UACE PHYSICS PAPER 2006 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 x10^{-19}C
Electron mass	9.11 x 10^{-31}kg
Plank's constant, h	6.6 x 10^{-34}Js
Speed of light in the vacuum, c	3.0 x 108ms^{-1}
Specific heat capacity of water	4.200Jkg^{-1}K^{-1}
Avogadro's number, N_A	6.02 x 10^{23}mol^{-1}
The constant, $\frac{1}{4\pi\varepsilon_0}$	9.0 x 10^{9}F^{-1}m
Permittivity of free space, μ_0	4.0π x 10^{-7}Hm^{-1}
Permittivity of free space, ε_0	8.85 x 10^{-12}Fm^{-1}
One electron volt	1.6 x 10^{-19}J
Resistivity of Nichrome wire at 25^{0}C	1.2 x 10^{-6}Ωm

SECTION A

1. (a) (i) What is meant by refraction of light? (01mark)

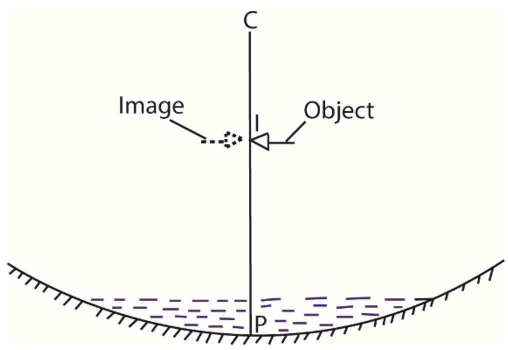
Refraction is the change in the direction of light from one medium to another due to different velocities of light.

(ii) State the laws of refraction. (02marks)

- incident ray, refracted ray and the normal at the point of incidence all lie in the same plane
- the ration of sini to sinr is constant for a given pair of media.

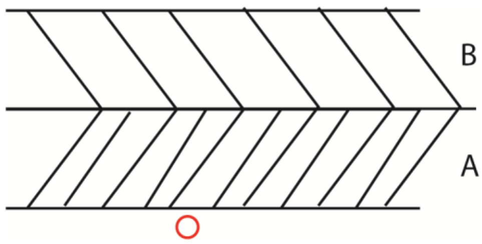
(b) Describe how the refractive index of a liquid can be determined using a concave mirror. (05marks)

An experiment to determine refractive index of a liquid using a concave mirror



- A clamped pin with its tip along the principal axis above the concave mirror is coincided with its image at C and distance PC is measured
- A small quantity of the liquid under test is poured into a concave mirror and a new point I at which the object pin coincides with its image is obtained.
- Distance IP is measured.
- The required refractive index of a liquid, $\boldsymbol{n_l} = \frac{\boldsymbol{PC}}{\boldsymbol{IP}}$

(c)



Two parallel sided blocks A and B of thickness 4.0cm and 5.0cm respectively are arranged such that A lies on an object O as shown above.

Calculate the apparent displacement of O when observed from directly above, it the refractive indices of A and B are 1.52 and 1.66 respectively. (05marks)

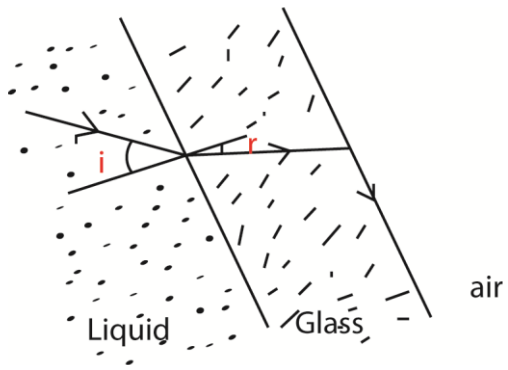
$$d = t_1\left(1 - \frac{1}{n_1}\right) + t_2\left(1 - \frac{1}{n_2}\right)$$

$$= 4\left(1 - \frac{1}{1.52}\right) + 5\left(1 - \frac{1}{1.66}\right) = 3.36\text{cm}$$

(d) (i) state two applications of total internal reflection. (02marks)

- Determination of refractive index of transparent medium
- Communication through optical fibers
- Radio broadcasting
- In binoculars

(ii)



In the figure above, a parallel sided glass slide is in contact with a liquid on one side and air on the other side. A ray of light incident on the glass slide from the liquid emerges in air along the glass air interface.

Derive an expression for the absolute refractive index, n_l, of the liquid in terms of absolute refractive index, n, of glass and the angle of incidence, i.

