UACE PHYSICS PAPER 2016 GUIDE

Instructions to the candidates:

Answer **five** questions taking at least one from each of the sections **A, B, C** and **D**, but not more than one question should be chosen from either section **A** or **B**

Any additional question (s) will not be marked.

Mathematical tables and squared paper will be provided

Non programmable calculators may be used.

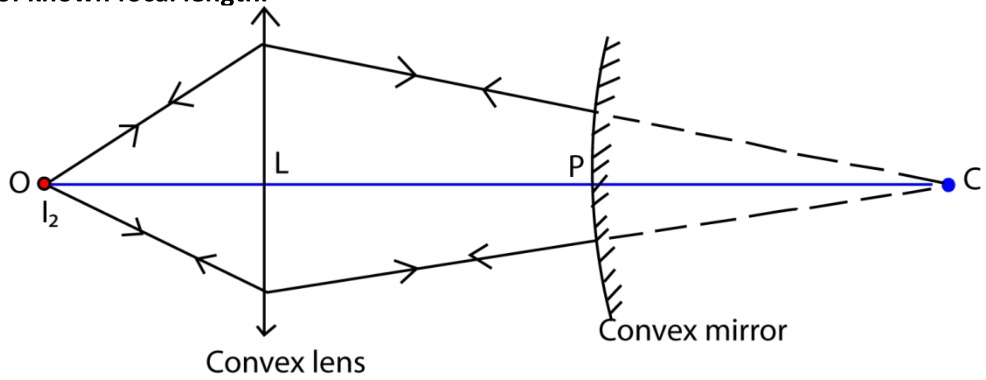
Assume where necessary

Acceleration due to gravity, g	$9.81ms^{-2}$
Electron charge, e	$1.6 \times 10^{-19}C$
Electron mass	$9.11 \times 10^{-31}kg$
Plank's constant, h	$6.6 \times 10^{-34}Js$
Speed of light in the vacuum, c	$3.0 \times 108ms^{-1}$
Specific heat capacity of water	$4.200Jkg^{-1}K^{-1}$
Avogadro's number, N_A	$6.02 \times 10^{23}mol^{-1}$
The constant, $\frac{1}{4\pi\varepsilon_0}$	$9.0 \times 10^{9}F^{-1}m$
Permittivity of free space, μ_0	$4.0\pi \times 10^{-7}Hm^{-1}$
Permittivity of free space, ε_0	$8.85 \times 10^{-12}Fm^{-1}$
One electron volt	$1.6 \times 10^{-19}J$
Resistivity of Nichrome wire at 25^0C	$1.2 \times 10^{-6}\Omega m$

SECTION A

1. (a) (i) Describe how the focal length of a convex mirror can be measured using a convex lens of known focal length. (04marks)

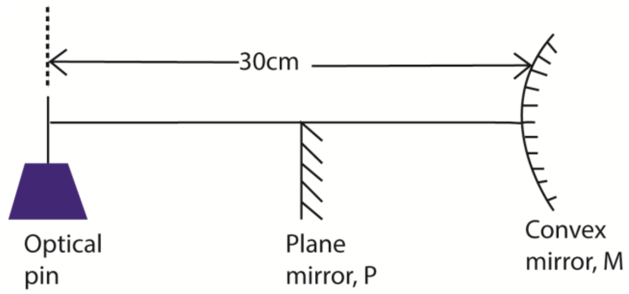
Determination of the focal length of a convex mirror can be measured using a convex lens of known focal length.



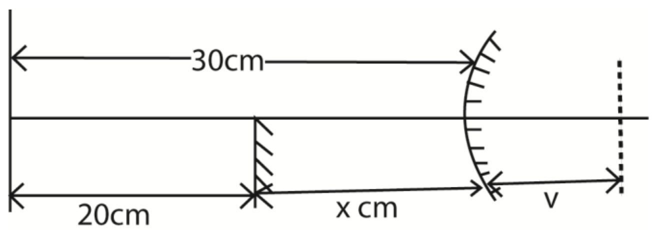
- The apparatus is arranged as shown above
- An object, O is placed in front of a convex lens L and its image formed at C
- The distance LC is measured and recorded.
- The convex mirror whose focal length, f, is required is placed is placed between L and C with its reflecting surface facing the lens.
- The lens is then moved along the axis, OC until a converging beam incident normally on the mirror forms its image at O
- Distance LP is measured

PC = LC – LP thus, f can be determined from f = $\frac{PC}{2}$

(ii) The plane mirror, P, in the figure below is adjusted to a position20cm from optical pin, the image of the pin in P coincides with its image in M.



Calculate the focal length of the convex mirror. (04marks)



$v = 20 - x$

$= 20 - (30-20) = 10cm$

Using $\frac{1}{f} = \frac{1}{u} + \frac{1}{V}$

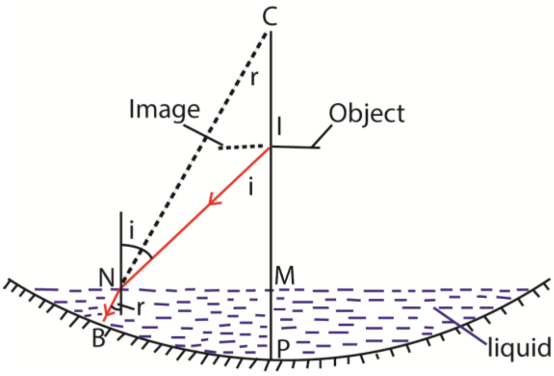
$= \frac{1}{30} + \frac{1}{-10}$

f = 15cm

(b) A pin is clamped horizontally above a concave mirror with its tip along the principal axis. When the pin is adjusted, it coincides with its image at a distance R from the mirror. When a small liquid of refractive index, n, is put on the mirror, the pin again coincides with its image at a distance R' from the mirror. Show that the refractive index, n, is given by

$n = \frac{R}{R'}$ (04marks)

Setup



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

From the diagram,

$\sin i = \frac{NM}{NI}$ and $\sin r = \frac{NM}{NC}$

$n = \frac{NM}{NI} \div \frac{NM}{NC} = \frac{NM}{NI} x \frac{NC}{NM} = \frac{NC}{NI}$

