. [3]

A transformer has a primary coil and a secondary coil wound around a soft iron core which is made of laminations of soft iron insulated from each other.



An alternating voltage has to be used in primary coil so that a **continuously / constantly changing magnetic field is produced in primary coil which is linked to the secondary coil through / via the soft iron core to induce an alternating e.m.f.**

[1] correct diagram with primary and secondary coils (both coils should have different no. of turns)
[1/2] for labelling

Paper 1

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
B	C	C	A	B	B	A	C	C	D	D	D	A	A	A	B	B	C	C	C
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
B	A	B	D	C	C	C	A	D	B	D	D	C	A	D	B	A	A	D	A