By Snell's law, nsini = constant

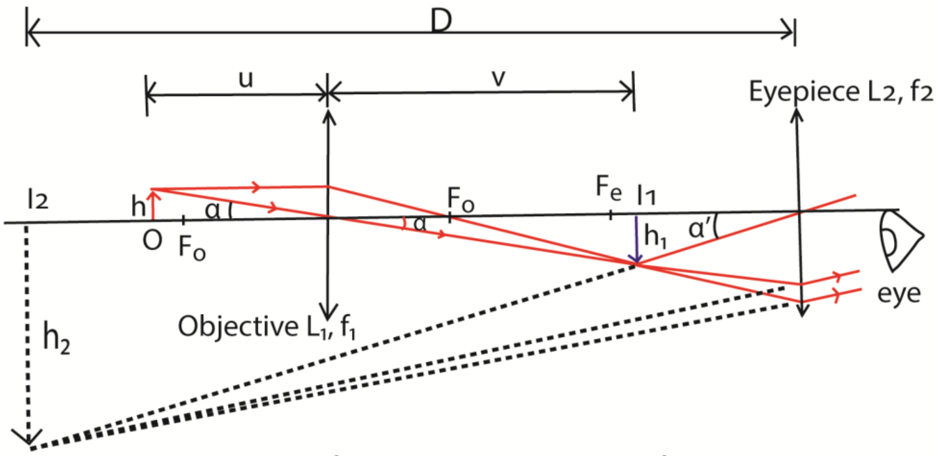
$n_L \sin i = n_g \sin r = n_a \sin 90^0$

$n_L = \frac{1}{\sin i}$

2. (a) (i) Define angular magnification of a compound microscope. (01mark)

Angular magnification is the ration of the angle subtended by the final image at the eye using a lens to the angle subtended by the object to unaided eye

(ii) Draw a labelled ray diagram to show how two converging lenses can be used to make a compound microscope in normal adjustment. (03marks)



Compound microscope in normal use

The objective forms a real magnified image of the object at a point between the principal focus of the eye piece and it optical center. The eye piece forms a virtual image at least distance of distinct vision (25cm)

(b) An object of size 2.0mm is placed 3.0cm in front of the objective of a compound microscope. The focal length of the objective is 2.5cm while that of the eye piece is 5.0cm. The microscope forms a virtual image of the object at the near point of the eye. Find the

(i) the size of the final image (05marks)

Action of objective lens

From $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$\frac{1}{2.5} = \frac{1}{3} + \frac{1}{v}$; v = 15cm

Objective magnification = $\frac{v}{u} = \frac{15}{3} = 5$

Action of eye piece

f = 5.0cm, V = -25cm (image is virtual) u=?

$\frac{1}{5} = \frac{1}{u} - \frac{1}{25}$; u = 4.2cm

Eye piece magnification= $\frac{v}{u} = \frac{25}{4.2}$ = 6

Effective magnification, M = M_1 x M_2 = 5 x 6 = 30

Height of the final image = M x h = 30 x 2 = 60mm

(ii) position of the eye ring

Eye ring is the image of objective in eye piece

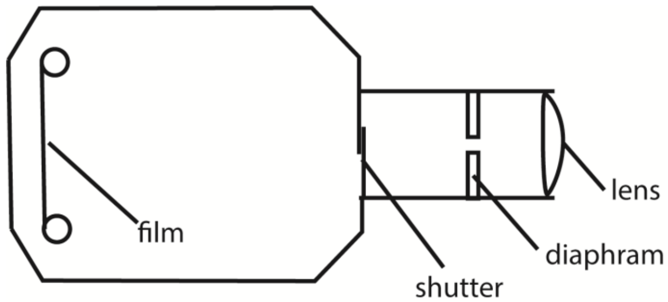
u = separation of lenses = $v_0 + u_e$ = 15 + 4.2 = 19.2cm

$\frac{1}{5} = \frac{1}{19.2} + \frac{1}{v}$; v = 6.76cm

Eye ring is 6.76cm from eye piece.

(c) (i) With the aid of labelled diagram, describe the essential parts of a photographic camera. (02marks)

Lens camera



- The lens focused light from the object on to film
- The diaphragm controls the amount of light reaching the film
- The shutter controls the exposure time of light reaching the film
- Film contain photosensitive chemicals and is where the image is stored.

(ii) Explain how chromatic and spherical aberration are minimized in a photographic camera. (02marks)

Correction of chromatic aberration

- Use **lenses** made of low-dispersion glasses, especially those containing fluorite
- By using combination of lenses of opposite nature (convex & concave) or chromatic doublet such that the dispersion produced by one lens is reversed by another.
- Placing the eye close to the lens such that images due to different colours subtend the same angle at the eye.