For small angle, i, and small liquid

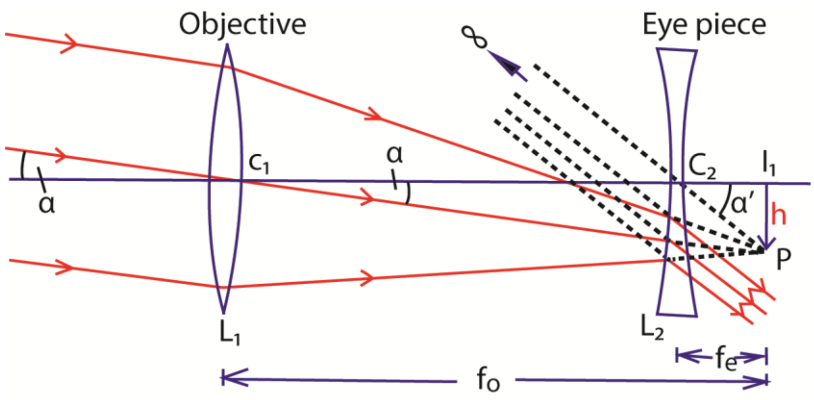
NC $\approx PC = R$ and NI $\approx PI = R'$

Thus, $n = \frac{R}{R'}$

(c)(i) Explain the term eye-ring as applied to the telescope. (02marks)

The eye-ring is the image of objective lens in eyepiece

(ii) Draw a ray diagram to show the formation of final image in Galilean telescope in normal adjustment. (03marks)



Galilean telescope in normal adjustment

(iii) Explain two advantages and one disadvantage of the telescope in (c)(ii) above. (03marks)

Advantages of a Galilean telescope

It forms a final erect image.

It is shorter than the terrestrial and astronomical telescopes because the separation of lenses is $f_0 - f_e$.

Disadvantages of a Galilean telescope

It has a small field of view.

It has a virtual eye ring not accessible to the observer

2. (a)(i) When does light pass through a prism symmetrically? (01marks)

Light is said to pass through a prism symmetrically when the angle of incidence is equal to the angle of emergence or when minimum deviation occurs.

(ii) Find the angle of incidence, i, on an equilateral prism of refractive index 1.5 placed in air, when light passes through it symmetrically. (03marks)

From Snell's law, $1.5 = \frac{sini}{\sin r}$

But, $r = \frac{A}{2} = \frac{60}{2} = 30^0$

Sin i = 1.5sin 30^0

i = 48.6^0

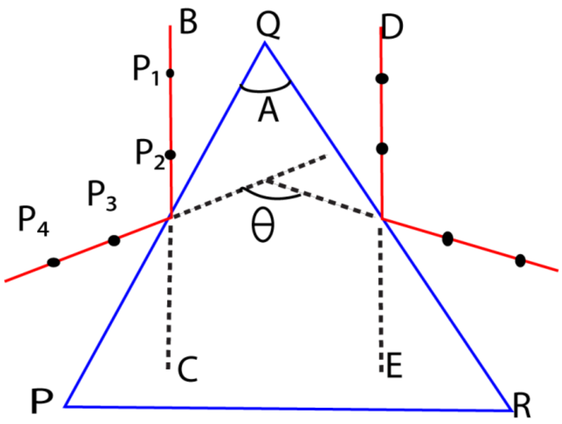
(iii) Describe what happens to the deviation of light passing through a prism in (a) (ii) when the angle of incidence is increased from a value less than i to a value greater than i. (02marks)

Angle of deviation increases when either angle i is increased or decreased.

(b) Describe how the refractive angle of a prism can be determined using optical pins. (05marks)

Using optical pins

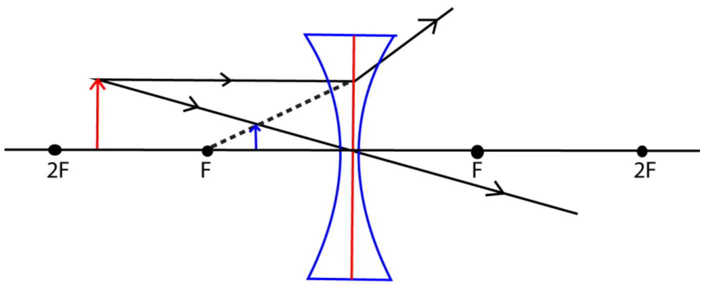
A white paper is stuck to the soft board using top-headed pins. Two parallel lines AB and DC are drawn on the paper and the prism is placed with its apex as shown.



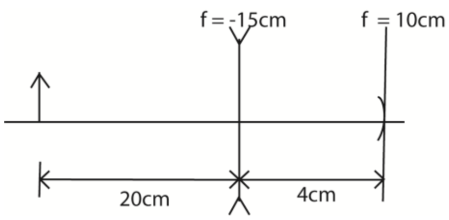
- Two optical pins **P1** and **P2** are placed along AB and pins **P3** and **P4** are placed such that they appear to be in line with the images of P1 and **P2** as seen by reflection from face PQ.
- The procedure is repeated for face QR. The prism is removed and angle θ is measured.

  The required refracting angle $A = \frac{\theta}{2}$

(c) (i) Draw a sketch ray diagram showing formation of the image of a finite size real object by a concave lens. (02marks)



(ii) A concave lens of focal length 15.0cm is arranged coaxially with a concave mirror of focal length 10.0cm, a distance of 4.0cm apart. An object is placed 20.0cm in from of the lens on the side remote from the mirror. Find the distance of the final image from the lens. (04marks)



Action of concave lens

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{-15} - \frac{1}{20}$$

$$v = \frac{-60}{7} = -8.6\text{cm}$$

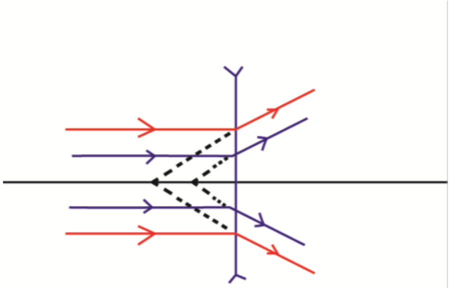
Action of concave mirror

u = 8.6 + 4 = 12.6cm, f = 10

$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{10} - \frac{1}{12.6}$; u = 48.5cm

Distance of image from the lens = 48.5- (20 + 4) =24.5 cm on the side remote to the mirror

(d) With the aid of a sketch ray diagram explain spherical aberration in a concave lens, and state how it is minimized. (03marks)



Concace lens

When a wide beam of light falls on the lens, marginal rays are refracted and appear to come from a point different from that of the central rays.

