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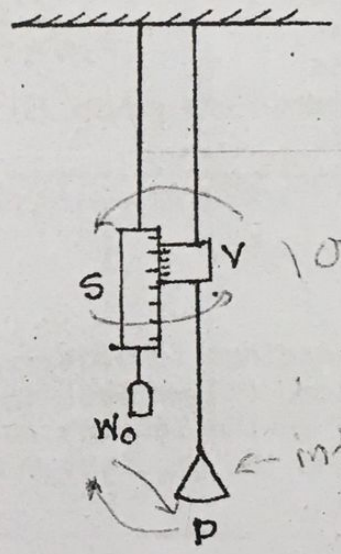
DEPARTMENT OF EXAMINATIONS , SRI LANKA

G.C.E. (A.L) Examination , August 1991

SCHEME OF ASSESSMENT FOR PHYSICS

PART A - Structured Essay

1. The apparatus used for determination of Young's modulus(Y) of a material in the form of a wire in a laboratory consists of two identical vertical wires of the on same material fastened to a rigid support. The wires carry a main scale(S) a vernier scale(V), a fixed load (W_o) and a scale pan(P).



(a) Draw a labelled diagram of this apparatus in the space provided.

A labelled diagram as shown 01

(b) What is the purpose of having two wires in this set-up

i. To minimize the error due to yielding of the support 01

ii. to minimize the error due to changes of ambient temperature

(c) In this experiment it is necessary to take readings while loading and unloading. Give reasons.

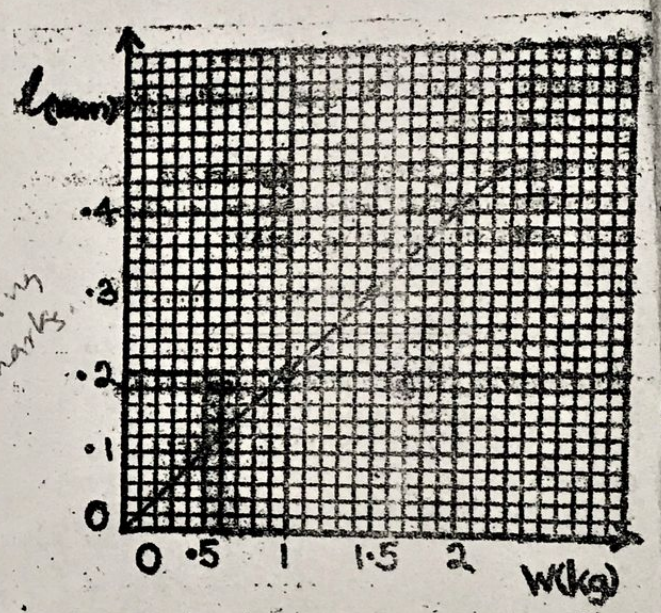
To reduce errors due to

i. Sliding of wires through the chuck
ii. Stretching of kinks in the wires during loading and
iii. to check whether the proportional limit (or elastic limit) has exceeded.

Any two reasons 01

(d) In such an experiment following measurements were taken by a student

load(Kg)	Average scale reading(cm) loading and unloading
1.0	1.236
1.5	1.246
2.0	1.256
2.5	1.266
3.0	1.276



reading no marks

Graph as shown above
Starting from ·1 ... 01

i. Use the above set of readings to plot a graph of effective load (W) vs the corresponding increase in the length of the wire(l), and find the gradient m.

$m = 2.0 \times 10^{-1}$ mm Kg^{-1}

or

$= 2.0 \times 10^{-2}$ cm Kg^{-1}

any answer with correct units

.....01

ii. What other additional measurements would you require to calculate Y for the material. State appropriate measuring instruments for the above measurements.

Measurement	Instrument
(a). Original length of the wire..α..(say)	Metre ruler.....01
(b). Diameter of the wire...β...(say)	Micrometre screw gauge 01

no marks for radius

iii. In measuring one of the quantities mentioned in (ii) above a particular procedure has to be followed in order to obtain an accurate value. State this procedure.

Measure the diameter of the cross section at different places along the wire and in each place at two perpendicular directions 01

this is enough.

only this no marks

iv. Write down an expression for the Young's modulus(Y) of the material used in this experiment in terms of the gradient(m) of the graph and the measurements and .

$Y = 4g\alpha/\pi\beta^2 m$.

g is not necessary

$= 4\alpha/\pi\beta^2 m$ 01

(Note: In d (ii) if the diameter is given the symbol α instead of β, then

$Y = 4g\beta/\pi\alpha^2 m$)

Cross section A for β can be used.

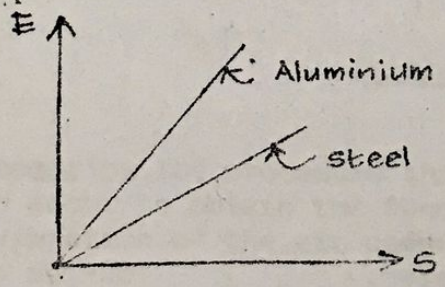
$\pi r^2 = \frac{l}{\pi r^2 m}$

r is radius

$= \frac{\alpha}{\pi\beta^2 m}$

v. Young's modulus of steel is approximately twice that of aluminium. Draw rough sketches of the stress(S) - Strain(E) curves for aluminium and steel on the diagram given.

Diagram 01



2. The method of mixtures is used in the laboratory to find the specific heat capacity of lead in the form of lead shots. One of the major items used in this experiment is the calorimeter.

(a) Make a list of other important apparatus used in this experiment.

Nicholson heater, (steam heater) or Steam generator complex — 01
Thermometer , Stirrer , Balance 01

any two other

(Diagram drawn in (e) also ✓ can give marks)

(b) State the processes by which the heat is lost in the calorimeter

no marks for Steam generator

1. Conduction
2. Convection
3. Radiation

.....01

(c) Outline briefly the methods adopted to minimize the heat loss from the calorimeter due to each of the above processes.

1. Place the calorimeter on an insulating support.
2. Close the calorimeter with a lid and place it in a large vessel, containing insulating material
3. Polish the outersurface of the calorimeter

Any two 02

(d) What is the main reason to select a fixed temperature such as the boiling point of water as the initial temperature of lead shots?

To ensure that all the lead - shots attain a constant (uniform) temperature .

or

To obtain an accurate value for the initial temperature of lead shots.

Any one reason 01

(e) State precautions that you would take when tranferring lead shots to the calorimeter.

Bring the calorimeter close to the outlet of the steam heater and transfer the lead shots carefully so that water will not splash 01

(f) In what way does the use of large pieces of lead instead of lead shots affe.ct the value of the final temperature of the mixture? Explain your answer.

Final temperature will be slightly less. 01

Compared to lead shots large pieces of lead

heat loss will be more.
OR 5 heat transfer will take longer time.

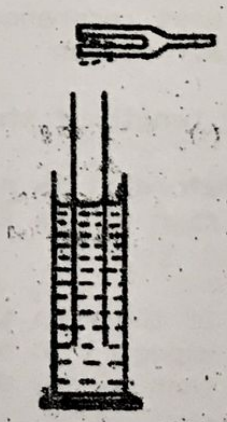
will take longer time to reach the equlibrium temperature and therfore heat loss to the surroundings will be more 01

(g) Cooling correction is important if the method of mixtures is used to determine the specific heat capacity of an insulating material such as rubber. Explain why?