Means of reduction of spherical aberration

- Using lenses with an aspheric surface
- Using lens of small aperture.
- Using a stopper such that only light incident on the middle of the lens pass, but this method reduces the brightness of the image since it reduces the amount of light energy passing through the lens.

3. (a) (i) What is meant by amplitude and wavelength as applied to wave? (02marks)

Amplitude is the maximum displacement of a particle in the transmitting medium from the mean position.

Wavelength is the distance between two successive crests or troughs in a wave or the distance between two adjacent particles in the medium which are n phase for a progressive wave.

(ii) State differences between progressive and stationary waves

Progressive wave	Stationary wave
- There is energy flow along the wave - Vibrations are the same amplitude and same frequency - Phase of vibration changes for different points along the wave - Particles in phase are nλ apart, n = 1, 2, 3 ….	- No energy flow - Amplitudes different and depend on position along the wave - Some points are permanently fixed - Particles at distance $\frac{n\lambda}{2}$ apart are in phase

(b) The displacement, y, of a wave travelling in the x- direction is given at time, t, by

y = asin2π $\left(\frac{t}{0.5} - \frac{x}{2.0}\right)$meters

Find the speed of the wave (04marks)

Compare with y= asinπ$\left(ft - \frac{x}{\lambda}\right)$

f = $\frac{1}{0.5} = 2Hz$ and$\frac{1}{\lambda} = \frac{2}{2}$; λ = 2m

From v = fλ

v = 2 x2 = 4ms^{-1}

(c) (i) What is meant by the terms overtones and beats? (03marks)

Overtones are notes of higher frequency than the fundamental frequency for a particular instruments.

Beats are periodic rise and fall in intensity of sound heard when two notes of nearly equal frequencies and similar amplitudes are sounded together.

(ii) State two uses of beats (02marks)

- Measurements of frequency of a note
- Tuning a musical instrument to a given note

(iii) A tube 1m long closed at one end has its lowest resonance frequency at 86.2Hz. With a tube of identical dimensions but open at both ends, the first resonance occurs at 171Hz.

Calculate the speed of sound and the end correction. (06marks)

For closed pipe; L + c = $\frac{\lambda}{4}$ => λ = 4(L + c)

Since $f = \frac{v}{\lambda}$

86.2 = $\frac{v}{4(L + c)}$ ………………………………………… (i)

For open pipe; L + 2c = $\frac{\lambda}{2}$ => λ = 2(L + c)

171 = $\frac{v}{2(L + c)}$ …………………………………………… (ii)

L =1m and dividing (i) by equation (ii)

$\frac{86.2}{171} = \frac{2+4c}{4+4c}$; c = 8.25 x 10-3m

Substituting c in equation (i)

v = 4 x 86.2 (1 + 8.25 x 10^{-3}) m=m347.6ms^{-1}

4. (a)(i) State the superposition principle as applied to wave motion. (01mark)

When two waves meet in a medium, the resultant displacement is the sum of the displacements due to the individual waves.

(ii) What is meant by optical path? (01mark)

Optical path is the length in a medium that maintains the same number of waves as a given length in a vacuum.

Or

It is the product of the refractive index of a medium and the geometrical path length in air or vacuum.

(b) (i) state the conditions which must be satisfied in order to observe an interference pattern due to two waves (02marks)

For observable interference pattern, the source should have equal amplitude and constant phase relationship.

The colors/source should be close to one another.

(ii) Explain why an oil film on a water surface appears to be colored. (04marks)

Colors on an oil film on water are due to interference of light.

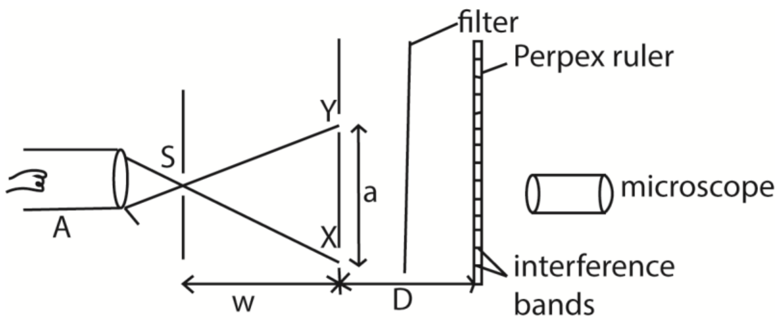
When light from the sky reaches the oil film, it is partly reflected and partly refracted.