The image formed is thus blurred (distorted). This is called spherical aberration. It is minimized by using an opaque disc with central hole to allow only central rays to pass through

SECTION B

3. (a) What is meant by the following as applied to waves

(i) Resonance

Resonance is said to occur when a body is vibrate at natural frequency due to impulses received from nearby source of the same frequency.

(ii) Frequency

Number of complete cycles made per second.

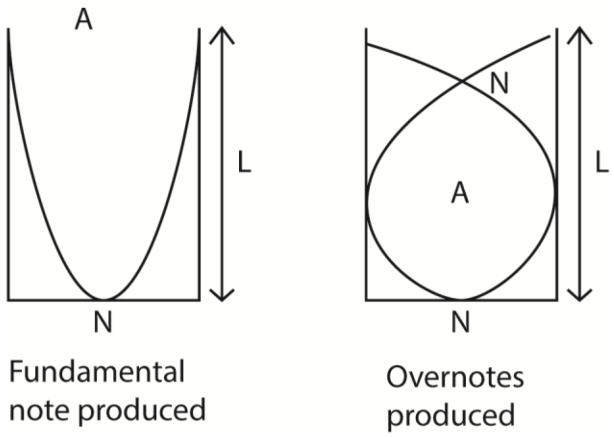
(b) Explain with the aid of a diagram the term fundamental note and overtone as applied to vibrating air in closed pipe.

When the air is brown into a pipe, it vibrates in many different modes, producing waves of different frequencies.

The note of lowest frequency is dominant one and is said to be the fundamental note.

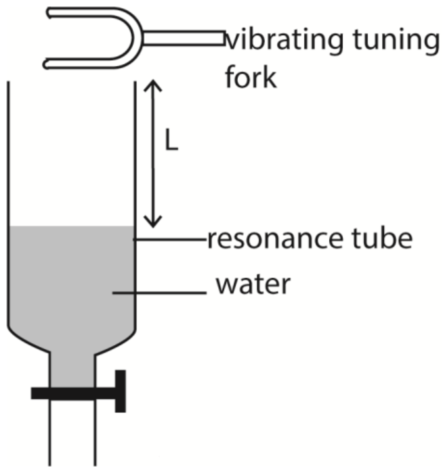
A fundamental note is formed by a wave of large amplitude and with a node N at the closed end and an antinode A at the open end.

The other notes have frequencies higher than that of the fundamental note and are usually have low amplitudes and are less intense. They are called over notes.



(c) Describe how you would determine the speed of sound in air using a resonance tube and several tuning forks.

Solution



- A glass tube which can be drained from bottom is filled with water.
- A sounding tuning fork of frequency f is brought to the mouth of the tube.
- The water is slowly drained until a loud sound is heard. The tap is closed and length L_1 is measured.
- The tuning fork is again sounded at the mouth of the tube and the water drained further until a loud sound is heard and distance L_2 is noted
- Velocity, v, of sound in air = $2f(L_2-L_1)$

(d) (i) Explain the formation of beat.

When two notes of slightly different frequencies but similar amplitudes are sounded together, they superpose producing a note whose intensity increases and reduces periodically. This phenomenon is called beats.

(iii) Derive expression for beat frequency.

Consider two notes of frequencies f_1 and f_2 sounded together. Suppose the wave of frequency f_1 makes one cycle more than that of f_2 in time T_0.

In time T, the number of waves of f_1 is f_1T

The number of waves of f_2 is f_2T

Therefore $f_1T - f_2T = 1$

$$f_1 - f_2 = \frac{1}{T}$$

$$\text{but } \frac{1}{T} = f$$

$\therefore f_1 - f_2 = f$, the beat frequency

(b) Two observers A and B are provided with sources of sound of frequency 750Hz. If A remains stationary while B moves away at a velocity of $2.0ms^{-1}$, find the number of beats heard per second by A. (Velocity of sound in air is $330ms^{-1}$)

Solution

A hears a note of frequency 750Hz due to its own source. He also hears a note of frequency, f' due to B.

But $f' = \frac{v}{\lambda'} = \left(\frac{v}{v+u_s}\right)f$ where $\lambda' = \frac{v+u_s}{f}$

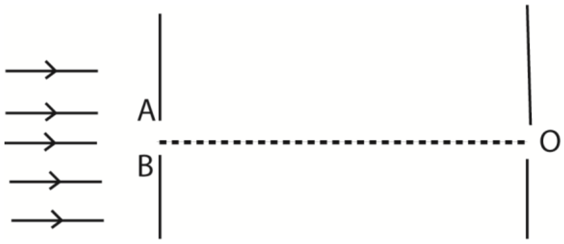
$$f' = \frac{330}{330+2} \times 750 = 745.5\text{Hz}$$

Beat frequency, $f = f_A - f = 750 - 745.5 = 4.5$Hz

4. (a) What is meant by diffraction?

This is the spreading of light waves beyond their geometrical boundaries leading to interference.

(c) Explain using Huygens's principle the diffraction pattern produced by a single slit.



The diffraction patterns formed are due to superposition of secondary wavelets formed from the main wave front at AB

Each point on the wave front in the gap AB acts as a secondary source of wavelets that propagate in forward direction

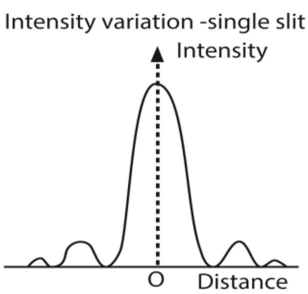
At O, most of the wavelets arrive in phase causing constrictive interference leading to formation of the central bright band.

On outwards from O, an increasing number of wavelets arrive out of phase and hence the bright bands reduces in intensity until a dark band is formed where all wavelets arrive out of phase.

As we move farther away from O parallel to AB, the intensity rises again to a much smaller maximum producing less bright band than at O.

More and more alternative bright and dark bands of reducing intensities are formed further from O parallel to AB where wave wavelets meet in phase and out of phase respectively.

The graph of intensity against distance is shown below.



(d) Light of wavelength 5.0 x 10^{-7}m falls on a grating with 600 lines per mm, determine the highest order of diffraction that can be observed.