Rubber being an insulator gives out heat slowly and takes long time to attain the final temperature of the mixture. As a consequence heat loss to the surroundings will be more , and therefore a cooling correction in necessary to find the correct temperature of the mixture 01

OR

3. An experimental set-up used in the laboratory to determine the speed of sound in air by resonating air columns is shown in the figure.



(a) Briefly describe the procedure that you would adopt to obtain the fundamental note of vibration of the air column with this set-up.

Starting with a very short length of the air column, move the tube up (or increase the length of the air column) until resonance (or a loud sound) occurs for the first time (or resonance occurs with the shortest length of the air column) minimum length .....01.

(b) If the corresponding length of the air column measured in (a) is l and the wavelength of sound waves in air is λ. Write down the relationship between l and λ. (Neglect

the end correction of the tube).

$l = \lambda/4$ 01

(c) i. Rewrite the expression in (b) in terms of l, speed of sound in air V, and the frequency n of the tuning fork.

$l = (V/4)(1/n)$ (or $V = 4nl$) 01

ii. If you are provided with several tuning forks of known frequencies and asked to determine V by plotting a graph state the quantities that you would plot

Independent variable = (1/n) } n
Dependdent variable = l } 1/l 01

(d) With a certain tuning fork the value of l was observed to be 35 cm. If the length of the tube is 75cm, explain whether it is possible to find another position of the tube in water where resonance is produced with the same tuning fork.

Next resonance length of the air column = 3 x 35 = 105 cm (or $3\lambda/4$) 01

(Length of the tube is $<$ 105 cm)

Therefore it is <u>not possible</u> to find another position of the tube this alone no mark. 01

(e) If the room temperature is increased, would you expect l to be greater than, equal to or less than 35 cm? Give reasons for your answer

l should be greater (than 35 cm) ✓ 01

Since V <u>increases</u> with temperature or $v \propto \sqrt{T}$ .....01.

(f) If alcohol is used instead of water in this experiment, would you expect the same value for V as measured in (c) (ii).? Explain the answer.

No → no marks.

Alcohol vapourises easily, therefore the <u>composition (density)</u> of the air column <u>will be different</u> 01

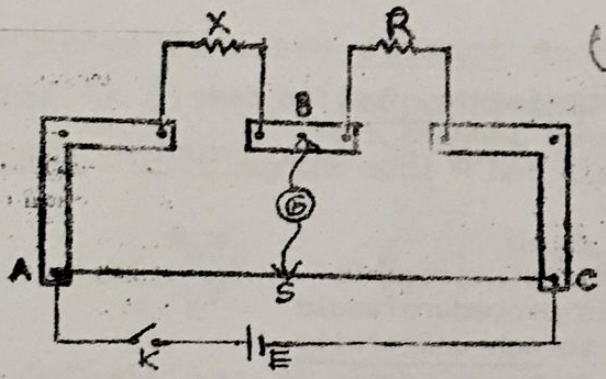
the reason is correct award marks | Q. 4. (a) 02 or 0. (with correct symbols) without key 01

(Award this mark for the ~~right~~ answer with the correct reason)

(g) For accurate calculations an end correction has to be introduced only to the open end of the tube and not to the closed end. Explain why?

At the open end of the tube, volume (air) elements outside the tube are free to move, therefore the exact displacement antinode does not occur at the end, however the displacement of volume elements at a closed end must always be zero. Therefore a closed end is a exact displacement node 01

4. The diagram shows a slide-wire metre bridge. You are provided with a resistance box R, a coil of unknown resistance X, a slider S, sensitive galvanometer G, a cell E, a key K, and some connecting wires



letters are not necessary

(a) Draw, on the given diagram, the circuit you would use to determine the resistance X using the apparatus provided.

Diagram 02

(b) After connecting the circuit with a suitable value in R, and while attempting to find the balance point it is observed that the galvanometer deflections are always in the same direction. What may be the cause for this?

An open circut or loose connection 01

(c)(i) For accurate determination of the unknown resistance what value in R is more suitable?

Value of R must be nearly equal to the

unknown resistance. or
the value must be adjusted so that the balance point is near the middle of the wire 01

(ii) Give the reason for your answer.

The resistances of the ends (and/or) metal strips ~~or~~ end correction. will be negligible compared to the resistances of balance lengths 01

or Otherwise (percentage) error of the length measurment is ~~the~~ more.

(d) In this type of experiment, while finding the balance point it is not advisable to slide s over the wire or press hard on the wire. Give the main reason for this.

To avoid local changes in diameter of the wire 01

(e) In all metre bridge experiments, for the same values of X and R two balance lengths are usually obtained by having X and R interchanged in positions. Explain why?

(The values are calculated and average is taken as the answer). This procedure would eliminate any errors due to non uniformity of the bridge wire. 01

(f) In these experiments, it is advisable to use an additional resistance box R' with the galvanometer. State the purpose of R'

To avoid large current flowing through the galvanometer before the balance point, is reached. 01

(g) For measuring or comparing low resistances which which are less than 1Ω, a potentiometer is more suitable than a metre bridge. Explain why.

If resistances are very low, the resistances of the connecting wires (and) the strips becomes comparable to the measuring resistances. 01

In potentiometer method, no current flows through the connecting wires, Where as in metre bridge method it is not so. 01

PHYSICS II

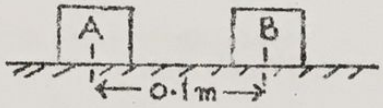
PART B — Essay

Answer four *questions only.*

($g = 10$ N kg^{-1})

1. *Answer* either *part* (a) *or part* (b).

(a) State Newton's law of universal gravitation.



Two identical blocks *A* and *B* of mass 100 kg each are placed on a light rough horizontal surface in a region where there are no other objects except the earth which exerts an attractive force on *A* and *B* in the vertically downward direction. The centres of gravity of the blocks are 0.1 m apart as shown in the figure and the coefficient of static friction of the horizontal surface is 0.1.

(i) Taking the universal gravitational constant (G) to be equal to 6.67×10^{-11} Nm^2 kg^{-2}, find the magnitude of the gravitational force acting on *B* due to *A*. Indicate the direction of this force on *B*.

(ii) Does the block *B* move towards *A* due to the gravitational force mentioned in (i) ? Explain your answer.

(iii) Is there a frictional force acting on *B* ? If so, what is its magnitude ?

(iv) Calculate the minimum mass that the block *A* should have in order to set the block *B* in motion.

Any two particles (masses) attract each other with a force which is directly proportional to their masses and inversely proportional to the square of their distance apart.

Or $F \propto \frac{m_1 m_2}{r^2}$ $\left(F = \frac{G m_1 m_2}{r^2} \right)$

with clear definitions of symbols used 02

(i) $F = G m_1 m_2 / r^2$

$= \frac{6.67 \times 10^{-11} \times 100 \times 100}{(0.1)^2}$ 01

$= 6.67 \times 10^{-5}$ N 02

(Deduct one mark for incorrect unit or no units.)

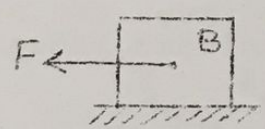


Diagram indicating the direction of F as shown

Or stating, the force on B acts towards A 01

(ii) NO

The magnitude of the force on B is not sufficient to overcome the limiting (maximum) frictional force acting on B

OR
stating $F < \mu R$ OR showing the inequality $F < \mu R$ by calculation. 02
(No marks for saying B does not move because of friction.)