The refracted light is dispersed into colors is totally internally reflected on oil-water boundary.

The two reflected waves superpose when they meet.

The colors for the waves that meet in phase are seen while those that meet out of phase are missing.

(c)



The figure above shows an experiment set up to demonstrate Young's interference fringes. Explain what is observed when the

(i) Slit X is covered. (02marks)

Interference patterns disappear and uniform illumination is observed on the screen. Since there is only one source, interference does not take place.

(ii) Slit S is widened (02marks)

The bands gradually disappear. This is equivalent to many slits causing overlap and hence uniform illumination.

(iii) Separation, a, of the slits X and Y is reduced keeping w fixed. (02marks)

The separation of fringes increase

Separation y = $\frac{\lambda D}{a}$where a is the separation of slits. Thus y $\propto \frac{1}{a}$

(iv) Distance, w, is reduced. (02 marks)

The separation of the fringes remain the same but the fringes become brighter. The smaller the distance the greater the intensity of light.

(d) Monochromatic light of wavelength 600mm is incident normally on a plane diffraction grating which has 500 lines per mm. calculate the

(i) Number of maxima observed

$\lambda = 600nm = 600 \times 10^{-9}m = 6.0 \times 10^{-7}m$

$d = \frac{1}{500 \times 10^3} = 2 \times 10^{-6}m$

First order $n_{max} = \frac{d}{\lambda} = \frac{2 \times 10^{-6}}{6 \times 10^{-7}} = 3.3$

$n_{max} = 3$

(ii) Angular position of the first diffraction maximum (02marks)

$d\sin\theta = n\lambda$

$\sin\theta = \frac{\lambda}{d} = \frac{6 \times 10^{-7}}{2 \times 10^{-6}} = 0.3$

$\theta = 17^0$

SECTION B

5. (a) Define magnetic flux density and state its units (02marks)

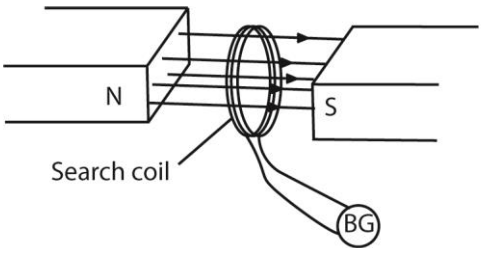
This is the force acting perpendicularly on a conductor carrying a current in a direction normal to the field.

The S.I unit of B is tesla (T)

This is the force acting perpendicularly on a conductor of length one meter carrying a current of one ampere in a direction normal to the field.

(b) Describe how the magnetic flux density between the poles of a powerful magnet can be determined. (03marks)

Solution



A search coil is connected in series with a ballistic galvanometer, B.G and a resistor.

The search coil is placed between the poles pieces of the magnet with its plane normal to the magnetic field.

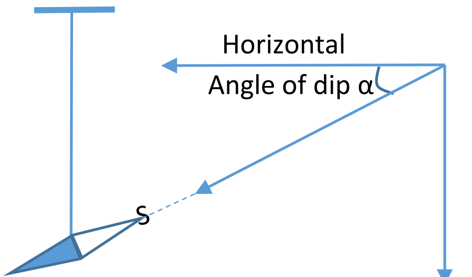
When the ballistic galvanometer pointer settles, the coil is completely withdrawn from the field and the first deflection θ of the B.G is noted.

A capacitor of known capacitance C is charged to a p.d V and then discharged through the ballistic galvanometer and the corresponding θ' is noted.

The magnetic flux density B is now calculated from $B = \frac{CVR\theta}{NA\theta'}$ where A is the area of the coil, N is the number of turns in the coil and R is the resistance of the coil circuit.

(c)(i) Explain with the aid of sketch, the terms angles of dip and declination. (04marks)

Angle of dip (inclination) α: Angle of dip is the angle that the axis of a freely suspended bar magnet makes with the horizontal when the magnet settles.



(ii) Explain what happens to the angle of dip as one moves along the same longitude from the equator to the North Pole. (02marks)

At the equator, the earth's magnetic force is parallel to the surface of the earth and thus the angle of dip is zero.
From the equator towards the North Pole, the field lines the angle of dip increases from zero to 90^0. As the field lines bend away from the horizontal. At the North Pole the field lines are perpendicular to the earth's surface.

