P510/2
PHYSICS
PAPER 2
July/August, 2024
2½ Hours

JINJA JOINT EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

PHYSICS

PAPER 2

2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

*Attempt only **FIVE** questions from the **four** sections A, B, C and D.*
*Answer **at least one question** from **each section** but **not more than one question** should be attempted from either section A or section B.*
Silent Non – programmable electronic scientific calculators may be used.

Where necessary assume the following constants:

Acceleration due gravity, g	=	$9.81\ m\ s^{-2}$
Speed of light in vacuum, c	=	$3.0 \times 10^{8}\ m\ s^{-1}$
Speed of sound in air	=	$330\ m\ s^{-1}$
Electronic charge, e	=	$1.60 \times 10^{-19}\ C$
Electronic mass, m_e	=	$9.11 \times 10^{-31}\ kg$
Permittivity of free space, ε_0	=	$8.85 \times 10^{-12}\ F\ m^{-1}$
The Constant, $\dfrac{1}{4\pi\varepsilon_o}$	=	$9.0 \times 10^{9}\ F^{-1}\ m$

SECTION A

1. (a) (i) State the laws of reflection of light (02 marks)
(ii) Distinguish between the nature of images formed by convex mirrors and those by concave mirror. (02 marks)

(b) (i) Draw a ray diagram showing the action of a concave mirror as a shaving mirror. (02 marks)
(ii) Briefly state what you would do in order to increase the magnification of the image formed by the mirror in (i) above. (01 mark)

(c) (i) Define the term ***refractive index*** of a liquid. (01 mark)
(ii) Describe how the refractive index of a liquid can be determined using a concave mirror. (05 marks)

(d) Monochromatic light is incident from air into a spherical water drop of radius 0.5 cm at an angle of 60° with point O being the center of the sphere as shown in figure 1

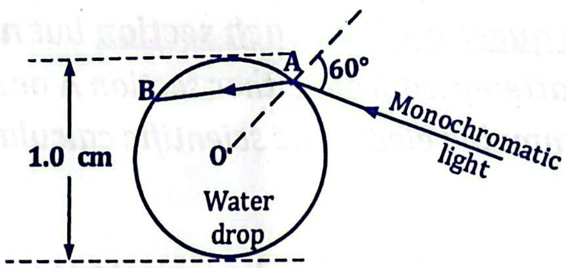


Fig. 1

If the refractive index of the water drop is 1.34, determine the length AB of the path of the light ray in the water drop. (04 marks)

(e) Explain why the surface of a tarmac road may appear watery on a dry and Sunny day. (03 marks)

2. (a) (i) What is meant by term ***myopia***? (02 marks)
(ii) Draw a ray diagram to show how myopia can be corrected in a human eye. (02 marks)

(b) (i) Describe with the aid of a ray diagram how a Galilean Telescope in normal adjustment, works. (05 marks)
(ii) A convex lens L_1 and a concave lens L_2 are arranged coaxially, with L_1 being in front of L_2. L_1 has a focal length of 100 cm while L_2 has a focal length of 5 cm. An object located in front of L_1 at infinity forms a final image at infinity after refraction by L_2. Determine the length of the

instrument formed by the lens system and the magnifying power of the instrument (04 marks)

(c) Explain why it is possible to form a white image free from colored edger using a thick convex lens of a shorter focal length. (03 marks)

(d) Two convex lenses P and Q are arranged coaxially some distance apart. A real object of height 5.0 cm is placed 15.0 cm Infront of lens P of focal length 10.0 cm. If lens Q has a focal length of 20.0 cm, determine the separation between the lenses that would produce a final real image of the same size as the original object. (04 marks)

SECTION B

3. (a) (i) Distinguish between Stationary waves and progressive *waves.* (03 marks)

(ii) Explain why the amplitude of a progressive wave decreases as the wave advances away from its source. (02 marks)

(b) A progressive wave travelling in the x - direction is represented by the equation, $y = a \sin 2\pi\left(ft + \frac{x}{\lambda}\right)$ metres.

(i) State direction, of travel of the wave. (01 mark)

(ii) Write down the equation of the wave that produces a stationary wave with the given wave. (01 mark)

(iii) Derive an expression for the resultant stationary wave and state its amplitude of vibration. (04 marks)

(c) (i) Define the terms ***harmonics*** and ***overtones*** as applied to waves. (02 marks)

(ii) A metal wire of length 0.5 m having a mass of 4.5 mg is held under tension of 16 N between two fixed points and plucked to set it into vibration at its third harmonic. The wire resonates with a pipe of length 0.06 m sounding at its first overtone. Determine the end correction of the pipe. (03 marks)

(d) (i) What is Doppler effect? (01 mark)

(ii) Describe briefly how the knowledge of Doppler effect can be used to measure the speed of a car on a highway. (03 marks)

(a) (i) Distinguish between Unpolarized light and Plane polarized light. (03 marks)

(ii) Why is it not possible to polarize sound waves? (01 mark)

(b) (i) Describe how you would obtain plane polarized light by the method of reflection. (05 marks)

(ii) Sunlight is reflected off a glass window of refractive index 1.52. What should the elevation of the sun to the glass pane surface be, if the reflected light is to be completely plane polarized? (03 marks)

(c) (i) What is meant by the term ***interference*** of waves? (02 marks)

(ii) In Young's double slit experiment, two slits are separated by a distance of 0.5 mm while the screen and the plane of the slits are 1.1 m apart. If the light used in the experiment is of wavelength 5.8×10^{-7} m. Calculate the distance of separation between the second and the sixth bright fringes of the interference pattern produced. (04 marks)

(d) Give two uses of interference of light waves. (02 marks)

SECTION C

5. (a) (i) Define the term ***magnetic field.*** (01 mark)

(ii) State three characteristics of magnetic field lines. (03 marks)

(b) Three conductors W, X and Y each of length 0.500 m carry currents of **5.0 A, 2.5 A** and **10.0A** respectively in the directions indicated on the diagram and are separated by 10.0 cm and 8.0 cm in free space as shown in figure 3.

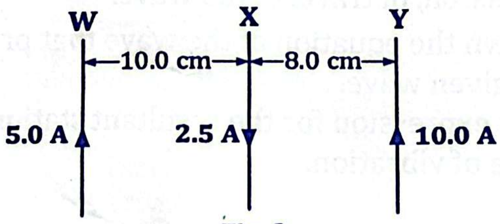


Fig. 2

(i) Calculate the net force per metre on conductor Q. (04 marks)

(ii) Determine the resultant magnetic flux density mid – way between conductors P and Q. (04 marks)

(c) (i) Write down the expression for the magnetic flux density at the centre of a plane circular coil, of radius **R** with **N** turns of the wire each carrying a current, **I** in free space. (01 mark)

(ii) A plane circular coil, of radius 5.0 cm carrying a current of 0.80 A in free space, produces a magnetic field of flux density 1.257×10^{-3} T at its centre when the coil is placed in free space. Determine the number of turns of the coil. (03 marks)

(d) Describe how a moving coil galvanometer of full-scale deflection 5 mA and having a coil of resistance 2 Ω can be converted into a voltmeter capable of measuring a maximum voltage of 3 volts. (04 marks)

(a) (i) Define the term *electromagnetic induction*? (01 mark)

(ii) State the laws of electromagnetic induction. (02 marks)

(b) (i) Derive an expression for the e.m.f. induced in a rectangular coil of **N** turns, area **A** being rotated across a uniform magnetic field of flux density, **B**, at an angular speed **ω**. (04 marks)

(ii) A rectangular coil of 50 turns has a length of 50.0 cm and a width of 30.0 cm. The coil is rotated about an axis parallel to its longer side and at right angles to a uniform magnetic field of flux density 0.04 T. Determine the peak value of the e.m.f. generated in the coil. (03 marks)

(c) (i) What are *eddy currents*? (01 mark)

(ii) Describe an experiment to show the damping effect of eddy currents. (04 marks)

(d) (i) State four sources of energy losses in an a.c. transformer. (02 marks)

(ii) A transformer connected to a 25 V supply has an output of 220 V. If the transformer is 80% efficient, calculate the input current if its output terminals are connected to a device rated 220V, 75W. (03 marks)

7. (a) Define the following terms as applied to an alternating current circuit.