(iii) Yes 01
It is equal to F (equals 6.67×10^{-5} N) 02

(iv) Let M be the required minimum mass of A.
Then the gravitational force acting on B due to A is just equal to the limiting frictional force.
limiting frictional force $= \mu R$ 01
but. $R = 100g$ 01
then, $\frac{GMx100}{(0.1)^2} = 0.1 \times 100 \times 10$ 01
$M = 1.5 \times 10^{3}$ kg 01

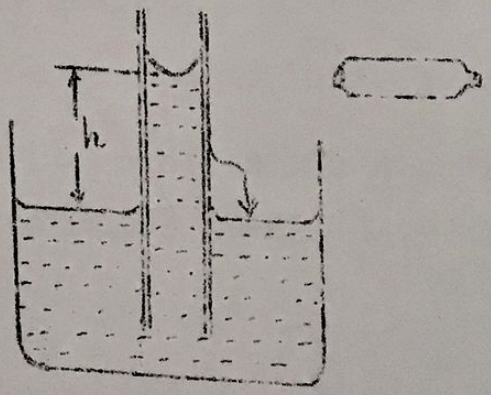
1 (b) Define surface tension. Describe briefly a laboratory method to determine the surface tension of water using capillary rise.

A glass tube of internal radius 12 mm, wall thickness 0.4 mm, and open at both ends, is suspended vertically from a sensitive spring balance. A beaker containing a liquid is now brought slowly so that the surface of the liquid just touches the lower end of the suspended glass tube. What happens to the reading of the balance? Explain your answer. The beaker of liquid is then raised until the original reading is seen again on the balance. If the depth of immersion of the tube is 3.67 cm, calculate the surface tension of the liquid assuming that the angle of contact of the liquid with glass is zero. Density of liquid is 1 000 kg m^{-3}.

Surface tension:
The force per unit length acting along the surface at right angles to one side of a line drawn in the surface 02

Experiment:

Diagram Experimental set up



Theory:

$$\frac{2T\cos\theta}{r} = h\rho g$$

$$\theta = 0$$

$$T = rh\rho g/2 \quad \text{.....01}$$

Method:

(i) Cleaning the tube
(Wash with NaoH, acid and distilled water) 01

(ii) Tip of the pin must be just touching the water surface. (or shown in a diagram) 01

(iii) Travelling microscope should be focussed first to the bottom of the meniscus and then to the tip of the pin, after removing beaker. Then the difference between the readings. 01

(iV) By weighing a thread of mercury and measuring its length l, obtain the radius of the tube
or
use a travelling microscope to measure the diameter of the tube directly. use the mercury thread Method ✓ 01

Due to the surface tension force (acting down words) the reading of the balance will increase reason 01

Surface Tension force acting on the bottom of the tube

$$F_1 = 2\pi rT + 2\pi(r+d)T \quad \text{.....02 (01+01)}$$

Upthrust on the tube

$$F_2 = \pi[(r+d)^2 - r^2]\, h\rho g \quad \text{.....02 or 0}$$

$$= \pi(d^2 + 2rd)\, h\rho g$$

When the reading of balance is equal to its original reading

$$F_1 = F_2 \quad \text{.....01}$$

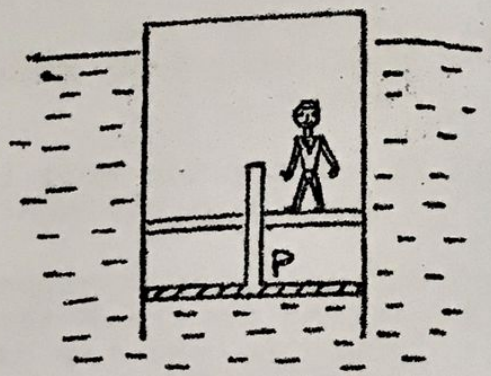
$$2\pi T(r + r + d) = \pi d(d + 2r)\, h\rho g$$

$$T = dh\rho g/2$$ correct substitution

$$T = 0.4 \times 10^{-3} \times 3.67 \times 10^{-2} \times 1000 \times 10/2 \quad \text{.....01}$$

$= 2 \times 3.67 \times 10^{-2}$

Surface Tension $= 7.34 \times 10^{-2}\ N\ m^{-1}$ 01



2. State Archimedes' Principle.

A large thin walled cylindrical vessel fitted with a mechanically operated pistion (*P*) at its open end as shown in the figure, is used to send a person to the sea bed to collect specimens. The water level inside the vessel can be adjusted by raising or lowering the piston. The air pressure inside the vessel is always maintained at the atmospheric pressure by means of an internal air pumping system.

(i) When the vessel is put into the sea the volume of air trapped inside the vessel is found to be 2 m^3 and the vessel is found to float with 1/10th of this air volume above the sea level as shown in the figure. Find the mass of the vessel and its contents.
(Density of water = 1 000 kg m^{-3})

(ii) If the area of cross section of the piston is 0.75 m^2, find at least by howmuch the water level inside the vessel be raised in order to make it sink.

(iii) When the specimens were stored in the vessel at the sea bed it was found that at least 0.05 m^3 of water had to be removed from the vessel to lift off. Calculate the mass of the specimens collected.

(iv) If the sea is 500 m deep how much minimum work has to be done on the piston in order to move the vessel up to the surface ? Neglect viscous effects.

Archimedes' Principle

When an object is immersed (partially or completely) in an (incompressible) fluid which is at rest, the upthrust acting on the object is equal to the weight of the fluid displaced by the object. 02

problem

(i) Let M be the mass of the vessel and its contents.

Then $(9/10) \times 2 \times 1000g = Mg$ 02

$M = 1800kg$ 01

(ii) Let h be the hight by which the water level be raised.

Then $h \times 0.75 = 2/10$

$h = 4/15$

$= 0.27\ m$ 02

(iii) Mass of the specimens $= 0.05 \times 1000$

$= 50kg$ 01

(iv) The excess pressure on the piston

$= 500 \times 1000 \times 10\ Nm^{-2}$

$= 5 \times 10^6\ Nm^{-2}$ 01

Therefore Force on the piston
$= 5\times10^6 \times 0.75$ N ——————— 01

The distance through which the piston has to be pushed in order to lift off
$= 0.05/0.75$ m 01

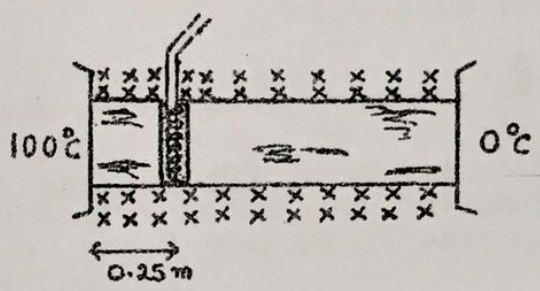
Therefore minimum work done on the piston 01
$= (0.05/0.75)5\times10^6 \times 0.75$ — — — —
$= 2.5\times10^5$ J

or $P\Delta V$

3. 'When an immersion heater is switched on' without inserting it in water it will burn out soon, but when it is in water it works normally". Explain this statement.

What will be the maximum temperature attained by the surface of the heater when it is used to boil water ?

One end of a uniform lagged steel bar, 1 m long and area of cross section 0.01 m² is kept at 100° C and the other end at 0°C as shown in the figure.



A thin slot is cut across the bar 0.25 m away from the 100° C end, and a 200 W flat electrical heating element is inserted into the slot as shown in the figure. The slot is then filled with mercury to ensure a good thermal contact between the heating element and the bar. When the heating element is switched on and the system has attained the steady condition calculate the surface temperature of the element. Assume that mercury is a perfect conductor of heat.

(Thermal conductivity of steel = 50 J m^{-1} s^{-1} K^{-1}.)