(iii) Find the force per unit length on a straight horizontal wire carrying a current of 2.0A in the direction north to south if the angle of dip is 70^0 and the earth's horizontal field component is 1.6×10^{-5}T. (04marks)

$B_v = B_H \tan\theta$

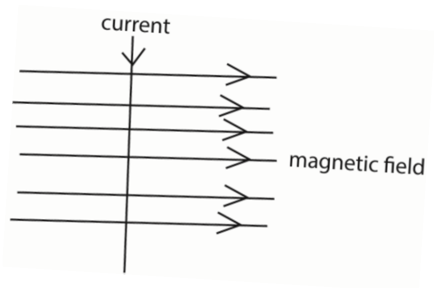
$\frac{F}{L} = B_v I$

$= B_H \tan\theta \times I$

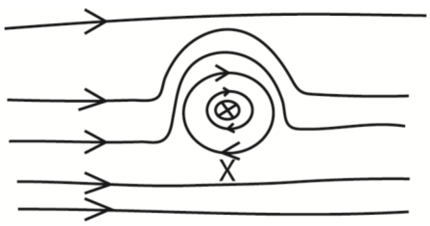
$= 1.6 \times 10^{-5} \tan 70^0 \times 2$

$= 8.8 \times 10^{-5}\ Nm^{-1}$

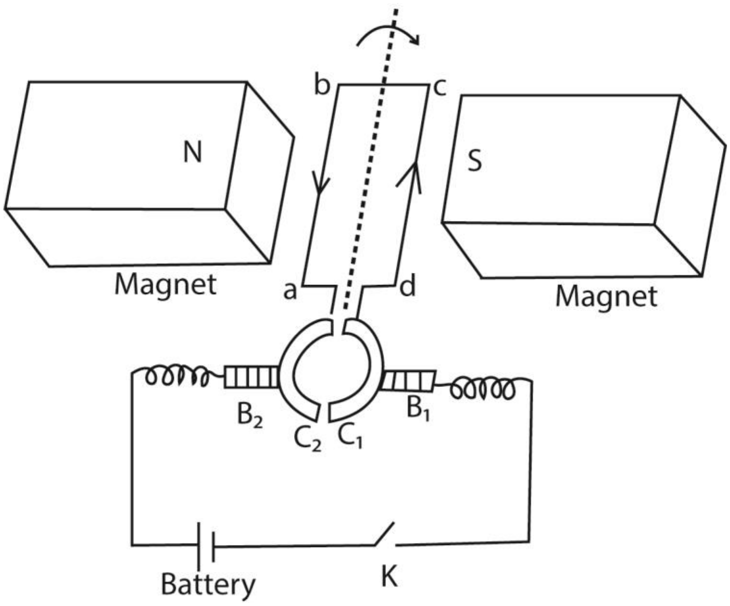
(d)



A wire is placed vertically in a horizontal magnetic field as shown in figure above. Sketch the resultant magnetic field pattern (03marks)



6. (a) (i) With the aid of diagram, describe how a simple d.c. motor works (06marks)



It consists of a rectangular coil abcd of wire pivoted between curved poles of a strong magnet and free to rotate about its axis with a uniform velocity.

The ends of the coil are connected to two halves of sprit ring (commutators) which press lightly against the carbon brush.

Mode of operation

The switch K is closed and current flows in the coil in the direction shown

Applying Fleming's left hand rule, ab experiences an upward force and side cd a downward force. The two forces constitute a couple which rotates the coil in a clockwise direction.

When the coil passes over the vertical position, the commutators change contact with the carbon brushes and current in the coil is immediately reversed. The force acting on the sides thus change and the coil continues to rotate in the same direction.

Because the conductor cuts the magnetic field, an e.m.f that oppose the supply voltage is induced in it called back e.m.f

If V is the supply voltage and E is the back e.m.f, then then the current Ia is given by

Ia = $\frac{V-E}{R_a}$ where Ra id the armature resistance

(ii) Explain the significance of back e.m.f. in the operation of a d.c. motor (02marks)

The back e.m.f in a d.c. motor provides the useful power of the motor.
back e.m.f also reduces the heating effect in motor by reducing the current, since
I = $\frac{V - E_b}{r}$ where Eb = back e.m.f

(b) A motor of armature resistance 0.75Ω is operated from a 240V d.c. supply.