(i) Reactance. (01 mark)

(ii) impedance. (01 mark)

(b) An alternating current source is connected across a pure inductor and two electric bulbs B_1 and B_2 of the same power rating as shown in figure 3.

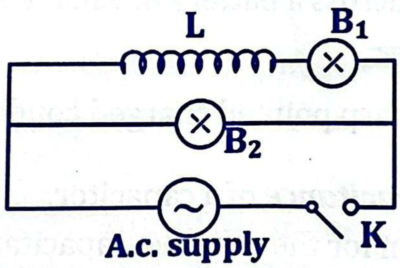


Fig. 3

Explain what is observed when;

(i) switch K is closed. (02 marks)

(ii) a bunch of soft iron rods are inserted into the coil and the switch K is closed. (03 marks)

(c) With the aid of a diagram describe how a thermocouple meter works. (05 marks)

(d) Show that when an alternating voltage $V = V_0 \sin 2\pi ft$ is applied across a capacitor of capacitance, C, the current, I, flowing in the circuit leads voltage by $\frac{\pi}{2}$ *radians.* (03 marks)

(d) An alternating voltage of root mean square value 20 V and frequency 50 Hz is applied across a 100 μF capacitor.
Calculate the;
(i) Capacitive reactance of the circuit. (02 marks)
(ii) Root mean square value of the current flowing in the circuit. (03 marks)

SECTION D

8. (a) What is meant by;
(i) work function of a material? (01 mark)
(ii) a neutral material? (01 mark)

(b) Describe an experiment to establish the type of charge carried by a body using a gold leaf electroscope. (06 marks)

(c) (i) Define the term *electric field intensity.* (01 mark)
(ii) Two-point charges, each of − 5.0 μC lie along the x − axis at points A and C separated by a distance of 6.0 cm. Point B is mid − way between A and C. while point D is 4.0 cm directly above point B. Determine the sign and size of charge that has to be placed at B, so that the resultant electric field intensity at point D is zero. (05 marks)

(d) Use a graphical method to show that the energy stored in a capacitor of capacitance, C, connected across a battery of e.m.f. V is given by, the expression, $E = \frac{1}{2}CV^2$ (04 marks)

(e) Give two applications of sharp pointed charged conductors. (02 marks)

(a) (i) Define the term ***capacitance*** of a capacitor. (01 mark)
(ii) Derive an expression for the effective capacitance, C of two capacitors of capacitances C_1 and C_2 respectively connected to a d.c source of e.m.f. (04 marks)

(b) The circuit in figure 4 shows a network of three capacitors C_1, C_2 and C_3 of capacitances $3\ \mu F, 6\ \mu F,$ *and* $12\ \mu F$ respectively all connected to a 12 V battery. Via switches, K_1, K_2 and K_3 and a ballistic galvanometer of sensitivity 5 μC per radian.

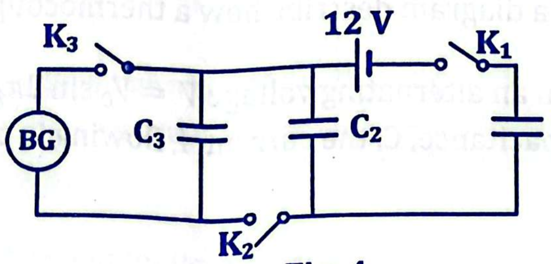


Fig. 4

Determine the;

(i) Charge stored in the system when switch K_1 alone is closed while the other two switches K_2 and K_3 are open. (03 marks)

(ii) Energy stored in the system when K_1 is closed for a short while then opened after which K_2 is closed. (03 marks)

(iii) Maximum deflection, on the ballistic galvanometer after a sequence of actions on the switches. First K_1 is closed then opened, next K_2 is closed then opened and finally K_3 is closed while K_2 is open. (03 marks)

(c) (i) What is a dielectric material with respect to a capacitor? (01 mark)

(ii) State two qualities of a good dielectric material. (02 marks)

(d) An isolated positively charged metal sphere of radius 10.0 cm placed in free space has a surface charge density of $3.98 \times 10^{-4}\,C\,m^{-2}$. Determine the electric potential on the surface of the sphere. (03 marks)

10. (a) (i) Define the term ***temperature coefficient of resistance*** of a material and state its unit. (02 marks)

(ii) Explain why copper has a positive temperature coefficient of resistance. (03 marks)

(b) (i) With the aid of a diagram, derive the balance condition of a metre bridge using well defined symbols. (04 marks)

(ii) Explain why standard resistors are made of special alloys such as constantan, nichrome and manganin. (02 marks)

(c) (i) Describe the principle of operation of a slide wire potentiometer. (03 marks)

(ii) Give two possible reasons why a slide wire potentiometer may fail to produce a balance point, even though the circuit is completed and has no loose connections. (02 marks)

(d) Figure 6, shows a circular loop of Nichrome wire of resistivity $1.50 \times 10^{-6}\,\Omega m$. The loop is made of two semi – circular parts each of length 0.500 m, and are both connected across a p.d of 1.50 V. The upper section X of the loop has a cross sectional area of $2.0 \times 10^{-6}\,m^2$ while the lower section Y of the loop has a cross sectional area of $1.5 \times 10^{-6}\,m^2$.

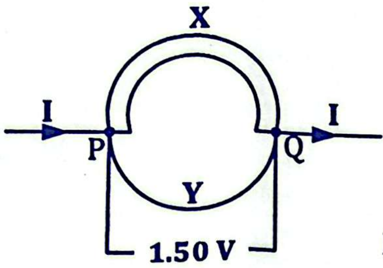


Fig. 5

Determine the size of the current, I fed into the loop at P and leaving the loop at point Q. (04 marks)

=END=

JINJA JOINT EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

MOCK EXAMINATIONS – JULY / AUGUST, 2024

P510/2 – PHYSICS

MARKING GUIDE

JJEB MOCK EXAMS JULY/AUGUST 2024
P510/2 PHYSICS MARKING GUIDE

✓	Full mark
✓/	Half mark

SECTION A

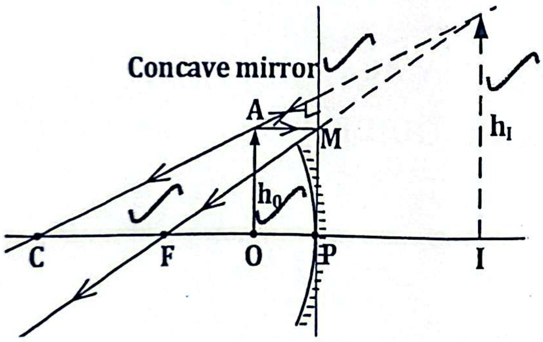
1. (a) (i) The angle of incidence is equal to the angle of reflection. ✓
The incident ray, the normal and the reflected ray at the point of incidence, all lie in the same plane. ✓ **[02]**

(ii)

Images formed by convex mirrors	Images formed by concave mirrors
- They are virtual for all real objects.	- They are real except when object is between principal focus F and the pole P ✓
- They are upright or erect.	- They are inverted except when object is between F and P ✓
- They are diminished for all positions of the object.	- The size depends on the position of the object.

Any two @ *Correct pair 1 mark.* **[02]**

(b) (i) **A concave mirror as a shaving mirror**



- Object b'tn F and P
- Rays from O through C and F after reflection.
- Vitual image behind the mirror.
- Correct mirror symbol and drawing.