When an immersion heater is switched on without inserting it in water most of the heat produced by the heater will not flow out of the device and as a consequence the temperature of the heater will go up until it burns out. 01
.....01
However, when it is in water, the heat produced by the heater is taken away by the water and therefore there is no possibility of increasing the temperature of the device without limit. 01

Maximum temperature attained by the surface of the heater when it is used to boil water is 100°C (or the boiling point of water) 02

Problem

Let θ be the surface temperature of the heating element.

Rate of generation of the heat by the heating element = 200W

Applying $Q/t = KA(\theta_1 - \theta_2)/l$ to the rod 01

rate of flow of heat towards the 100°C end

$= \underbrace{50\times0.01}_{KA}\times(\theta - 100)/0.25$ 02

Rate of flow of heat towards the 0°C end

$= \underbrace{50\times0.01}_{KA}\times(\theta - 0)/0.75$ 02

At the steady state

$200 = 50\times0.01\times(\theta - 100)/0.25 + 50\times0.01\times\theta/0.75$ 03

(01 for the addition of two terms at RHS
02 for equating LHS and RHS)

$$200 = \frac{0.5\,(3\theta - 300 + \theta)}{0.75}$$

$4\theta = 600$

$\theta = 150\,^{\circ}C$ 02

[If θ is assumed to be less than 100 °C the rate of flow of heat towards the slot

$$= 50 \times 0.01 \times \frac{(100 - \theta)}{0.25}$$ 02

Rate of flow heat away from the slot(i.e. towards the 0°C end)

$$= 50 \times 0.01 \times \frac{(\theta - 0)}{0.75}$$ 02

At the steady state

$$50 \times 0.01 \times \frac{(100 - \theta)}{0.25} + \frac{200}{} = 50 \times \frac{0.01 \times \theta}{0.75}$$ 03

(One mark for addition of two terms at LHS
Two marks for equating LHS and RHS)

$$200 = \frac{0.5\,(3\theta - 300 + \theta)}{0.75}$$

$\theta = 150\,^{\circ}C$] 02

4. Describe briefly the wet-and-dry bulb hygrometer and discuss how you would use it to find relative humidity of the atmosphere. State precautions, if any, that have to be taken in order to obtain an accurate value for the relative humidity.

On a day when the relative humidity of the atmosphere is 80% a certain room of capacity 48 m^3 was isolated from the rest of the atmosphere and its relative humidity was reduced to 50% by means of a machine which absorbs water vapour from air without changing its temperature. Once the room had attained the 50% humidity level it was found that the machine had collected 430 g of water from the air inside the room. Use the above data and the table given below to calculate

(i) the dew point of the room to the nearest degree.

(ii) absolute humidity of the atmosphere outside the room.

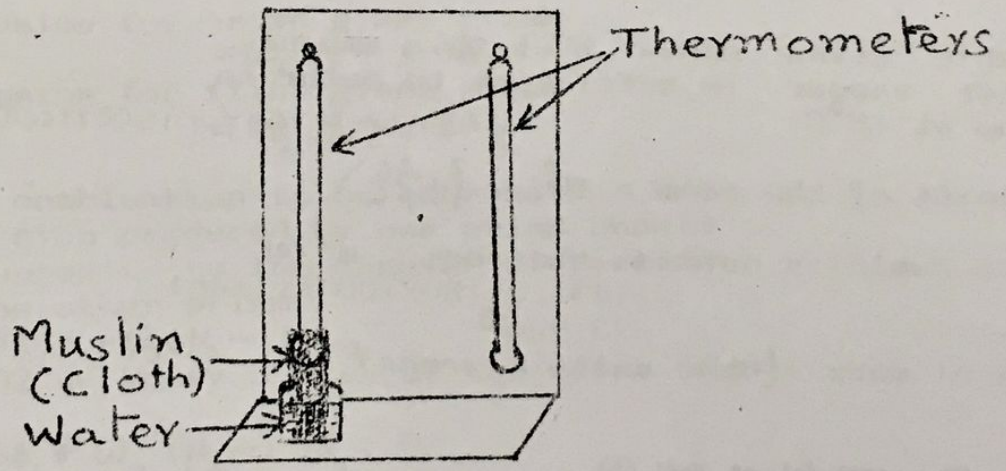
Temperature °C	Mass (g) of water vapour required to saturate 1 m^3 of air
24	21.54
22	19.22
20	17.42
18	15.22
16	13.50

Temperature °C	Mass (g) of water vapour required to saturate 1 m^3 of air
14	11.96
12	10.57
10	9.33
08	8.21
06	7.22

Hygrometer

Wet and dry bulb ~~thermometer~~ consists of two thermometers placed side by side the bulb of one being surrounded by muslin, kept moist by means of a peice of cotton wick dipping into a small vessel of water. 01

(or labled diagram) 01 02



The wet bulb thermometer indicates a lower temperature due to the evaporation of water.

The relative humidity is obtained by first noting the dry bulb temperature and the wet bulb dipression and then referring to tables. 02

(any two) (01+01)

An accurate value for the relative humidity can be obtained by keeping the thermometer in a stream of air. (or by rotating the thermometer) 01

(i) Let m' be the mass of water vapour present in the room when the relative humidity is 80% and m_o be the mass required to saturate the room at the same temperature.
Then $m'/m_o = 80/100$ 01

If m'' is the mass of water vapour left in the room when its relative humidity is reduced to 50%
Then $m''/m_o = 50/100$ 01

Therefore $(m'-m'')/m_o = 30/100$

But $m'-m'' = 430g$ 01

Therefore $430/m_o = 30/100$
$m_o = 1433.3g$

The mass of water vapour present in the room, $m'' = (50/100)m_o$
$= (50/100) \times 1433.3$
$= 716.65g$ 01

∴ Mass of water vapour present in $1m^3$ of room
$= 716.65/48$ 01
$= 14.9g$ 01

The table given shows that this amount of water vapour is sufficient to saturate the room at 18°C.

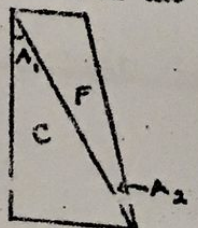
Only if 14.9 g is correct.

Dew point of the room = 18°C (17°C) 01

(ii) Absolute humidity outside the room = $m''/48$
$= 1433.3 \times (80/100) \times (1/48)$ 01
$= 23.9gm^{-3}$
(Reduce 01 mark if the unit is wrong) 02

5. *Answer* either *part* (a) *or part* (b).

(a) What do you mean by dispersion of light ?
Define the dispersive power of a prism. Write down an expression for the deviation of a monochromatic ray of light refracted through a small angled prism.
Two small angled prisms, made of crown (C) and flint (F) glasses of dispersive powers ω_1 and ω_2 respectively, for the yellow colour, are placed as shown in the figure.



If the prism combination is achromatic, show that,
$$\omega_1 (\mu_1 - 1) A_1 + \omega_2 (\mu_2 - 1) A_2 = 0$$
where μ_1 and μ_2 are the refractive indicies of crown glass and flint glass respectively, for yellow light, and A_1 and A_2 are the respective refracting angles of the prisms.

A flint glass prism is to be combined with a crown glass prism of refracting angle 10° so that the combination is achromatic between the red and blue light. What should be the angle of the flint glass prism.

Refractive index of flint glass for blue light = 1.6691
Refractive index of flint glass for red light = 1.6501
Refractive index of crown glass for blue light = 1.5232
Refractive index of crown glass for red light = 1.5146

Variation of refractive index of transparent materials with colour is known as the dispersion of light.