λ = 0.5 x 10^{-6}m

sin θ = $\frac{n\lambda}{d}$; d = $\frac{1}{600000}$ m^{-1}

$l = 1\ x\ n\ x\ 0.5\ x\ 10^{-6}\ x\ 600000$

n = $\frac{1}{0.5\ x\ 10^{-6}\ x\ 600000} = \frac{1}{3\ x\ 10^{-2}} = \frac{100}{30} = 3\frac{1}{3}$

(e) (i) Explain what is meant by plane of polarized light?

A plane polarization of light is on in which the electric vector of polarized light varies or vibrates.

Plane polarized light is one whose electrical vectors varies in only one plane perpendicular to the direction of travel of the wave.

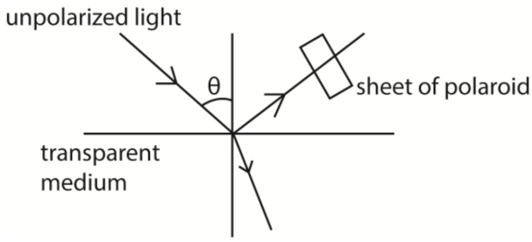
(ii) One application of polarized light.

Determination of concentration of glucose

(iv) A liquid of refractive index 1.3 is used to produce polarized light by reflection. Calculate the angle of incidence of incidence on the liquid surface.

(e) (i) Describe how polarized light can be produced by reflection

Solution



- A narrow beam of light is made incident on transparent medium.
- The reflected light is observed through a Polaroid.
- The angle of incidence is varied
- At each angle of incidence, the polaroid is rotated about the axis along the light incident on it
- At one angle of incidence, the light gats cut off the observer as the Polaroid is rotated.
- The reflected ray is now completely polarized.

(ii) State two uses of polarized light.

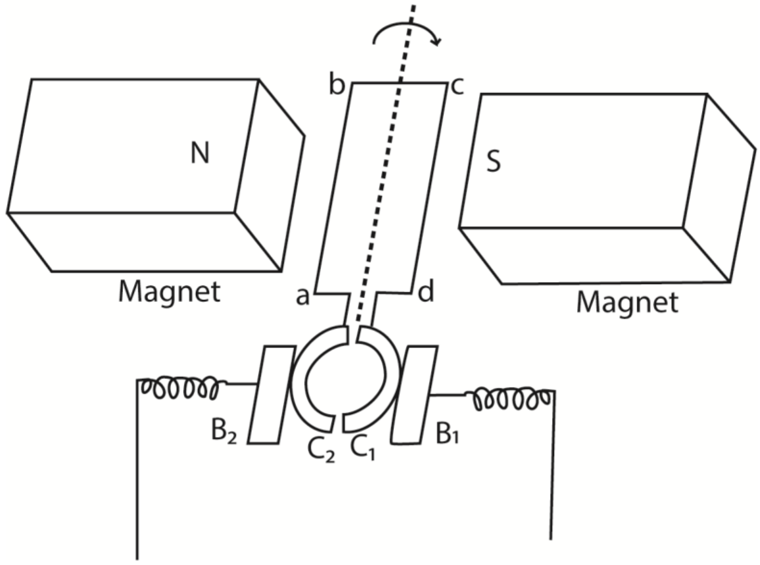
- Measurement of sugar concentration
- Determination of stress distribution in materials like glass
- In film to give illusion of three dimension (orography)
- In liquid crystal display

SECTION C

5. (a) (i) what is the difference between a motor and a dynamo? (01mark)

A dynamo converts mechanical energy to electrical energy while a motor converts electrical energy into mechanical energy.

(ii) Describe with the aid of a labelled diagram the structure and mode of operation of a d.c generator. (06marks)



B_1 and B_2 are carbon brushes, C_1 and C_2 are split ring commutators and abcd is a rectangular coil

When the coil rotates at uniform velocity in magnetic field, e.m.f is induced in it.

When the coil is in vertical position, the commutators change brushes C_1 to B_2 and C_2 to B_1.

E.m.f reverses direction but the current does not change direction. Hence current flows in the same direction in a resistor.

(iii) Describe briefly the factors that determine the peak value of the induced e.m.f. (03 marks)

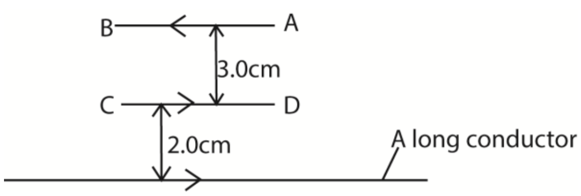
The peak value of induced e.m.f increases with increase in

- The number of turns in the coil
- The area of the coil
- The strength of the magnetic field
- The frequency of rotation of the coil

(iv) How can a d.c. generator be converted into an a.c. generator. (01mark)

To convert a d.c. generator to an a.c. generator, the ends of the rectangular coil are connected to a pair of slip rings instead of the commutators.

(b) Figure below shows two wires AB and Cd of length 5.0cm each currying a current of 10.0A in the direction shown. A long conductor carrying a current of 15A is placed parallel to the wire CD 2.0cm below it.



(i) Calculate the net force on the long wire (06marks)

$F_1 = \frac{\mu_0 I_1 I_2}{2\pi r_1}\ xCD$

$= \frac{4\pi\ x\ 10^{-7}\ x\ 10\ x\ 15\ x\ 10^{-2}}{2\pi\ x\ 2\ x\ 10^{-2}}$ = 7.5 x 10^{-5}N

$F_2 = \frac{\mu_0 I_1 I_2}{2\pi r_0}\ xAB$

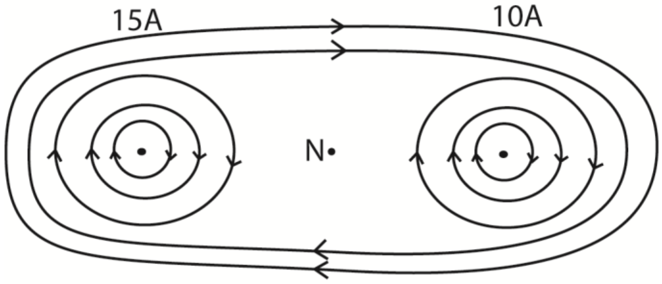
$= \frac{4\pi\ x\ 10^{-7}\ x\ 10\ x\ 15\ x\ 10^{-2}}{2\pi\ x\ (2+3)\ x\ 10^{-2}}$ = 3 x 10^{-5}N

Net force = $F_1 - F_2$

= 7.5 x 10^{-5}N - 3 x 10^{-5}N

= 4.5 x 10^{-5}N toward CD.