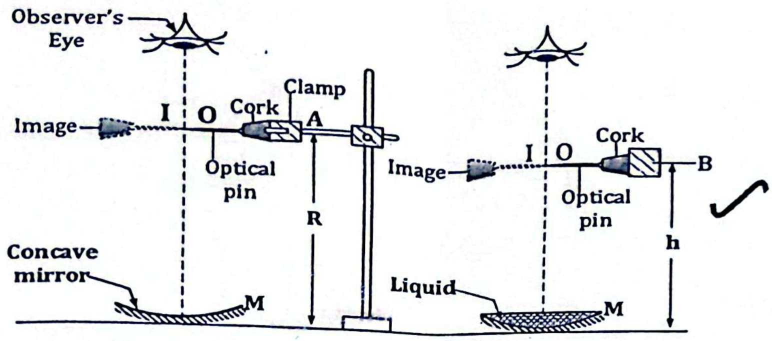
[02]

(ii) Placing the object *much closer to the principal focus* but still between Principal focus F and the pole P. ✓ **[01]**

(c) (i) R*efraction index* – is the ratio of the speed of light in a vacuum to the speed of light in a liquid. ✓

or The ratio of the sine of the angle of incidence, to the sine of the angle of refraction of light as it moves from a vacuum to the liquid. **[01]**

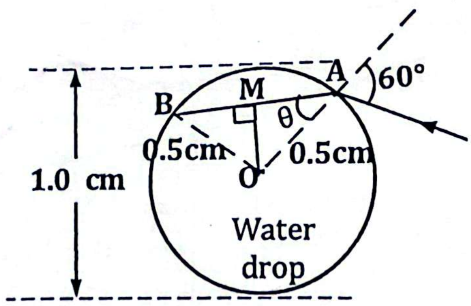
(ii) A concave mirror M is placed on a flat horizontal surface with its reflecting surface facing up. ✓
An optical pin O is then clamped horizontally directly above the mirror with its tip lying along the principal axis of the mirror. ✓
Pin O is moved slowly up and down until it coincides with its own image, I by no parallax. ✓



Distance, **R** from point **O** of no parallax up to the mirror surface is measured using a metre rule and recorded down.
A small quantity of the liquid under test is then poured into the mirror.
The optical pin, **O** is again moved up and down until it coincides with its image **I** by no parallax at a new position, of the pin.
A new distance, **h**, from the table up to the point of coincidence between **O** and its image is noted.
The refractive index, n, of the small quantity of the liquid, is then calculated from the expression, $n = \frac{R}{h}$ **[05]**

(d) OAB is an isosceles triangle

OA = OB = 0.5 cm
OM is normal to AB
AM = MB = AO cos θ
But sin 60°=1.34sin θ
Thus, **θ = 40.3°**
AM = MB = 0.5 cos 40.3°
AM = 0.38 cm
Hence, **AB = 0.76 cm**

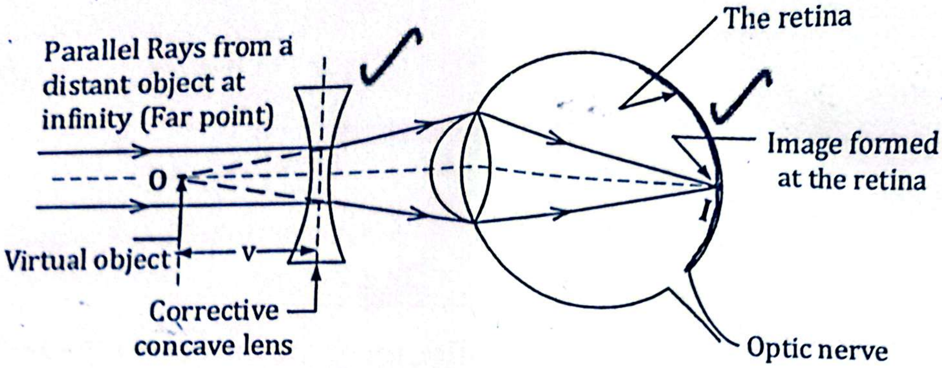


[04]

(e) On a hot and sunny day, the Layers of air near the road surface are hotter than the layers higher up in the sky.
Light rays from the sky are thus gradually and continuously refracted away from the normal as they pass from denser air to less dense air until at some point the light gets totally internally reflected.
An observer on earth, receiving the totally internally reflected sees a reflection of the sky on the ground appearing silvery. **[03]**

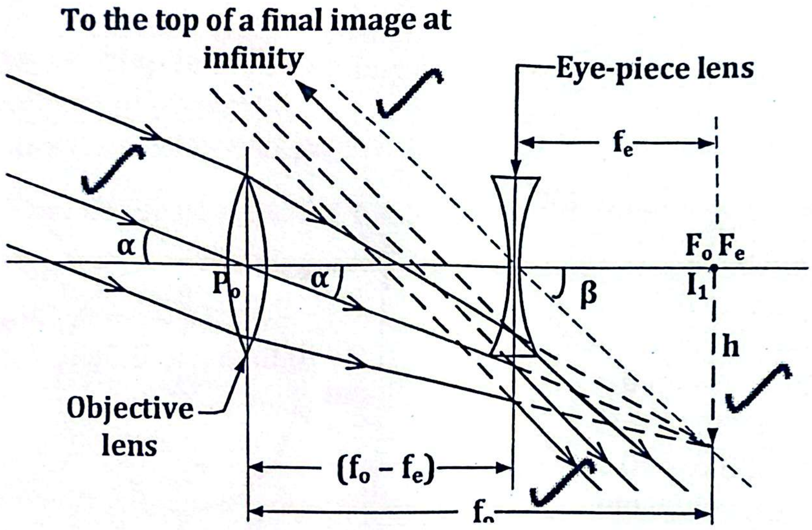
:. (a) (i) **Myopia** - is a defect in a human eye that causes the images of distant objects to be formed ***in front*** of the retina. ***i.e. images of distant objects are blurred*** but the eye is able to ***see nearby objects*** distinctly with a clear vision. **[02]**

(ii) The defect is corrected by the use of a concave lens.



The corrective diverging lens acts in such a way that the rays incident onto the concave lens are refracted in such a way that they appear to originate from the near ***point of the normal eye***, so that the final image is formed at the retina. **[02]**

(b) (i) The structure of a Galilean Telescope in normal adjustment.



Parallel rays from a distant object at infinity incident onto an objective lens of focal length f_o are ***refracted by the lens*** and forms a real inverted and diminished image intermediate ***image, I_1 at the focal plane of the objective lens, L_o.***

The eyepiece lens, L_e arranged coaxially with the objective lens, is then adjusted so that the intermediate image by the objective also lies in the focal plane of the eyepiece lens, but behind the lens. This implies the principal foci of the objective and eyepiece lenses coincide.

The image I_1 now acts as a virtual object to the eyepiece lens that then forms a final virtual but upright image at infinity.

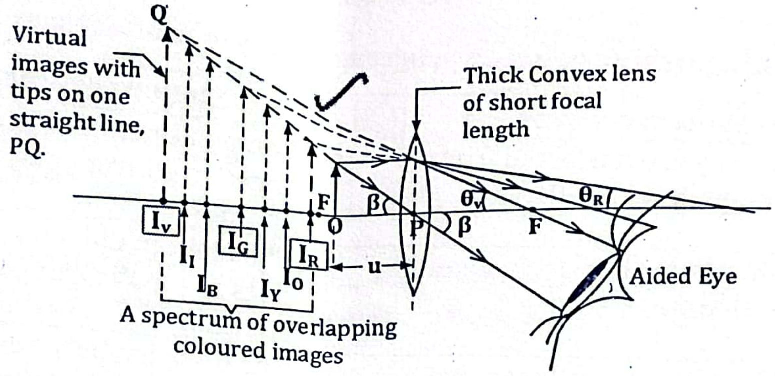
[05]

(ii) *The length of the telescope,* $= (f_1 + f_2) = (100 + 5) = (100 + 5) = 105\ cm$ **[02]**

The angular magnication of the telescope, $M = \frac{f_1}{f_2} = \frac{100}{5} = 20$

[02]

(c) Why a thick convex lens may survive chromatic aberration?

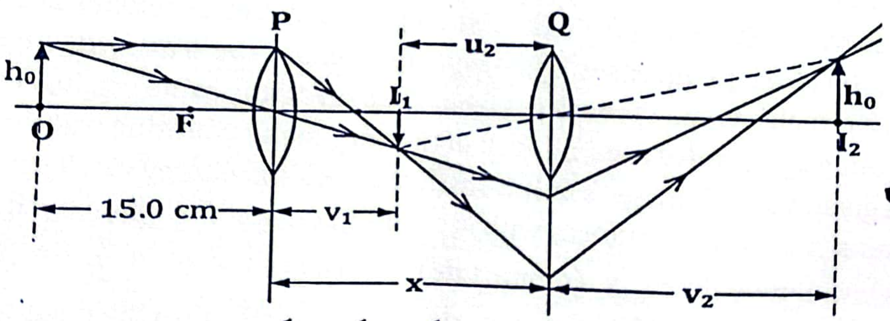


Dispersion of white light occurs on the surface of a simple thick convex glass lens resulting into formation of colored images.