OR separation of white light into colours due to refraction is known as the dispersion of light. 02

The ratio,
angular dispersion between blue and red rays

Deviation of yellow ray (mean deviation)

is defined as the Dispersive power.

OR [dispersive power = $\frac{\delta_b - \delta_r}{\delta_y}$

where δ_b, δ_r and δ_y are the deviations for blue, red and yellow colours. .....02]

$d = (\mu - 1)A$ 01

deviation for blue light = $\delta_b = (\mu_b - 1)A$

deviation for red light = $\delta_r = (\mu_r - 1)A$

angular dispersion =

$$\delta_b - \delta_r = (\mu_b - 1)A - (\mu_r - 1)A$$

$$= (\mu_b - \mu_r)A \quad \text{- - - -

$$\frac{(\mu_b - \mu_r)A_1(\mu_1 - 1)}{(\mu_1 - 1)} = \frac{-(\mu_b' - \mu_r')A_2(\mu_2 - 1)}{(\mu_2 - 1)} \quad \text{.....02}$$

$$\omega_1(\mu_1 - 1)A_1 = -\omega_2(\mu_2 - 1)A_2$$

where the symbols have their usual meaning, and dash symbols stand for flint glass.
(Here also do not emphasise on the minus sign)

$$\frac{(\mu_b - \mu_r)(\mu_1 - 1)A_1}{(\mu_1 - 1)} + \frac{(\mu_b' - \mu_r')(\mu_2 - 1)A_2}{(\mu_2 - 1)} = 0$$

$$(1.5232 - 1.5146)10^0 + (1.6691 - 1.6501)A_2 = 0 \quad \text{.....02}$$

$$A = -4^0 32' \quad \text{.....02}$$

(when awarding marks disregard the minus sign)

or

$$(1.5232 - 1.5146)10^0 = (1.6891 - 1.6501)A_2 \quad \text{.....02}$$

$$A_2 = 4^0 32' \quad \text{.....02}$$

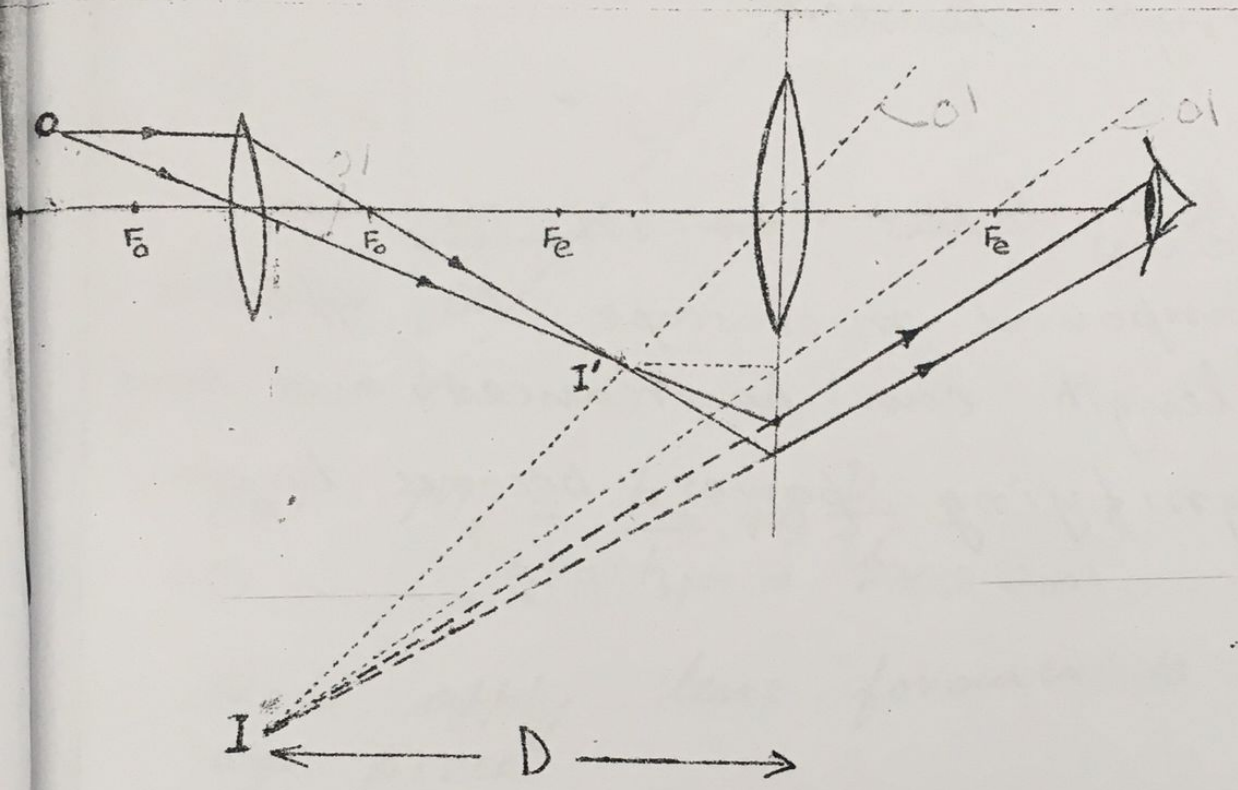
The negative sign indicates that the prisms should be placed in opposite directions to each other.

5 (b) A compound microscope in normal adjustment is used to view a point object situated off the axis. Draw the paths of two light rays from the object to the eye through the microscope.

Define the magnifying power of a microscope and explain why a compound microscope is usually employed rather than a single lens, when a large magnifying power is required.

The desired overall magnifying power of a compound microscope is 140. The objective itself has a magnifying power of 12. Find the required focal length of the eye piece assuming that the final image will be formed 25 cm from the eye. Derive any formula you may use.

In a certain experiment it is necessary to place a cross-wire in the compound microscope. Show on a diagram where this would be located. Assume that the final image is formed at infinity in this case.



Two rays from O to the ~~eye piece~~ I' ---01

Location of the final image I (both rays) ---02 01

Two rays ~~from~~ through eye piece ~~to the eye~~ ---01

Correct position of the eye ---01

Magnifying power $M = \frac{\beta}{\alpha}$

$M = \frac{\text{Angle subtended at the eye by the image}}{\text{Angle subtended at the eye by the object at the near point}}$ ---02

To obtain a large magnifying power a lens with a short focal length should be used. However, there is a practical limit for making short focal length lenses.

----- ⊙1

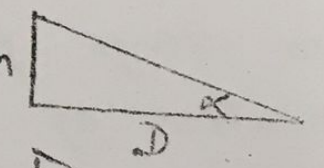
Using two lenses as in the case of a compound microscope the effective focal length can be reduced and hence the magnifying power becomes larger.