(i) When the motor turns freely without a load, the current in the armature is 4.0A and the motor makes 400 revolution per minute. Calculate the back e.m.f. (02marks)

V = 240V, R = 0.75Ω, I = 4.0A
Eb = V – IR = 240 – 4 x 0.75 = 240 -3 = 237V

(ii) When a load is placed on the motor, the armature current increases to 60.0A. Find the new speed of rotation of the motor (04marks)

E_{b1} = 237V
$E_b \propto \omega$
=> $E_{b1} = k\omega_1$ ………………………… (i)
$E_{b2} = k\omega_2$ ………………………… (ii)
Eqn (ii) ÷ Eqn (i)

$$\frac{E_{b2}}{E_{b1}} = \frac{k\omega_2}{k\omega_1}$$

$$\omega_2 = \frac{E_{b2}}{E_{b1}} x\ \omega_1$$

$But\ E_{b2}$ = 240 – 60 x 0.75 = 195V

$\therefore \omega_2 = \frac{195}{237}\ x\ 400$ = 329.1 revolution per minute

(c) (i) A circular coil of 10 turns and radius 5.0cm carries a current of 1.0A. Find the magnetic flux density at its center. (02marks)

B = $\frac{\mu_0 NI}{2R} = \frac{4\pi\ x\ 10^{-7}\ x\ 10\ x\ 1}{2\ x\ 5\ x\ 10^{-3}}$ = 1.26 x 10^{-4}T

(ii) A copper wire of cross section area 1.5mm^2 carries a current of 5.0A.The wire is placed perpendicular to magnetic field of flux density0.2T. If the density of free electrons in the wire is 10^{29}m^{-3}, calculate the force on each electron. (04marks)

V = $\frac{1}{nLA}$
Force on the rod, F = BIL
But I = nevA, where n = number of electrons per unit volume and v is the drift velocity… (i)
F = BnevA
∴ Force of each electron, F' = $\frac{F}{N}$ = Bev ………………. (ii)
From v = $\frac{1}{neV}$

Putting into EQn

F' = $\frac{BIe}{neA} = \frac{BI}{nA} = \frac{0.2 \times 5}{10^{29} \times 1.5 \times 10^{-6}}$ = 6.67 x 10^{-24}N

7. (a) Define the terms root mean square, peak of an alternating current and derive the relation between them for a sinusoidal a.c. (06marks)

Peak of an alternating current is the maximum value of alternating current.

Root mean square value of an alternating current is the value of steady current that dissipates heat at the same rate as alternating current.

(b) A sinusoidal alternating current, I =I_0 sinωt, passes through a pure inductor of inductance, l

(i) Derive an expression for the reactance of the inductor. (04marks)

Induced e.m.f = -L$\frac{dI}{dt}$

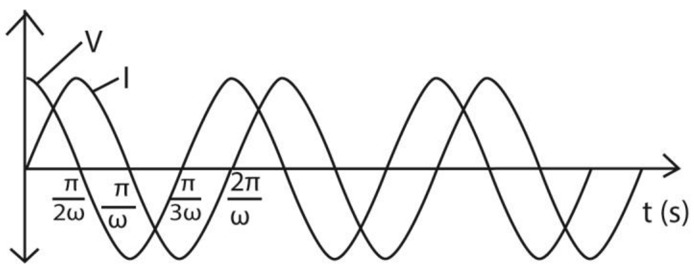
E= -L$\frac{d(I_{)}sin\omega t)}{dt}$ = -ωLI_0cosωt

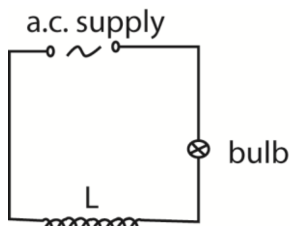
Current flow in a pure inductors, V = -EωLI_0cosωt

Hence V = V_0cosωt where V_0 = ωLI_0

Inductance = X_L = $\frac{V_0}{I_0} = \frac{\omega L I_0}{I_0}$ = ωL

(ii) Using the axes, sketch graphs to show the relative phases of the current and voltage across the inductor. (02marks)





The figure above is a circuit consisting of an air coil, L, a bulb, X and an alternating voltage source connected in series, an iron core is introduced into the coil. Explain why the

(i) Bulb becomes dimmer (03marks)

When the iron core is introduced in the coil, the magnetic flux linking the coil is enhanced. The rate of change of magnetic flux linking the coil thus increases, leading to increase in back e.m.f. High e.m.f leads to low current flowing through the bulb, hence dim light.

(ii) Iron core becomes warm. (02marks)

The iron core warms up due to:

- Hysteresis: E energy used to turn the magnetic domains of the core is dissipated as heat.
- Eddy currents induced in the core are dissipated as heat by I^2R mechanism.