However, ***when the eye is placed very close to the lens***, all the ***tips of these images lie along one straight line, PQ*** and they ***subtend the same visual angle, β*** at the aided eye.

The images then, ***overlap and get superimposed on each other***, resulting into ***uniform white illumination***, and hence the ***lens forms a white image*** instead of several colored images and is said to be ***free from chromatic aberration.*** [03]

(d) **Sketch**



Using action of lens 1: $\frac{1}{u_1} + \frac{1}{v_1} = \frac{1}{f_1} \Rightarrow \frac{1}{v_1} = \frac{1}{f_1} - \frac{1}{u_1}$

$i.e.\ \frac{1}{v_1} = \frac{1}{10.0} - \frac{1}{15.0} \Rightarrow v_1 = 30.0\ cm$

$But\ magnification, m = (m_1 \times m_2) = \left(\frac{30}{15} \times \frac{v_2}{u_2}\right) = 1 \Rightarrow u_2 = 2v_2$

Using action of lens 2: $\frac{1}{u_2} + \frac{1}{v_2} = \frac{1}{f_2} \Rightarrow \frac{1}{2v_2} + \frac{1}{v_2} = \frac{1}{20}$

$\frac{3}{2v_2} = \frac{1}{20} \Rightarrow v_2 = 30.0\ cm\ and \Rightarrow u_2 = 2v_2 = 60.0\ cm$

$\therefore The\ lens\ separation, x = (v_1 + u_2) = (30.0 + 60.0) = 90.0\ cm$

[04]

SECTION B

3. (a) (i) Distinguishing between progressive and stationary waves:

Progressive waves	Stationary waves
- Energy is transferred from one point to another.	- Energy is localized and not transferred from one point to another.
- The wave profile advances with time	- The wave profile is stationary i.e. does not move from one location to another.
- The distance between two successive crests or troughs is equal to one wave-length.	- The distance between two successive nodes or anti-nodes is equal to one half wave length.
- All the particles in the wave profile have a constant amplitude.	- Particles within the wave profile have varying amplitudes of oscillations between any two successive nodes.
- Within one cycle all particles oscillating are out of phase with each other but each attains the same amplitude of the wave.	- Within one loop (between 2 successive nodes) all the oscillating particles are in phase but with different amplitudes.

Any three *Correct pairs @ 1 mark.* **[03]**

(ii) All waves transmit energy from their source to whatever eventually absorbs them.
- Thus, as the ***wave progresses***, some ***energy is lost to the transmitting medium.***
- Also, as a circular wave spreads out from the source, the same original energy is spread out over a wider area, so each of the very many vibrating wave particles along a given wave front gets only a small share of this energy.
- The intensity therefore reduces with increase in distance, d, given by the inverse square law. $I \propto \frac{1}{d^2}$ *but* $I \propto (amplitude)^2$ *but* $(\text{amplitude})^2 \propto \frac{1}{d^2} \Rightarrow (a) \propto \frac{1}{d}$
- Thus, amplitude $\propto \frac{1}{d}$ amplitude is inversely proportional to the distance.
- ***Therefore, amplitude reduces as the distance from the source increases.***

[02]

(b) (i) A progressive wave $y = a \sin 2\pi \left(ft + \frac{x}{\lambda}\right)$ *is* travelling in the **negative x – direction or form Right to Left.** **[01]**

(ii) $y' = a \sin 2\pi \left(ft - \frac{x}{\lambda}\right)$ *superimposed on y produces a stationary wave.*

[01]

(iii) $y = y + y'$ ***Using identity,*** $\sin A + \sin B = 2\left[\sin\frac{(A+B)}{2}\cos\frac{(A-B)}{2}\right]$

$$y = a \sin 2\pi\left(ft + \frac{x}{\lambda}\right) + a \sin 2\pi\left(ft - \frac{x}{\lambda}\right)$$

$$y = 2a\left\{\sin\frac{\left[2\pi\left(ft + \frac{x}{\lambda}\right) + 2\pi\left(ft - \frac{x}{\lambda}\right)\right]}{2}\cos\frac{\left[2\pi\left(ft + \frac{x}{\lambda}\right) - 2\pi\left(ft - \frac{x}{\lambda}\right)\right]}{2}\right\}$$

$$y = 2a\sin\frac{2(2\pi ft)}{2}\cos\frac{2(2\pi\frac{x}{\lambda})}{2}$$

$$y = 2a\sin 2\pi ft\cos\frac{2\pi x}{\lambda}$$

$$y = 2a\cos\frac{2\pi x}{\lambda}\sin 2\pi ft$$

Amplitude, $A = 2a\cos\frac{2\pi x}{\lambda}$ **[04]**

(c) **Harmonics**

These *are* ***integral multiples*** *of the* ***fundamental frequency note,*** that include the fundamental frequency note itself. *i.e.* nf_0 *where,* $n = 1, 2, 3, \ldots$

Overtones:

These are ***higher frequency multiples*** *of the fundamental frequency note, that are produced by a given musical instrument in its allowed modes.* **[02]**

(d) Length of wire, L = 0.5 m, Tension, T = 16 N mass of wire, m = 4.5×10^{-6} kg

For closed pipe on one side, L_T = 0.06 m its fundamental frequency, f_0 is given by

<u>ALTERNATIVE 1 (Closed pipe at one end)</u>

$$f_o = \frac{v}{4(L+e)} \quad \therefore \textit{First overtone}, f_1 = \frac{3v}{4(L+e)}$$

Third harmonic of a wire, $f_3 = \frac{3}{2L}\sqrt{\frac{T}{\mu}} = \frac{3}{2\times 0.5}\sqrt{\frac{16\times 0.5}{4.5\times 10^{-6}}} = 4000\ Hz$

$\therefore$ ***At resonance between the pipe and the wire,*** $f_1 = f_3$

$$\Rightarrow \frac{3v}{4(L+e)} = \frac{3}{2L}\sqrt{\frac{T}{\mu}} \quad \Rightarrow \frac{3\times 330}{4(0.06+e)} = 4000$$

$\therefore$ ***End correction, of closed pipe,*** $e = 1.875\times 10^{-3}\ m$

<u>ALTERNATIVE 2 (Open pipe at both ends)</u>

$$f_o = \frac{v}{2(L+2e)} \quad \therefore \textit{First overtone}, f_1 = \frac{v}{(L+2e)} = 2f_o$$

Third harmonic of a wire, $f_3 = \frac{3}{2L}\sqrt{\frac{T}{\mu}} = \frac{3}{2\times 0.5}\sqrt{\frac{16\times 0.5}{4.5\times 10^{-6}}} = 4000\ Hz$

$\therefore$ ***At resonance between the pipe and the wire,*** $f_1 = f_3$

$$\Rightarrow \frac{v}{(L+2e)} = \frac{3}{2L}\sqrt{\frac{T}{\mu}} \quad \Rightarrow \frac{330}{(0.06+2e)} = 4000$$

$\therefore$ ***End correction, of closed pipe,*** $e = 1.125\times 10^{-2}\ m$ **[03]**

(e) (i) **Doppler effect** – is the apparent change of frequency of the waves received by the observer due to relative motion between the source of the waves and the observer. **[01]**

(ii) A police traffic officer stands at some strategic position holding a speed gun and points the speed gun onto an approaching car and switches it on.

The radar waves are sent out of the gun to intercept the approaching car, which then reflects back these radar waves to the speed gun.

The sent out signal and the received reflected signal superimpose in the gun and produce beats whose beat frequency in the speed gun can be determined.

The computer inside the speed gun quickly computes the speed of the car and displays it on the screen.