----- ⊙1

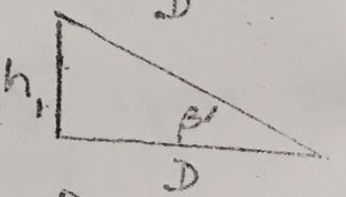
Problem:

Magnifying power of the compound microscope

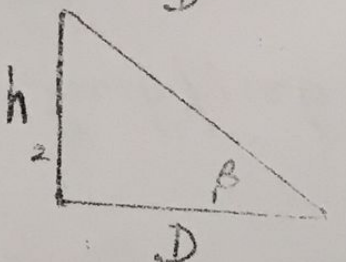
$$M_{c.m.} = \frac{\beta}{\alpha} \simeq \frac{\tan\beta}{\tan\alpha}$$



$$M_{c.m.} = \frac{\tan\beta}{\tan\alpha} = \frac{h_2/D}{h/D} = \frac{\frac{h_2}{D}}{\frac{h_1}{D}} \times \frac{\frac{h_1}{D}}{\frac{h}{D}}$$



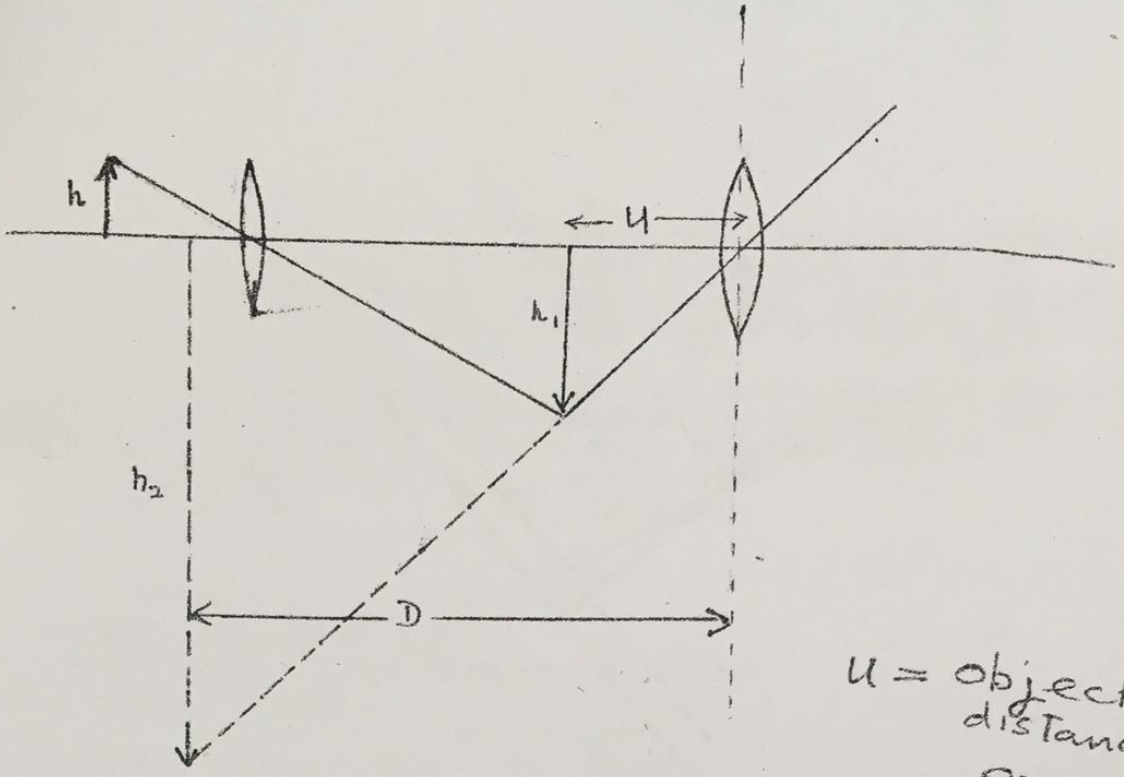
$$= \frac{\beta}{\beta'} \times \frac{\beta'}{\alpha} \quad \text{---- ⊙1}$$



$$M_{c.m.} = M_e \times M_o \quad \text{----- ⊙1}$$

$$140 = M_e \times 12.$$

$$M_e = \frac{140}{12} \quad \text{----- ⊙1}$$



u = object distance for the eye piece.

But $M_e = \frac{h_2}{h_1} = \frac{D}{u}$

Now apply lens formula to the eye piece.

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$v = D$; $f = -f_e$

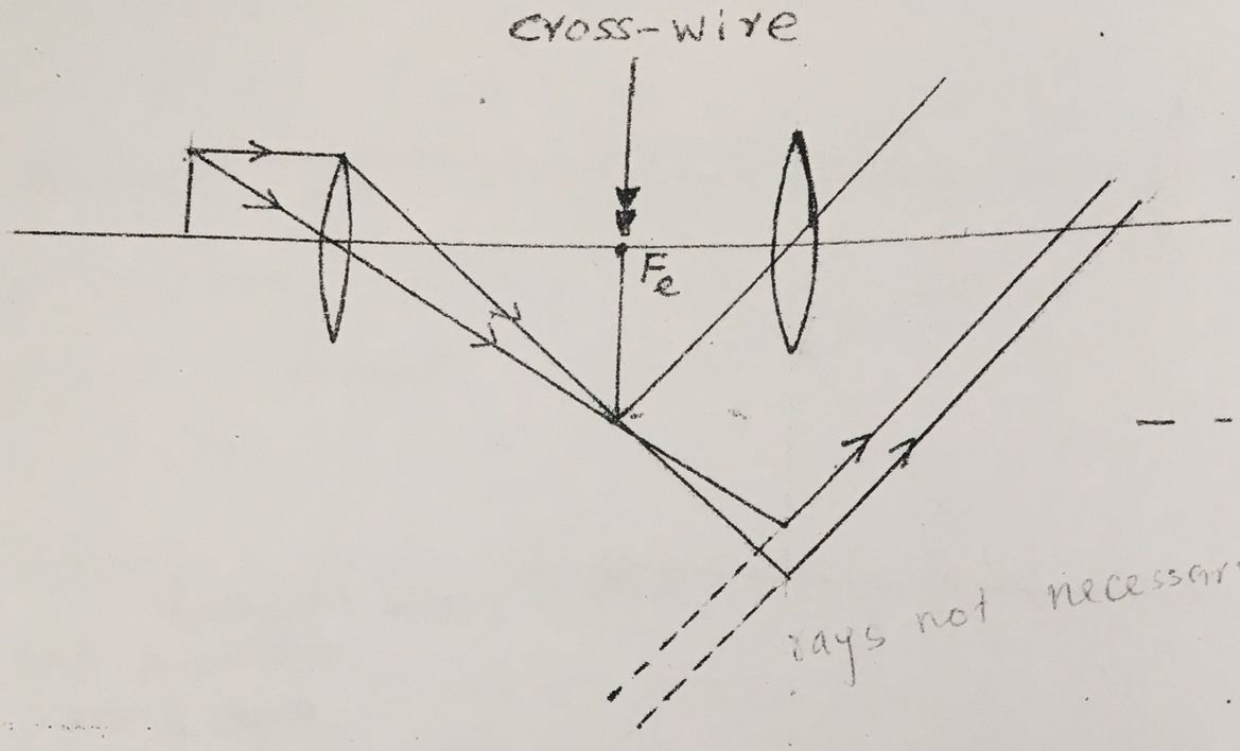
$$\frac{1}{D} - \frac{1}{u} = -\frac{1}{f_e} \quad \text{---------- (01)}$$

$$1 - \frac{D}{u} = -\frac{D}{f_e}$$

$$\frac{D}{u} = \frac{D}{f_e} + 1 = M_e = \frac{140}{12}$$

$$\frac{D}{f_e} = \frac{140}{12} - 1 = \frac{128}{12}$$

$$f_e = 2.34 \text{ cm} \quad \text{---------- 01}$$



--- 02

5. Write down expressions for transverse and longitudinal wave speeds along a stretched wire. Show that the expression for longitudinal wave speed is dimensionally correct.

A heavy wire is hung freely and vertically from a fixed support. Transverse and longitudinal waves are sent up along the wire, separately from its lower end. Will these waves have constant speeds along the wire? Explain your answer.