(ii) Sketch the magnetic field pattern between the long wire and wire CD after removing wire AB. Use the field pattern to define a neutral point (03marks)



N- neutral point

A neutral point is appoint where two magnetic field are equal and opposite and the resultant is zero.

6. (a) What is meant by the following as applied to the earth's magnetic field?

(i) Magnetic meridian (01mark)

Magnetic meridian is a vertical plane in which a freely suspended magnet sets itself.

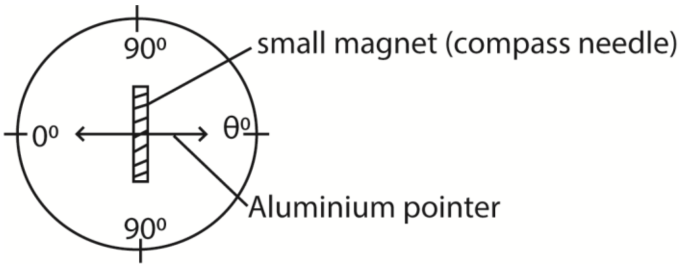
(ii) Magnetic variance (01mark)

Magnetic variation is the angle between the magnetic and geographical meridians.
Or,
angle between the earth's magnetic axis and geographical axis.

(b) Describe the structure and mode of action of the deflected magnetometer (06marks)

It is used to compare magnetic moments of magnets

It consists of a small compass needle (small magnet) which is pivoted on a vertical axis and carries alight aluminium pointer. The pointer can rotate over a circular scale (0-90^0)



The deflection magnetometer is used to compare two magnetic field flux densities, one being the horizontal component of the earth's flux density B_H.

The two fields i.e. BH and any other field to be compared are arranged at right angles to each other. The compass needle then sets itself at angle, θ, to its initial direction when it was in the field BH alone.

The needle now points in the direction of the resultant field of B_H and B.

The angles of deflection θ1 and θ2 of the needle are measured.

The average deflection θ = $\frac{\theta_1 + \theta_2}{2}$ is determined.

The ratio $\frac{B_C}{B_H}$ = tan θ

(c) A circular coil of four turns and diameter 11cm has its plane vertical and parallel to the magnetic meridian of the earth. Determined the resultant magnetic flux density at the center of the coil when a current of 0.35A flows in it.

(Take the horizontal component of the earth's magnetic flux density to be 1.6 x 10^{-5}T) (04marks)

Bc = $\frac{\mu_0 NI}{2r} = \frac{4\pi \ x \ 10^{-7} \ x \ 4 \ x \ 0.35}{2 \ x \ 5.5 \ x \ 10^{-2}}$ = 1.6 x 10^{-5}T (due to east or west

Let the resultant field be Br

$B_R = \sqrt{(B_C^2 + B_H^2)} = \sqrt{(1.6 \ x \ 10^{-5})^2 + (1.6 \ x \ 10^{-5})^2}$ = 2.26 x 10^{-5}T

tan θ = $\frac{B_C}{B_H} = \frac{1.6 \ x \ 10^{-5}}{1.6 \ x \ 10^{-5}}$ = 1

θ = 45^0

(d) (i) Define **self-induction** and **mutual induction** (02marks)

Self – induction is the generation of e.m.f in a circuit (coil) due to a change in the current in the same circuit; and mutual induction is the generation of e.m.f in a circuit (coil) due to a change in current in adjacent but separate circuit.

(ii) Give the causes of power loss in an a.c. transformer and state how each can be minimized. (04marks)

Cause of power loss	Means of minimizing the loss
Ohmic loss	Use of thick copper wires
Eddy currents	Use of a laminated core
Magnetic flux leakage	Winding secondary coil on primary coil

(iii) Explain why the current in the primary coil of a transformer increases when the secondary is connected to the load.

When load is connected to the secondary winding, a current flows in it. The current flows in such a direction as to reduce the back e.m.f in primary coil, hence the current increase.

7. (a) Define root mean square (rms) value of alternating voltage (01mark)

Root mean square value (r.m.s) of an alternating current is the steady current which would dissipate heat at the same rate in a conductor as the a.c.

(b) A resistor of resistance 100Ω is connected across an alternating voltage, V = 20sin120πt.

(i) Find the frequency of the alternating voltage (01mark)

ω = 2πf

120π = 2πf

f = 60Hz

(ii) Calculate the mean power dissipated in the resistor. (03marks)

Power, P = $\frac{V^2_{r.m.s}}{R} = \frac{v_0^2}{2R} = \frac{20\ x\ 20}{2\ x\ 100}$ = 2W

(c) (i) Show that when an inductor s connected to an a.c supply voltage of V = V_0sin2πft, the resulting current lags the voltage by 90^0. (04marks)

$E_B = -L\frac{dI}{dt}$

But for finite current, V = $-E_b$

V = $\frac{LdI}{dt}$; but V = V_0sin2πft,

$\frac{dI}{dt} = \frac{-V_0}{L} sin2\pi ft$

$\int dI = \frac{V_0}{L}\int \sin 2\pi ftdt$

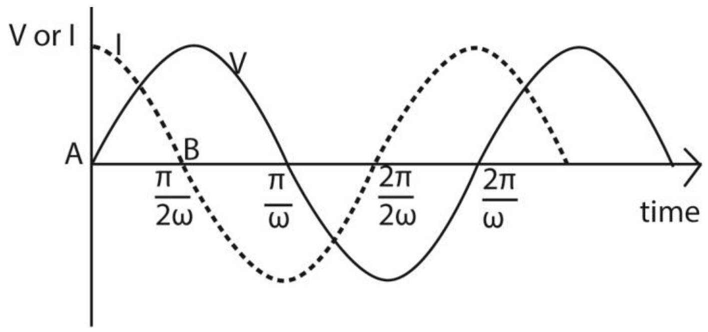
I= $\frac{-V_0}{2\pi ftL}cos2\pi ft$

From trigonometry, $cos2\pi ft = \sin(2\pi ft + \frac{\pi}{2})$

Thus, I= $\frac{-V_0}{2\pi ftL}\sin(2\pi ft + \frac{\pi}{2})$

⇨ I lags V by $\frac{\pi}{2}$ or 90^0

(ii) Sketch on the same axes the variation with time of the voltage and current is a capacitor is connected to the voltage supply in (c)(i). (02marks)



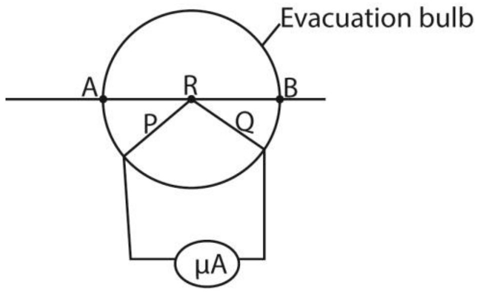
Explanation

The current I through (not across) a capacitor is C $\frac{dV}{dt}$. This is the slope of the voltage.