The police officer then takes the next action depending on the speed of the motorist displayed on the speed trap. E.g. Fining the culprit, taking him/her to courts of law or warn the driver and let go free. [03]

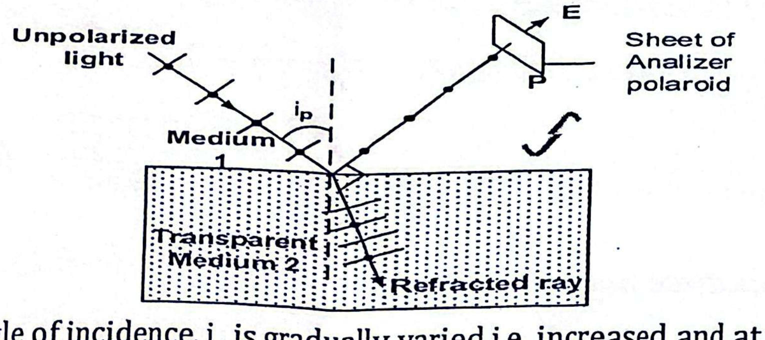
4. (a) (i) **Un Polarized light** – is light whose electric vector vibrates in all planes perpendicular to the direction of propagation of the light
while
Plane polarized light – is light whose electric vector vibrates in only one plane perpendicular to the direction of propagation of the light. [03]

(ii) **Sound waves** – longitudinal waves whose direction of propagation is along the direction of travel of the waves, so they cannot be polarized. [01]

(b) (i) **Producing Polarized Light by method of Reflection.**

A narrow beam of un-polarized light is made incident onto the transparent optical medium e.g. rectangular glass slab.

The reflected light is observed through a Polaroid P, placed perpendicular to the direction of propagation of the reflected light.



The angle of incidence, i, is gradually varied i.e. increased and at each angle of incidence, the analyzer Polaroid P is rotated about the axis along which the light is incident on it.

At one angle of incidence called the Polarizing angle i_p, the light gets cut off from the observer at other angles of rotation as the Polaroid is rotated except at only two positions of the Polaroid P.
This implies the **reflected light** is now is said to be completely **plane polarized.** [05]

(ii) Using, $\tan i_p = \frac{n_g}{n_a}$ or $i_p = \tan^{-1}\left(\frac{n_g}{n_a}\right)$

$\therefore i_p = \tan^{-1}\left(\frac{1.52}{1.00}\right)$

$\therefore i_p = 56.7°$

Thus, the angle of elevation θ of the sun to the window pane,

$\theta = (90° - i_p)$

$\Rightarrow \theta = 33.3°$ **[03]**

(c) (i) ***Interference*** – is the superposition of two coherent waves giving rise to permanent regions of alternating bright and dark bands (fringes).

Bright bands or fringes (constructive interference) occurs when the path difference between the wave trains is an integral multiple of the wavelength i.e.($n\lambda$) while dark bands (fringes) occur when the path difference between the wave trains is an odd multiple of half the wavelength $(2n + 1)\lambda/2$.

[02]

(ii) Given that, the n[th] bright fringe is $x_n = \frac{n\lambda D}{a}$ where $a = 0.5\ mm, D = 1.1\ m$

The Sixth bright fringe, $x_6 = \frac{6\lambda D}{a}$

The second bright fringe, $x_2 = \frac{2\lambda D}{a}$

The separation between them, $\Delta x = (x_6 - x_2) = \left(\frac{6\lambda D}{a} - \frac{2\lambda D}{a}\right) = \frac{4\lambda D}{a}$

$$= \frac{4 \times 5.8 \times 10^{-7} \times 1.1}{5.0 \times 10^{-4}}$$

$\therefore \Delta x = 5.104 \times 10^{-3}\ m$ **[04]**

(d) Uses of interference of light:

- For checking for the flatness of a glass surface.
- For measurement of wavelength of a given source of light used. **[02]**

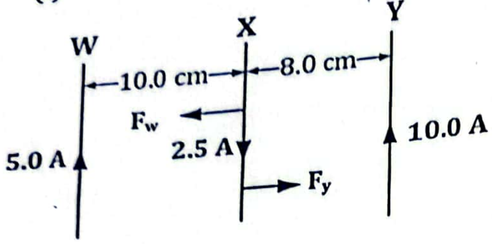
SECTION C

(a) (i) ***Magnetic field*** – is the region of space where a magnetic force is experienced by a magnetic dipole or by a small bar magnet. **[01]**

(ii) Magnetic field lines originate from the north pole and end on the south Pole.
They do not cross each other's paths.
Where two fields are equal and opposite a neutral point is obtained
Where there are many field lines always form closed loops
Magnetic field lines are crowded near the pole of a magnet and spread apart from each other where the field is weak.
The direction of the magnetic field at a point is given by the tangent to the field at that point.
The density of the magnetic field lines gives the intensity of the magnetic field at any point on the space.

[03]

(b) (i) Net force on wire X.



Force on X due to W, $F_w = \frac{\mu_0 I_W I_X L}{2\pi d}$

$= \frac{4\pi \times 10^{-7} \times 5.0 \times 2.5 \times 0.5}{2\pi \times (0.10)}$

$F_W = 1.25 \times 10^{-5}$ *N to the right*

Similarly

$F_y = \frac{\mu_0 I_X I_y L}{2\pi d} = \frac{4\pi \times 10^{-7} \times 2.5 \times 10.0 \times 0.5}{2\pi \times (0.08)}$

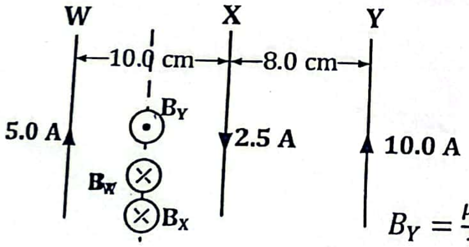
$F_y = 3.125 \times 10^{-5}$ *N to the left of wire X*

The resultant force on wire, Y, $F_X = F_y - F_w$

$\Rightarrow F_X = (3.125 \times 10^{-5} - 1.25 \times 10^{-5})$

$F_X = 1.875 \times 10^{-5}$ *N to the right of X* **[04]**

(ii) Mid – way between X and Y, the axis is 5.0 cm from X and also Q



$B_W = \frac{\mu_0 I_W}{2\pi d} = \frac{4\pi \times 10^{-7} \times 5.0}{2\pi \times (0.05)} = 2.0 \times 10^{-5} T\ IN$

$B_X = \frac{\mu_0 I_X}{2\pi h} = \frac{4\pi \times 10^{-7} \times 2.5}{2\pi \times (0.05)} = 1.0 \times 10^{-5} T, IN$

$B_Y = \frac{\mu_0 I_y}{2\pi d} = \frac{4\pi \times 10^{-7} \times 10.0}{2\pi \times (0.13)} = 1.54 \times 10^{-5} T, OUT$

∴ The resultant magnetic flux density mid-way b'tn wires, X & Y, $B = B_W + B_X - B_y$

$B = (2.0 \times 10^{-5} + 1.0 \times 10^{-5} - 1.54 \times 10^{-5})$

$B = 1.46 \times 10^{-5} T$ *into the paper* **[04]**

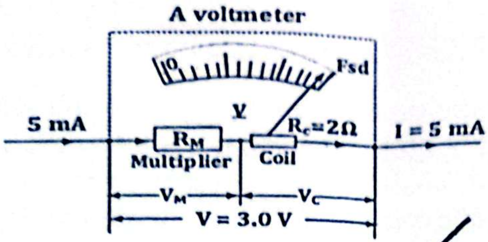
(c) (i) $B = \frac{\mu_0 N I}{2R}$ **[01]**

(ii) Using, $B = \frac{\mu_0 N I}{2R} \Rightarrow 1.257 \times 10^{-3} = \frac{4\pi \times 10^{-7} \times 0.80 \times N}{2 \times (0.05)}$

$\therefore N = \frac{1.257 \times 10^{-3} \times 2 \times (0.05)}{4\pi \times 10^{-7} \times 0.80}$

$\therefore N = 125.04$ *turns* $\cong 125$ *turns* **[03]**

(d) $R_c = 2.0\,\Omega$, $I_c = 5\,mA$, *Full scale voltage* $= 3.0\,V$



From, $V = I_c(R_c + R_M)$ *from which,* R_M *is calculated.*

$\therefore R_M = \left[\left(\frac{V}{I_c}\right) - R_c\right]$ *is the value of the Multiplier to be used.*

$\therefore R_M = \left[\left(\frac{3.00}{5.0\times10^{-3}}\right) - 2\right] = 598\,\Omega$

$\therefore R_M = 5.98 \times 10^2\,\Omega$ is the multiplier ***connected in series*** with the meter.