A uniform steel wire of area of cross section 1.2×10^{-6} m^2 is stretched horizontally. What should be the tension of the wire such that the speed of transverse wave along the wire is same as that of longitudinal wave? Explain why this condition cannot be achieved practically.

Young's modulus of steel $= 2 \times 10^{11}$ N m^{-2}.
Density of steel $= 7.8 \times 10^{3}$ kg m^{-3}.

Transverse wave speed $= \sqrt{T/m}$ 01

T is the tension of the wire and m is the mass per unit length

Longitudinal wave speed $= \sqrt{E/\rho}$ 01

'E' is the Young's modulus and ρ is the density of the material.

dimensions of 'E' $= ML^{-2}/L^2 = ML^{-1}T^{-2}$ 01

dimensions of $\rho = ML^{-3}$ 01

dimensions of $\sqrt{E/\rho} = \left[ML^{-1}T^{-2}/ML^{-3}\right]^{1/2} = LT^{-1}$

This is the dimensions of speed 01

Tension of the wire is not the same or changes or increases with the height (due to its weight) 01

Therefore speeds of transverse waves is not a constant (increases) as it travels up. 01

speed of longitudinal waves remains as a constant. 01

Since E and ρ are constants for the material 01

$m = \rho A$ 01

A is the area of the cross section of the wire

$\sqrt{T/m} = \sqrt{E/\rho}$

or $T/m = E/\rho$ 01

$T = mE/\rho = AE$

$= 1.2\times10^{-6}\times2\times10^{11}$ 01

$= 2.4\times10^{5}$ N 01

This tension is too large and therefore the (wire will break) 02

7. *Answer* **either** *part* **(a)** *or part* **(b).**

(a) Define the term 'resistivity' of a conducting material.

A d c generator supplies a voltage of 240 V to a resistive load of 120 Ω situated 1 km away from the generator.

(i) If the resistive load is connected to the generator by means of copper wires having diameter of 0.5 mm calculate the voltage of the d c generator.

(Resistivity of copper $= 1.7 \times 10^{-8}$ Ω m).

(ii) What is the power dissipated in the wires ?

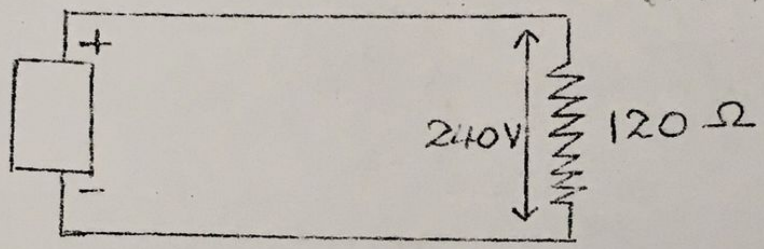
(iii) If the d c generator can provide only 241 V how would you supply the above mentioned voltage (i.e. 240 V) to the resistive load using the wires of same material ?

(iv) In long distance power transmission why it is advantageous to use an alternating high voltage ?

The resistivity of a conducting material is resistance between the two (opposite faces) of a material which has unit length and unit cross sectional area. 02

$R = \rho \frac{l}{A}$

$l = 1$ $A = 1$ $R = \rho$



(i) Current through the load = 240/120

= 2A 01

Resistance of the connecting wire = $\rho l/A$ 01

$= \frac{1.7 \times 10^{-8} \times 10^{3} \times 2}{22/7 \times (.5/2)10^{-3})^2}$ 01

= 173.2 Ω

Potential drop across the connecting wires

= (173.2)2 multiplication only 01

= 346.4V

Voltage of the d.c. generator

= (346.4) + 240 addition

= 586.4V 01

(ii) Power dissipated in the connecting wires

$= I^2R$

= 4x173.2

= 692.8W 01

(iii) Potential drop across the connecting wires

= 241 − 240

= 1V 01

∴ Resistance of the wires = 1/2 Ω 01

This can be achieved only by increasing the diameter of the wires. .....

If d is the required diameter of the wires

Then $1/2 = \frac{1.7\times10^{-8} \times 10^{3} \times 2}{22/7 \times (d/2)^2}$ 01

i.e. $1/2 = \frac{4.33\times10^{-5}}{d^2}$

$d = 9.3\times10^{-3}$ m 01

In the long distance power transmission, the power dissipation I^2R in cables must be kept at a minimum level. 01

Use of low resistance cables(i.e. very large diameters) is uneconomical as well as not practicable. Therefore the current has to be kept minimum during the transmission of electrical power which is equal to the product VI. i.e. For the transmission of given power (VI), V has to be increased as much as possible in order to keep I at a very low value, ...01

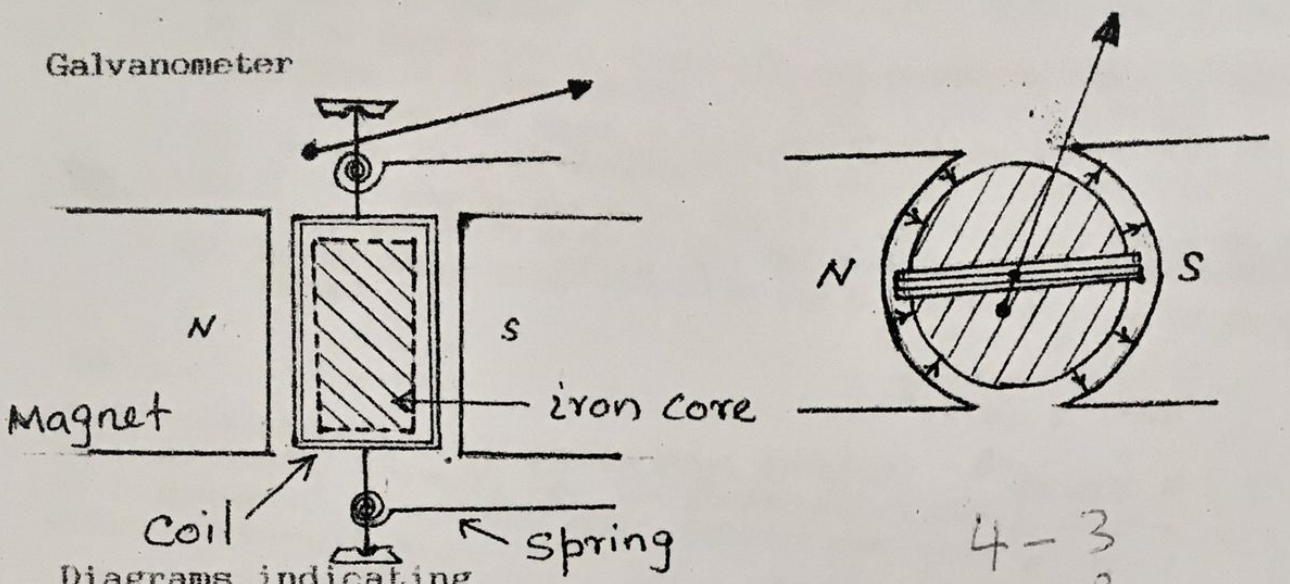
and this increase is possible only if the voltage is an a.c. voltage. 01

7 (b) Draw a clear labelled diagram showing the essential features of a moving coil galvanometer. Explain how a steady deflection is produced when a steady current is passed through such a galvanometer.

A galvanometer with a resistance of 39.8 Ω is fitted with a shunt resistance of 0.2 Ω to function as an ammeter with a full scale deflection of 10 A. What is the actual current through the galvanometer when it shows a full scale deflection ?