(d) Explain why a moving coil ammeter cannot be used to measure alternating current from the mains. (03marks)

The coil rotates about a vertical axis between the north and south concave poles of strong magnet. This provides a radial magnetic field. When an alternating current is passed through the coil, the torque on the coil reverses direction at the same frequency as current. The pointer vibrates with very small amplitude about the mean position hence a steady current reading cannot be taken

SECTION C

8. (a) Define the terms electrical resistivity and temperature coefficient of resistance (02marks)

Electrical resistivity s the electrical resistance across opposite faces of a cube of a material of 1m length.

Temperature coefficient of resistivity is fractional change in resistance at 00C per degree rise in temperature.

(b) (i) Explain why the temperature coefficient of resistance is positive for metals. (03marks)

In metals, free electrons are charge carrier. As temperature increases, the amplitude of vibration of lattice ions increases and this increase the obstruction to electron drift leading to increase n resistance.

(ii) what is a super conductor (01marks)

Super conductors are materials whose resistance vanishes when they are cooled to temperatures near -273^{0}C

(c) The temperature coefficient of resistance of two wires A and B of diameters 1.20mm and 0.80mm are 0.0004K^{-1} and 0.0003K^{-1} respectively. If the ratio of their resistances at 0^{0}C is 1.5, calculate

(i) the ratio of resistances at 100^{0}C

From $R_\theta = R_0(1 + \alpha\theta)$

⇨ $R_{100A} = R_{0A}\,(1 + 100\alpha_A)$ .... (i)

$R_{100B} = R_{0B}\,(1 + 100\alpha_B)$ .... (ii)

From (i) and (i)

$$\frac{R_{100A}}{R_{100B}} = \frac{R_{0A}}{R_{0B}}\ x\ \frac{(1+100\alpha_A)}{(1+100\alpha_B)} = 1.5 \text{ x } \frac{1+100\ x\ 0.0004}{1+100\ x\ 0.0003} = 1.51$$

(ii) their electrical resistance at 100^0C

From R = $\rho\frac{L}{A}$

$R_A = \rho_A \frac{L}{\pi(0.6 \ x \ 10^{-3})^2}$ …………… (i)

$R_B = \rho_B \frac{L}{\pi(0.4 \ x \ 10^{-3})^2}$ …………… (ii)

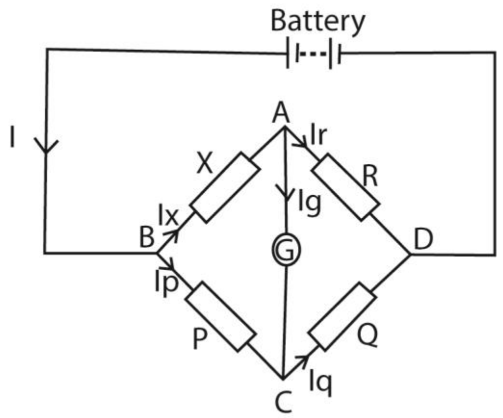
From (i) and (ii)

$\frac{R_{100A}}{R_{100B}} = \frac{\rho_A}{\rho_B} \ x \ \frac{(0.4 \ x \ 10^{-3})^2}{(0.6 \ x \ 10^{-3})^2} = \frac{\rho_A}{\rho_B} \ x \ \frac{2^2}{3^2}$

$\frac{R_{100A}}{R_{100B}} = 1.51$

$\therefore \ \frac{\rho_A}{\rho_B} = 1.51 \ x \ \frac{3^2}{2^2} = 3.3975$

(d) (i) Derive the balance condition for Wheatstone bridge. (04marks)



When resistances P, Q, R and X are such that no current flows through the galvanometer, the bridge is said to be balanced, i.e., Ig = 0

⇨ Potential at A = potential at C

$V_{AB} = V_{BC}$ and $V_{AD} = V_{DC}$

IxX = IpP and IrR = IqQ

$\frac{I_x X}{I_r R} = \frac{I_p P}{I_Q Q}$

Since Ig = 0, then Ix = Ir and Ip = Iq

Hence $\frac{X}{R} = \frac{P}{Q}$

(ii) Explain why the Wheatstone bridge is not suitable for measuring very low or very high resistances. (04marks)

- Cannot measure low resistances because the resistance of the connecting wires become significant.
- It cannot measure very high resistances because the instrument become insensitive

9. (a)(i) Define electric potential and electric field intensity. (02marks)

Electric potential is a point in electric field is work done to transfer 1C charge from infinity to that point.

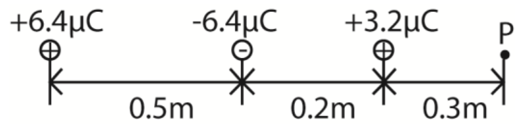
Electric field intensity at a point is the force experienced by 1C of positive charge placed at that point in electric field.