[04]

6. (a) (i) **Electromagnetic induction** – is the production or generation of an induced e.m.f in a coil, or conductor whenever there is relative change of magnetic flux linked with it.(i.e. coil, or conductor). **[01]**

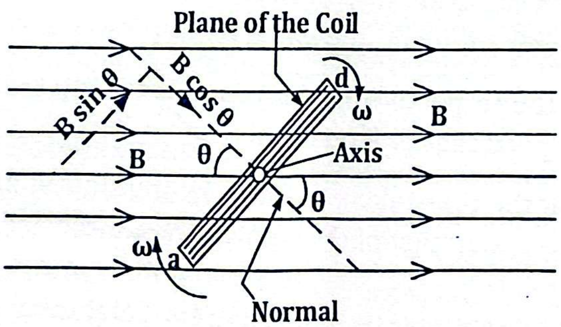
(ii) **Laws of electromagnetic induction:**

Faraday's law *states that* – The *magnitude* of the e.m.f. induced in a coil or across the ends of a conductor is directly proportional the rate of change magnetic flux linkage or to the rate of cutting of the magnetic flux.

Lenz's law states that – The ***direction of the induced e.m.f.*** in a coil or closed circuit acts in such a way ***as to oppose the change of the magnetic flux that causing it.*** **[01]**

Or It can also be stated as – The ***direction*** of the induced e.m.f. is such that the induced current that it causes to flow in a closed circuit, opposes the change of flux which is producing it. **[01]**

(b) (i) Suppose a rectangular coil ad is initially vertical at a time t = 0 s



Initially at t = 0 s the plane of the coil is Normal to the magnetic field.

Magnetic flux linking the plane of the coil normally after a time t,

$\Phi = BAN\cos\theta$ *where* $\theta = \omega t$

E.m.f. induced in the coil because of its rotation,

$$E = -\frac{d(BAN\cos\theta)}{dt} = -NAB\frac{d(\cos\omega t)}{dt}$$

$\therefore E = NAB\omega \sin \omega t$

$\therefore E = E_0 \sin \omega t$ *where* $E_0 = NAB\omega$ *is the Maximum value of the e.m.f. induced in the rotating coil.* [04]

(ii) Peak value of e.m.f.

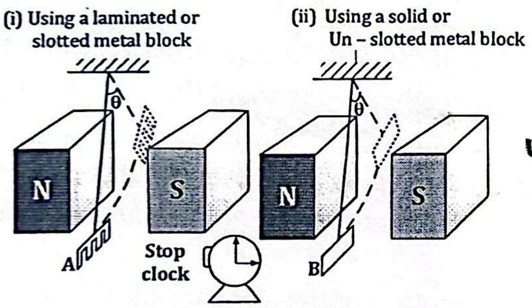
$E_0 = NAB\omega$ where, $N = 50$ turns, $A = 0.5 \times 0.30 = 0.15\ m^2$, $B = 0.04$ T

$\therefore E_0 = 50 \times 0.15 \times 0.04 \times \omega$

$\therefore E_0 = (0.30\ \omega)$ volts [03]

(c) (i) **Eddy currents** – are currents induced in a thick metal conductor placed in a changing magnetic flux, of associated with a magnetic flux linkage. They flow in such a direction as to oppose the change causing them to be generated

(ii) **The damping effect of eddy currents.** [01]



A slotted metal piece and a non-slotted metal piece respectively, are set into free swinging motion at the same time between the pole pieces of similar strong permanent magnets after displacing each through the same angle θ. The metal blocks **A** and **B** are displaced either simultaneously or one at a time, and at the same time the stopwatch or stop clock is started.

The time it takes the respective blocks, t_1 and t_2 to stop swinging are noted on each of the stopwatches or stop clocks.

It is observed that the time taken, t_1, taken by the slotted metal piece, **A** to stop is much longer than that of the solid or the un–slotted metal piece, **B.** i.e. $t_1 > t_2$.

Implying large eddy currents are induced in the solid metal block **B,** caused a magnetic force that acts in a direction that opposes motion of the solid metal block each time and greatly damping its motion.

while the slotted metal block has negligible induced eddy currents loops that minimized the damping thus having almost no resistive effect on its motion.

[04]

(d) (i) ***Energy losses in an a.c. transformer.***

- **Magnetic flux leakage** Not all the magnetic flux generated in the primary reaches the secondary coil hence reducing the efficiency of the transformer.
- **Hysteresis power loss.** Due to continuous magnetic dipole reversals leading to the generation of heat in the magnetic core.
- **Eddy current power loss in I^2R** – mechanism leading to heat generation at the magnetic core.
- **Resistance of the windings of the coil** - Leading to heat generation in the coils in the I^2R – mechanism. **[02]**

(ii) $V_p = 20\,V, V_s = 220\,V, Efficiency\,\eta = 80\%,\ I_p = ?$

Output of the device connected to the secondary,

$P = IV \Rightarrow I_s = \frac{75}{220} = 0.341A$ *Since the transformer is* 80% *efficient*

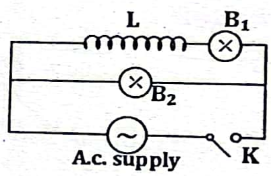
$I_S V_S = 80\%\ I_P V_P \quad \Rightarrow I_P = \frac{100 \times 0.341 \times 220}{80 \times 20} = 4.69\,A$ **[03]**

7. (a) (i) **Reactance** – is the non – resistive opposition offered by a reactive circuit containing a capacitor or inductor to the passage of a.c. through it. **[01]**

(ii) **Impedance** – is the net opposition to the passage of a.c. through a resistor, a capacitor or an an inductor or both. **[01]**

(b) (i) When switch k is opened, bulb ***B_1 will appear dimmer while bulb B_2*** will be ***brighter*** than B_1

The back e.m.f. induced in the inductor L acts each time in such away as to oppose the e.m.f of the source, ***causing induced current, to oppose the applied current.***



[02]

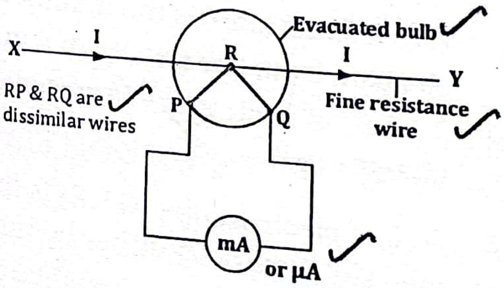
(ii) When a bunch of iron rods are inserted into the coil, ***bulb B_1 becomes dimmer*** while the B_2 remains brighter than B_1.

The soft iron ***rods enhance the magnetic flux linkage*** in the coil and hence increases the self-inductance, L of the coil hence ***reactance to a.c. increases*** and current through B_1 reduces making it become much dimmer than B_2.

[03]

(c) *The thermocouple meter:*

P and **Q** are wires made up of two ***different metals*** joined together at **R** so as to form a hot junction a long wire **XY**, carrying current **I** to be measured.



Current, I being measured is passed through the fine *resistance wire XY* and warms it up.