This galvanometer is now to be used as a voltmeter with two different ranges having full scale deflections of 3V and 15 V respectively. What resistances should be used and how should they be fitted to achieve this ?

Galvanometer

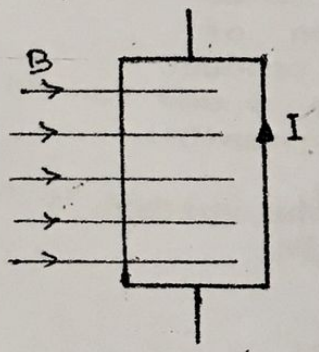


Diagrams indicating
magnets (N & S)
coil
radial field (or cylindrical shapes for magnetic poles)
spring

4 – 3
3 – 2
2 – 1 03
1 – 0

labelling 01

Explanation



When a current I flows through the galvanometer, the deflecting torque produced = NABI 01

N – Number of turns in the coil
B – Flux density of the magnetic field
A – Area of the coil

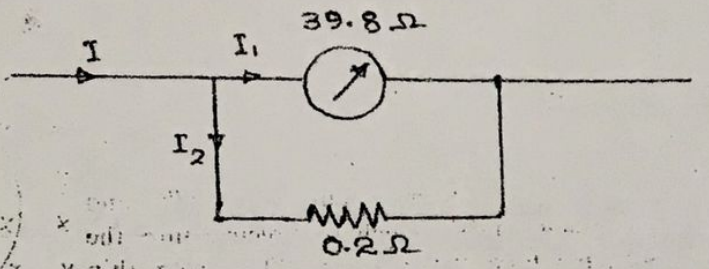
This torque makes the coil turn and is opposed by the restoring torque exerted by the springs. 01

restoring torque $\propto$ deflection

Steady state is reached when the two torques balance each other.
i.e. $NABI = C\theta$
C – Spring or torsion constant
θ – is the steady deflection ---> steady reading
Or in equilibrium the couple produced by the current flow is balanced by the torsional couple exerted by the Springs. 01

This gives rise to the steady deflection.

Problem



When the galvanometer shows full scale deflection

$I = I_1 + I_2 = 10A$ (1) 01

Also $39.8I_1 = 0.2I_2$ 01

$I_2 = (39.8/0.2)I_1 = 199I_1$

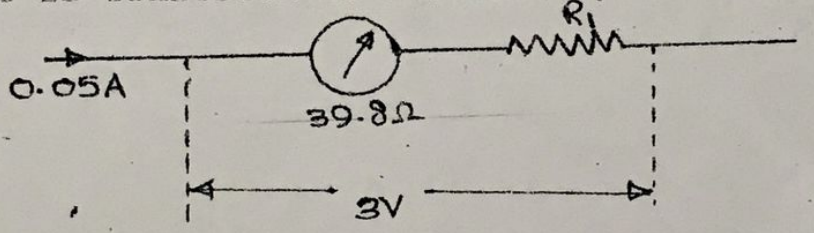
Hence (1) ⟶ $200I_1 = 10$

$\therefore I_1 = 10/200 = 0.05A$ 01

i.e. the actual current through the galvanometer

$= 0.05A$

To function as a voltmeter, high resistance must be connected in series.



for full scale deflection 0.05A must flow through the galvanometer

for 3V, $(39.8 + R_1) \times 0.05 = 3V$ 01

$39.8 + R_1 = 3/0.05 = 300/5 = 60$

$R_1 = 60 - 39.8 = 20.2\ \Omega$ 01

for 15V,

$(39.8 + R_2) \times 0.05 = 15$ .....

$39.8 + R_2 = 15/0.05 = 300$

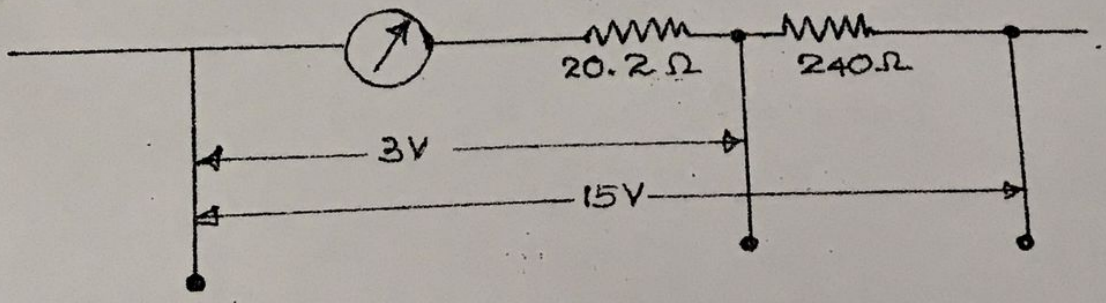
$R_2 = 300 - 39.8$

$= 260.2\ \Omega$ 01

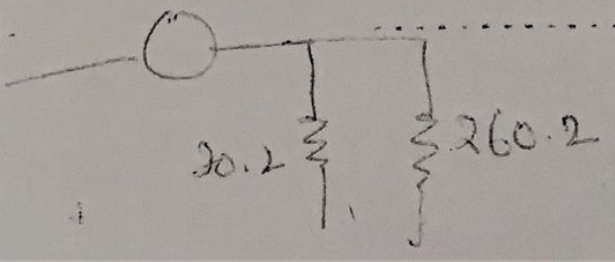
$R_2 - R_1 = 260.2 - 20.2$

$= 240\ \Omega$

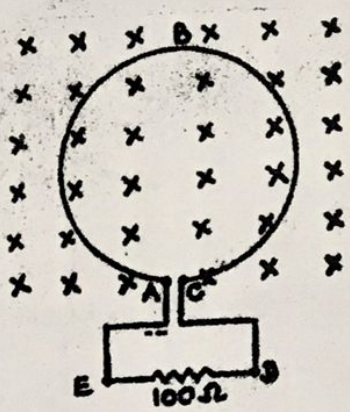
Then the circuit that can be used as



or a statement to their effect. 02



8. State the laws of electromagnetic induction.



As shown in the figure a thin rigid wire is formed into a circular loop *ABC* and placed perpendicular to a uniform magnetic field which is directed into the plane of the paper. The loop is connected to a resistance of 100 Ω using thin connecting wires. The radius of the loop is 7 cm and the, magnetic flux density of the field decreases with time at a constant rate of 10^{-2} T s^{-1}.

(i) Neglecting the effect of connecting wires, calculate the magnitude of the e.m.f. induced in the loop.

(ii) Assuming that the resistances of the loop and connecting wires are negligible, find the magnitude of the current through 100 Ω.

(iii) What is the direction of the current through 100 Ω resistor ? (from *D* to *E* or *E* to *D*) ? Explain clearly how you arrived at the answer.

(iv) When the current flows through the loop a tension is developed in the wire. Explain how this arises and calculate this tension at the instant when the magnitude of the magnetic flux density, threading the loop is 0.1 T.

The electro motive force induced in a circuit is proportional to the rate of change of magnetic flux linked with the circuit. 01

If the magnetic flux links with a closed circuit is changing, a current which tends to keep the flux constant is induced in the circuit. 01

OR

The induced current flows in such a direction as to oppose the change causing it.

(i) Induced e.m.f. $= \pi r^2 B/t$ 01

$= \frac{22}{7} \times (7 \times 10^{-2})^2 \times 10^{-2}$ 01

$= 1.54 \times 10^{-4} V$ 01

(ii) Current through 100 $= E/r$

or

$= (1.54 \times 10^{-4})/10^2$ 01

$= 1.54 \times 10^{-6}$ A 01