When a capacitor is connected to an AC voltage (at the zero crossing) the maximum current flow will occur immediately, i.e. t = 0,$\frac{dV}{dt}$ will approach infinity instantly and then repeat as a sinusoidal waveform.

There will be a peak current at every zero crossing of the voltage waveform. The current waveform will lead the voltage waveform 90 degrees.

(d) (i) Describe how thermocouple meter works. (04marks)



P and Q are dissimilar wires

Current to be measured is passed through the wire AB and heats the junction R of the thermocouple. The thermoelectric effect generated at R causes a direct current to flow through the micrometer calibrated to measure the r.m.s value of current.

(ii) Explain any precautionary measure taken in the design of thermocouple meter (02mark)

The fine wire is enclosed in an evacuated glass bulb to shield it from draughts. If the wire was in the open, some heat would be lost to the surrounding so that the temperature difference between the hot and cold junctions would not be proportional to the power dissipated in the wire.

(e) A capacitor of capacitance 60μF is connected to an a.c. voltage supply of frequency 40Hz. An a.c ammeter connected in series with the capacitor reads 2.2A. Find the p.d across the capacitor. (03marks).

$$X_c = \frac{I}{2\pi f C} = \frac{1}{2\pi \; x \; 40 \; x \; 60 \; x \; 10^{-6}}$$

Voltage, $V_{r.m.s} = I_{r.m.s} \times X_c$

$$= \frac{2.2 \; x \; 1}{2\pi \; x \; 40 \; x \; 60 \; x \; 10^{-6}}$$

= 146V

SECTION D

8. (a)(i) Define electrical resistivity. (01mark)

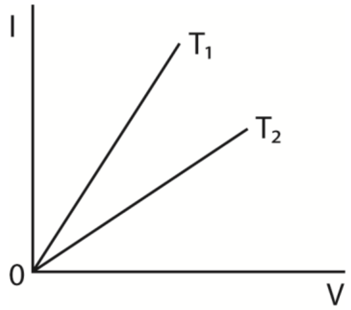
Electric resistivity is the resistance across opposite faces of 1m cube of material.

(ii) Explain how length and temperature of a conductor affect its resistance. (04marks)

Length: Increase in length leads to longer path of electrons. This means more collision will occur with the metal ions. This leads to a reduction in current and hence increase in resistance.

Temperature- increase in temperature increases the amplitude of vibrations of ions. This increases the rate of collision between the electrons and the ions. This will reduce the amount of current flowing and hence increase in resistance.

(iii) The figure below shows a circuit-voltage graphs for a metallic wire at two different temperatures T_1 and T_2.

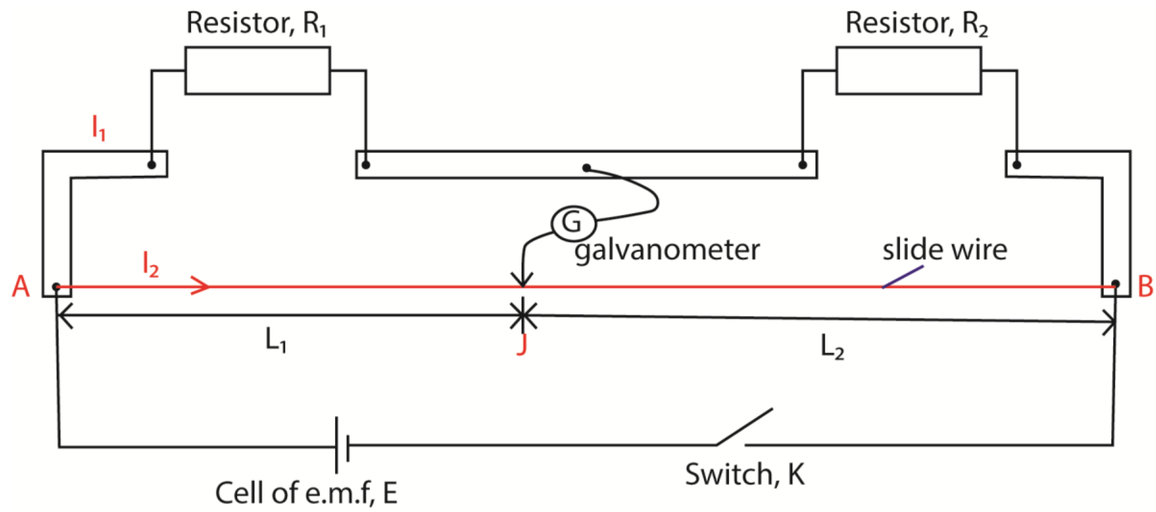


State in which of the two temperatures resistance is greater and explain your answer (03marks)

$T_2 > T_1$

At T_1 the gradient is higher than at T_2 (or at each voltage the current flowing at temperature T_1 is higher than at temperature T_2). This implies that the resistance at T1 is lower than the resistance at T_2.