Contact R at the centre of the bulb and shielded off from draughts acts as the *hot junction* with junctions P and Q made up of two *dissimilar wires* acting as *cold junctions.*

A temperature gradient is then set up between R, and the other two junctions P and Q *thus causing a thermo-electric e.m.f.* to be produced that in turn causes a thermo-electric current, (*the root mean square current,* I_{rms}) to flow through the mA or the μA connected in series with the set up already *calibrated to measure direct current.*
A current through the meter causes a deflection, θ which is proportional to the root mean square current (I_{rms})
The thermocouple meter has *high sensitivity* because of its low inductance and capacitance. **[05]**

(d) The instantaneous charge Q, at any time, t, stored in the capacitor plates is given by, $Q = CV, Q = CV_0 \sin \omega t$
The instantaneous current, $I = rate\ of\ change\ of\ charge\ with\ time$

$$i.e\quad I = \frac{dQ}{dt} \Rightarrow I = \frac{d}{dt}(CV_0 \sin \omega t) = \omega CVo\ \cos \omega t$$

$$I = \omega CV_0\ cos\omega t \Rightarrow I = I_0\ \cos \omega t$$

Hence, current $I = I_0\ sin\left(\omega t + \frac{\pi}{2}\right)$ is leading voltage, $V = V_0 \sin \omega t$ by $\frac{\pi}{2}$ *radians*

[03]

(e) Given that, $V_{rms} = 20\ V, f = 50\ Hz, C = 100\mu F$

(i) $$X_c = \frac{1}{2\pi f C}$$

$$X_c = \frac{1}{2\pi \times 50 \times 100 \times 10^{-6}}$$

$$\therefore X_c = 31.83\ \Omega$$

[02]

(ii) Using, $X_c = \frac{V_{rms}}{I_{rms}} = \frac{1}{2\pi f C}$

$$\Rightarrow \frac{V_{rms}}{I_{rms}} = 31.83$$

$$\therefore I_{rms} = \frac{V_{rms}}{X_c} = \frac{20}{31.83} = 0.628\ A$$

[03]

SECTION D

(a) (i) **Work function** – is the minimum amount of energy required to just remove an electron from the surface of a material. **[01]**

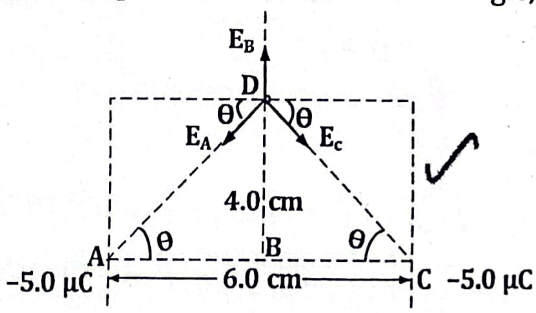
(ii) **A neutral material** – is one with equal number of positive and negative charges in it. **[01]**

(b) A gold leaf electroscope (G.L.E) is first given one type of charge e.g. the G.L.E. is first charged say ***positively*** either by induction or by contact.
A body under test is now bought near the metal cap of the charged G.L.E. but not in contact with it.
If there is an ***increase in the divergence*** of the leaf, then ***the body*** under test ***is positively charged*** (has the same charge as that of the G.L.E).

If however, there is a collapse or decrease in the divergence of the gold leaf, or leaves, then the body under test is ***either negatively charged or*** is ***neutral.***
The ***G.L.E. is*** now ***discharged*** by earthing its metal cap.
The G.L.E. is then ***charged negatively*** (i.e. given opposite charge to the charge that was initially put on the G.L.E).
The body under test is again brought ***near the metal cap*** of a negatively charged gold leaf electroscope and the new divergence on the golf leaf or gold leaves is noted.
If the **divergence** of the ***G.L.E. increases***, then the body is concluded to be **negatively charged.**
If on the other hand the gold leaf ***collapses*** again, the body, is concluded to be a ***neutral body.*** **[06]**

(c) (i) **Electric field intensity** – is the force exerted on a +1C charge placed in an electric field. **[01]**

(ii) Triangle ACD is an isosceles triangle, with BD as perpendicular bisector of AC



From Pythagoras theorem,

$AE^2 = AB^2 + BE^2$
$= 3^2 + 4^2$
$= 25$

Thus, BE = 5.0 cm

$\tan\theta = \dfrac{4}{3} \Rightarrow \theta = tan^{-1}\left(\dfrac{4}{3}\right)$

$\therefore\ \theta = 53.1°$

Let, Electric field intensity at point, E due to a charge, Q_A be $E_A = \frac{Q_A}{4\pi\varepsilon_0 r^2}$

$$\therefore\ |E_A| = \frac{(5.0\times10^{-6})\times(9.0\times10^{9})}{(5.0\times10^{-2})^2} = 1.80\times 7\ NC^{-1}\ from\ E\ towards\ A$$

$$\therefore\ E_C = \frac{(5.0\times10^{-6})\times(9.0\times10^{9})}{(5.0\times10^{-2})^2} = 1.80\times10^7\ NC^{-1}\ from\ E\ towards\ C$$

$$\sum E_x = (E_C\cos\theta) - (E_A\cos\theta) = (E_B - E_C)\cos\theta$$

$$(1.80 - 1.80)\times10^7\cos 53.1° = 0\ NC^{-1}$$

$$\sum E_y = -(E_A + E_C)\sin 53.1° = -3.60\times10^7\sin 53.1° = 2.88\times10^7 NC^{-1}$$

$\therefore\ E_x = 0\ NC^{-1}$
$\therefore\ E_y = -2.88\times10^7 NC^{-1}$ *and the resultant of* E_X & $E_y = -2.88\times10^7 NC^{-1}$

Thus, for the resultant electric field at point D, to be zero, $E_B = +2.88\times10^7 NC^{-1}$

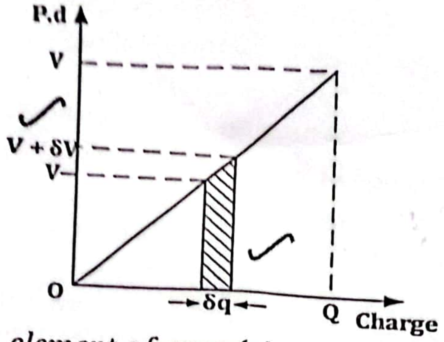
$$E_B = \frac{(Q_B)\times(9.0\times10^9)}{(4.0\times10^{-2})^2} = 2.88\times10^7$$

$\therefore\ Q_B = +5.12\times10^6\ C$ **so as to create opposite E – field to that at D.**

[05]

(d) (i) **The graphical method.**

Small work done by a p.d, V, in increasing charge on the plates by δq



$\delta W = element\ of\ area\ (shaded\ part)$

$\delta W = \frac{1}{2}\delta q[V + (V + \delta v)]$

$\delta W = \frac{1}{2}\delta q(2V + \Delta v)$

$\delta W = \frac{1}{2} \times 2V\delta q + \frac{1}{2} \times \delta v\delta q$

But $\delta v\ \delta q$ *tends to* 0 *since they are very small*

$\therefore\ E.O.A = V\delta q$

Total area = total work done increasing the charge from 0 *to* Q

$W = \frac{1}{2}bh = \frac{1}{2}QV$, *But* $Q = CV$ $\therefore$ *Energy stored*, $E = \frac{1}{2}CV \times V$

$\therefore$ *Energy stored*, $E = \frac{1}{2}\ C\ V^2$

[04]

(ii) ***Applications of sharp pointed charged conductors***

- Lightning conductors
- Van De Graff generators
- Hamilton's electric wind mill.

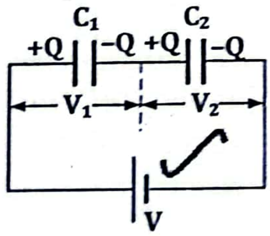
Any two *Correct applications @ 1 mark.*

[02]

9. (a) (i) ***Capacitance*** – is a ratio of the ***magnitude*** electric charge on any one of the plates of the capacitor to the p.d. between the plates. **[01]**

(ii) **The Same** magnitude of **charge**, Q, is induced on all the plates of the capacitors.

The same magnitude of charge, Q, is induced on all the capacitors but the p.d V is the sum of individual p.ds.



Net p.d, $V = V_1 + V_2$

But, $V_1 = \frac{Q}{C_1}$ and $V_2 = \frac{Q}{C_2}$

$\Rightarrow V = \frac{Q}{C_1} + \frac{Q}{C_2}$

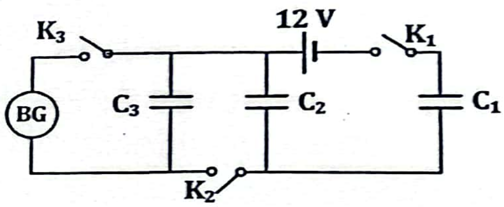
$V = Q\left(\frac{1}{C_1} + \frac{1}{C_2}\right) \Rightarrow \frac{V}{Q} = \left(\frac{1}{C_1} + \frac{1}{C_2}\right)$ but $\frac{V}{Q} = \frac{1}{C}$

Hence, $\frac{1}{C} = \left(\frac{1}{C_1} + \frac{1}{C_2}\right) = \frac{C_1 + C_2}{C_1\, C_2}$

$\therefore$ *Effective capacitance* $C = \left(\frac{C_1 \times C_2}{C_1 + C_2}\right) = \frac{\textit{Product of Capacitances}}{\textit{Sum of Capacitances}}$ **[04]**

NB: ***Accept the other alternative of capacitors in parallel, since none was specified in the question.***

(b) (i) In the circuit diagram, when K_1 is closed, the capacitors C_1 and C_2 are in series, so they acquire the same charge, Q



Their effective capacitance.

$C' = \frac{3.0 \times 6.0}{3.0 + 6.0} = \mathbf{2.0\ \mu F}$

The **Charge stored** in the network,

$Q = CV \Rightarrow (2.0 \times 10^{-6} \times 12.0)$

$Q = 2.4 \times 10^{-5}$ C or **24μC** **[03]**

(ii) In the circuit diagram, when K_1 is opened and K_2 is closed, the capacitors C_2 and C_3 are in parallel, so their effective, capacitance, $C'' = C_2 + C_3$

$C'' = (6.0 + 12.0) = \mathbf{18.0\ \mu F}$ But Charge remains that held by C_2 ***alone***

Energy stored in the system, $E = \frac{Q^2}{2\,C''} = \frac{1}{2} \times \frac{(2.4 \times 10^{-5})^2}{18.0 \times 10^{-6}}$

$\therefore$ ***Energy stored,*** $\boldsymbol{E = 1.60 \times 10^{-5}}$ **J** **[03]**

(iii) When, K_3 is finally closed, the charge, $Q = 2.4 \times 10^{-5}$ C, remains conserved

Using $Q = k\theta$

$\Rightarrow \theta_{max} = \frac{Q}{k} = \frac{2.4 \times 10^{-5}}{5.0} = 4.8 \times 10^{-6}$

$\therefore \boldsymbol{\theta_{max} = 4.8 \times 10^{-6}}$ ***radians*** **[03]**

(c) (i) **A dielectric** – is an ***insulator*** placed to fill all the space between the plates of a capacitor. **[01]**

(ii) It should not have conductible charges (free electrons)

It should be easily polarizable.

It should increase the dielectric field strength of a capacitor. **[02]**

(d) Charge density, $\delta = \frac{Q}{A} = 3.98 \times 10^{-4}\ C\,m^{-2}$ *and surface area,* $A = 4\pi r^2$

$\therefore$ *Charge,* $Q = \delta \times A = 4\pi r^2 \delta = 4\pi \times 0.10^2 \times 3.98 \times 10^{-4}$

$\therefore$ *Charge,* $Q = 5.00 \times 10^{-7} C$

$$Electric\ Potential = \frac{kQ}{r} = \frac{(5.0\times10^{-7})\times(9.0\times10^{9})}{0.10}$$

$\therefore$ ***Electric Potential,*** $V = 4.50 \times 10^{4}\ V$ **[03]**

10. (a) (i) **T.C.R.** – is the fractional change in the resistance of a material at 0°C per degree Celsius or per kelvin rise in temperature.

or It's the change in resistance of a material per kelvin or degree rise in temperature divided by resistance of the material at zero degree Celsius.

SI unit – is per degree Celsius or per kelvin ($°C^{-1}$ or K^{-1}) **[02]**

(ii) Copper is a metal and when all metals are heated, the lattice ions vibrate with larger amplitudes.

This reduces the mean free path of the conduction electrons.

This in turn increases the number of collisions between the conduction electrons and the lattice ions.

The average speed of the conduction electron is thus reduced and reduces the number of electrons crossing a section of the conductor per second.

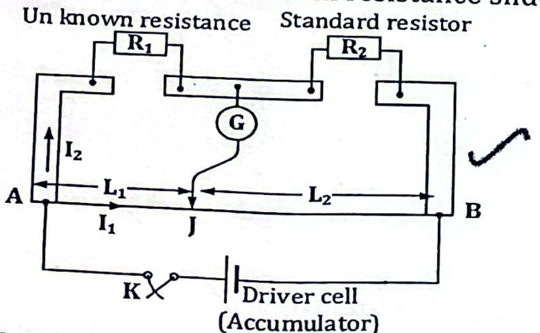
The current flowing in the conductor thus reduces and since current is inversely proportional to the resistance, thus resistance increases.

Hence, increase in temperature of copper, increases its resistance, hence copper has a positive temperature coefficient of resistance. **[03]**

(b) (i) Let I_1 = current through the uniform resistance slide wire AB.

I_2 = current through the resistances R_1 and R_2 when $i_g = 0$

k = resistance per cm of the uniform resistance slide wire AB



When switch K is closed and jockey J moved along AB until, G shows no, deflection, the p.d across R_1 = p.d across AJ

$I_2R_1 = I_1k\,L_1$ ……………………………… (i)

The p.d. across R_2 = p.d across JB

$I_2R_2 = I_1k\,L_2$ ……………………………… (ii)

Eqn. (i) ÷ (ii) $\frac{R_1}{R_2} = \frac{L_1}{L_2}$ or $\frac{R_1}{R_2} = \frac{L_1}{100-L_1}$ is the balance condition. **[04]**

(ii) Standard resistors are made of special alloys such as constantan, nichrome and manganin that are specially tailored to achieve ***high desired electrical properties and standards*** of resistant devices in metal mixtures that can attain conditions such as: -

Increased melting point of such alloys
High resistivities
High tensile strength
Low temperature coefficient of resistance
Free from oxidation when exposed to atmosphere, e.t.c.
Higher Specific gravity or relative density.
High ductility and high malleability.
Such conditions cannot easily be obtained from a single metal.

Any correct condition @ 1 mark **[02]**

(c) (i) An ***accumulator*** acting as the driver cell provides ***a steady current*** through a ***uniform resistance slide wire*** for a relatively longer period of time before running down.
This steady current then, sets up ***a constant p.d per unit length*** *(e.g. p.d per cm or p.d per metre)* across the slide wire.
An *unknown e.m.f. or p.d, V,* is ***connected in opposition*** to the driver cell so as to supply current in the opposite direction to that of the driver cell.
The ***jockey is tapped on*** the slide wire until the ***centre zero galvanometer shows no deflection***, and ***a balance length L is noted,*** it means the *unknown p.d. equals the p.d set up along the slide wire.*
Hence, the unknown ***p.d is proportional to the balance length*** i.e. $V \propto L$

[03]

(ii) A slide wire potentiometer ***may fail to produce a balance point if***: -

- The slide wire has no resistance, extremely very high resistance or has a very low resistance.
- The unknown e.m.f. or p.d. is connected the same way round as the driver cell. i.e. +ve of one cell is connected to the – ve of the other cell.
- One cell or battery is nearly run down while the one of the other source may be very new.
- The cell holder terminals are contaminated with rust and other impurities.

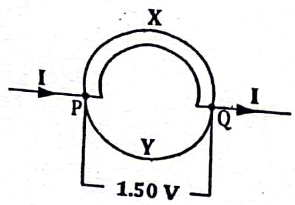
Any two *Correct responses* *<u>except loose connections</u>* ***@ 1 mark.*** **[02]**

(d) Using, $R_x = \frac{\rho l}{A_x}$

$l = 0.50\ m, A_x = 2.0 \times 10^{-6} m^2, \ \rho = 1.50 \times 10^{-6} \Omega m$

$R_x = \frac{1.50 \times 10^{-6} \times 0.50}{2.0 \times 10^{-6}} = 3.75 \times 10^{-1}\ \Omega$ and similarly

$R_y = \frac{1.50 \times 10^{-6} \times 0.50}{1.5 \times 10^{-6}} = 5.00 \times 10^{-1}\ \Omega$



$Effective\ resistance\ of\ the\ loop, R = \frac{0.375 \times 0.500}{0.375 + 0.500} = 0.214\ \Omega$

But, p.d across PQ, $IR = 1.50 \Rightarrow Current\ I = \frac{1.50}{0.214} = 7.01\ A$ **[04]**

=END=