(b) (i) Derive the balance condition when using a meter bridge to measure resistance. (03marks)

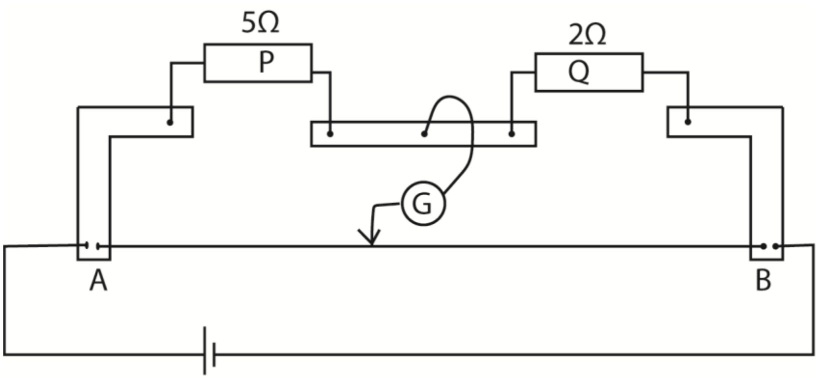


- The setup is as shown above, J is the balancing point.
- At balance the current through R_1 = current through R_2 and current through AJ = current through JB
- ∴ p.d across R_1 = p.d across AJ
- $I_1R_1 = I_2R_{AJ}$
- If r is the resistance per meter of wire AB,
- Then, $I_1R_1 = I_2rL_1$ …….. (i)
- P.d across R_2 = p.d across JB
- $I_1R_2 = I_2R_{JB}$
- Then, $I_1R_2 = I_2rL_2$ ……… (ii)
- Dividing (i) by (ii)
- $\frac{R_1}{R_2} = \frac{L_1}{L_2}$

(ii) State **two** precautions taken to achieve an accurate measurement. (02marks)

- The slide wire should have uniform resistance
- The resistors should be chosen such the balance point is approximately in the middle of slide wire.
- The resistors should be interchanged to use average values.

(c) The figure below shows two resistors P and Q of resistance 5Ω and 2Ω respectively connected in the two gaps of the meter bridge.



A resistor X of cross-sectional area $1mm^2$ is connected across P so that the balance point is 66.7cm from A. if the resistivity of wire X is $1.0 \times 10^{-5}\Omega m$ and the resistance wire AB of the meter bridge is 100cm long, calculate the length of X. (04marks)

Let the combined resistance of P and X be R

- $\frac{R}{Q} = \frac{L_1}{L_2}$

  $\frac{R}{2} = \frac{66.7}{33.3}$

  R = 4Ω

  Since P and X are in parallel

  $R = \frac{5X}{5+x} = 4$

  X = 20Ω

  From $L_x = \frac{XA}{\rho} = \frac{20 \times 1.0 \times 10^{-6}}{1 \times 10^{-5}} = 2.0m$

(d) Explain how electrons attain a steady drift velocity when current flows through a conductor. (02marks).

When a p.d is supplied across a conductor, the free electrons are accelerated in the direction of the field. As they move, they collide with the metal ions until they attain a steady drift velocity.

9. (a) (i) Explain equipotential surface. (04marks)

Equipotential surface is one on which the electric potential is the same (or constant) at all points. The work done to move a charge from one point to another along the surface is zero. This implies that the electric field is perpendicular to the surface.

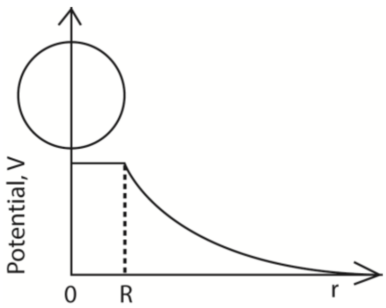
(ii) Give an example of an equipotential surface (01mark)

- the surface of the earth
- the surface of charged conductor.
- An imaginary surface containing points equidistant from a point charge

(b) (i) State coulomb's law. (01 marks)

Coulomb's law states that the force between two point charges is directly proportional to the product of the magnitude of charges and inversely proportional to the square of the distance between them.

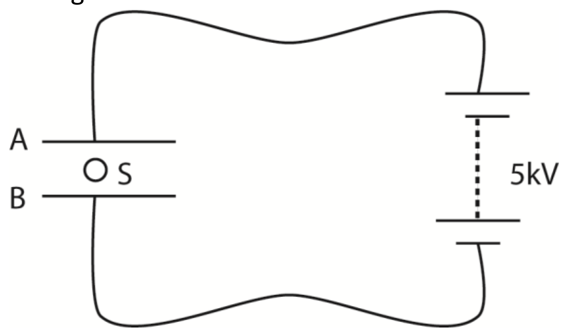
(ii) With the aid of a diagram, explain the variation of electric potential with distance from the center of charged metal sphere (03marks)



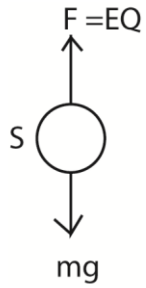
Within the sphere, electric potential is constant. There is no charge inside.

Outside the sphere, the potential is inversely proportional to the distance r from the center of the sphere.

(iii) Two metal plates A and B, 30cm apart are connected to a 5kVdic supply as shown in the figure below.



When a small charged sphere, s, of mass 9.0×10^{-3}kg is placed the plates, it remains stationary. Indicate the forces acting on the sphere and determine the magnitude of the charge on the sphere. (04marks)



Since the sphere is stationary, F = mg

EQ = mg where Q is the charge on the sphere

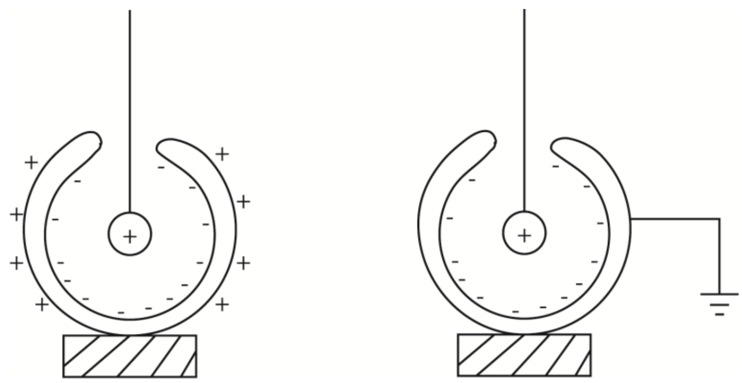
E = $\frac{V}{d}$;

$\therefore$Q = $\frac{mgd}{V} = \frac{9 \times 10^{-3} \times 9.81 \times 30 \times 10^{-2}}{500}$ = 5.3×10^{-6}C or 5.3μF

(c) (i) Define electric field intensity. (01marks)

Electric field intensity at a point is the force exerted on positive charge of 1C placed a point in an electric field.

(ii) With the aid of a diagram, explain electrostatic shielding. (04marks)



- The test material is suspended in an almost enclosed conducting can.
- It includes an equal and opposite charge inside the can and similar charge to it on the outer wall such that the net charge inside the can is zero.
- An external field only affects charge distribution on the outer surface of the can.
- Hence the material is shielded from the external field.

  NB. Electrostatic shielding is the act of protecting material from the influence of an electric field or creating an electrically neutral space in an electric field.

(d) Explain briefly why a neutral metal body is attracted to a charged body when brought near it. (02marks)

- When a neutral metal is brought near a charged material, opposite charge is induced the side of the metal and the charge similar to that of the charged body on the far side.
- Since opposite charges are now closer to each other, the attraction force between the material is greater that the repulsion force. Hence the metal body is attracted.

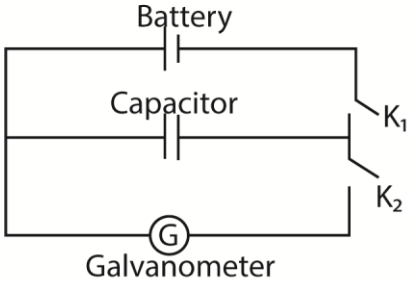
10. (a) (i) What is meant by capacitance of a capacitor? (01mark)

Capacitance of a capacitor is the ratio of the magnitude of charge on either plates of a capacitor to the capacitor to the potential difference between the plates

(ii) A parallel plate capacitor is connected across a battery and charged fully. When a dielectric material is now inserted between its plates, the amount of charge stored in the capacitor changes. Explain the change. (04marks)

- When a dielectric is inserted between the plates of a charged capacitor, its molecules get polarized. The surfaces of the dielectric thus develops charges opposite to those on adjacent capacitor plates.
- Electric field intensity develops between the faces of the dielectric in the opposition of the applied field and this reduces the electric field between the plates.
- Since the p.d is now less than the terminal p.d of the battery, more charges are conducted to the capacitor until the p.d is again equal to that of the battery. Hence charge on the capacitor increase.

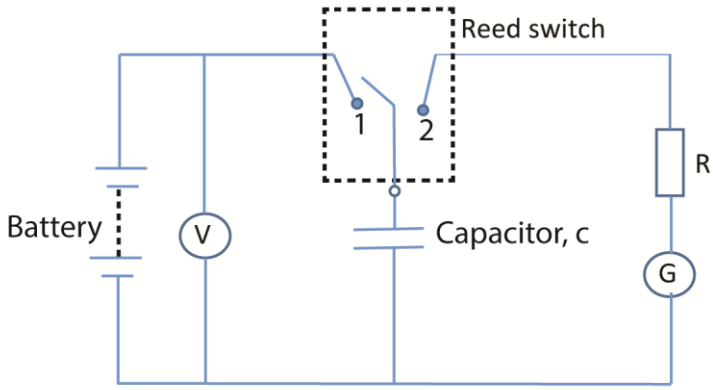
(iii) Describe an experiment to determine the relative permittivity of a dielectric. (04marks)



- The circuit is set up as shown above,
- Switch K_1 is close for some time and opened, then switch K_2 is closed and the deflection θ1 of the ballistic galvanometer is noted.

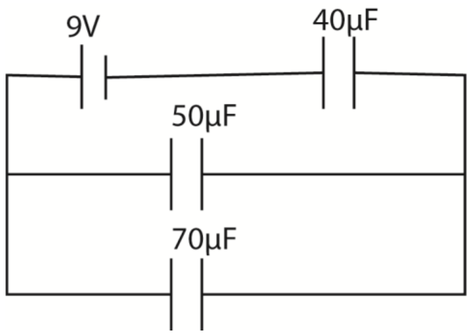
- The procedure is repeated when the capacitor contains a dielectric and θ_2 is noted
- The relative permittivity, $\varepsilon_r = \frac{\theta_2}{\theta_1}$

Alternatively
The circuit is as shown below



- The capacitor is alternatively charged and discharged trough a sensitive light beam galvanometer, G by the reed switch at reasonable frequency, f and steady current I_1 is noted.
- The procedure is repeated when the capacitor contains a dielectric and steady current I_2 is noted
- Relative permittivity, $\varepsilon_r = \frac{\varepsilon}{\varepsilon_0} = \frac{I_1}{I_2}$
- Thus ε_r is the ratio of respective currents in G with and without the dielectric between plates.

(b) A network of capacitors of capacitances 40μF, 50μF and 70μF is connected to a battery of 9V as shown in the figure below



Calculate

(i) Charge stored in the 50μF capacitor. (05marks)

Effective capacitance in parallel = 50 + 70 = 120μF
Net capacitance in the network = $\frac{120 \times 40}{120+40}$ = 30μF
Total charge in the network = CV = 30 x10^{-6} x 9 = 270 x 10^{-6}C

p.d across the parallel combination = $\frac{Q}{C_{eff}} = \frac{270 \, x \, 10^{-6}}{120 \, x \, 10^{-6}}$ = 2.25V

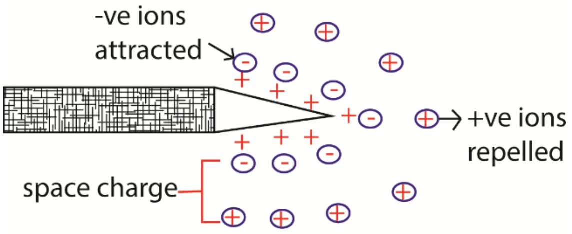
charge on 50μF capacitor = CV = 50 x 10^{-6} x 2.25 = 1.125 x 10^{-4}C

(ii) Energy stored in the 40μF (03marks)

E = $\frac{Q^2}{2C} = \frac{(270 \, x \, 10^{-6})^2}{2 \, x \, 40 \, x \, 10^{-6}}$ = 9.11 x 10^{-4}J

(c) Explain corona discharge

Corona Discharge



- On a pointed charged conductor, there is high charge density and thus high electric field at the sharp point.
- This causes air molecules around the sharp point to ionize and form positive and negative ions.
- The similar charges to those on the conductor are repelled while those opposite are attracted to neutralize some of the charges on the conductor.
- The apparent loss of charge from the conductor in this way is called Corona discharge.

END