(ii) What is the relationship between electric potential and electric field intensity? (01mark)

Electric field intensity at a point is equal to the negative of potential gradient at that point,

i.e, $E = -\frac{dV}{dx}$

(b)



Three point charges of +6.4μC, -6.4μC and 3.2μC are arranged in line as shown in the figure above. Find the field intensity at P. (06marks)

From $E = \frac{kQ}{r^2}$ (k = 9 x 109F^{-1}m)

Let intensity due to +6.4μC, -6.4μC and +3.2μC be E_1, E_2 and E_3 respectively

$E_1 = \frac{6.4 \, x \, 10^{-6} \, x \, 9 \, x \, 10^{9}}{1^2}$ = 5.76 x 10^4NC^{-1}

$E_2 = -\frac{6.4 \, x \, 10^{-6} \, x \, 9 \, x \, 10^{9}}{0.5^2}$ = -23.04 x 10^4NC^{-1}

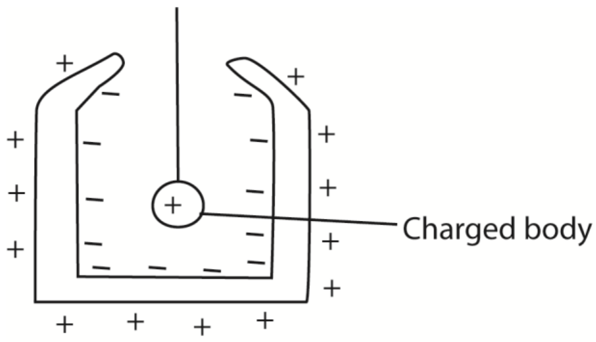
$E_1 = \frac{3.2 \, x \, 10^{-6} \, x \, 9 \, x \, 10^{9}}{0.3^2}$ = 32 x 10^4NC^{-1}

Since E is a vector quantity, E at P is the sum of E_1, E_2 and E_3;

E = (5.76 -23.04 + 32) x 10^4NC^{-1} = 14.72 x 10^4NC^{-1}

(c) (i) Explain with the aid of a diagram, how a charged body cab be screened against external electric fields (03marks)

Place the charged body in a hollow conductor (Faraday cage). This is equal but opposite charges to be induced on the inside wall of hollow conductor. An equal and similar charge is induce on one outside wall.



Any external field do affect the outside wall only; i.e, the charged body is shielded electrostatically.

(ii) Describe briefly how the sign of a charge on a given body can be detected using a gold leaf electroscope (04marks)

- A gold leaf of known charge is used
- The test charge is brought near the cap of the electroscope.
- If divergence of the leaf increases, the body has the same charge as the gold leaf electroscope.

(ii) What is meant by action points in electrostatics? (04marks)
Point action is the apparent loss of charge at the sharp point of a charged body. The high electrostatic intensity at the sharp point of a charged body causes ionization of air molecules around. Ions with similar charge as that on the sharp point are repelled while those with opposite charges are attracted and partially neutralize the charges on the sharp point.

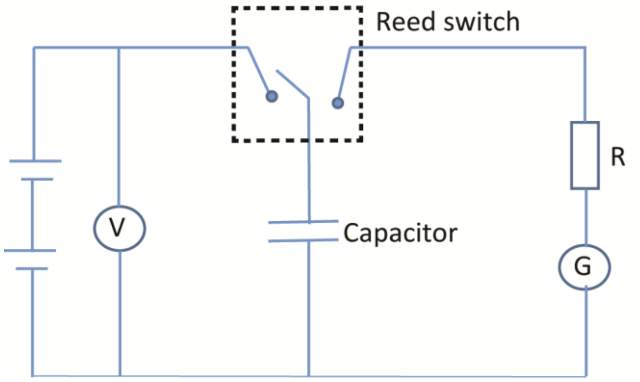
10. (a) Define the farad (01mark)
A farad is the capacitance of a capacitor is the p.d across its plate is 1V and the charge on the capacitor is 1C.
(b) Describe briefly the energy transformations that take place when charging a capacitor using a dry cell. (03marks)

Energy changes from chemical energy in the battery to electrical energy in the connecting wire to electrical potential energy in capacitor plus heat energy dissipated in connecting wire.

(c) The capacitance of a variable radio capacitor can be can be charged continuously from10pF to 900pF by turning the dial from 0^0 to 140^0. With the dial set at 140^0, the capacitor is connected to a 9V battery. After charging, the capacitor is disconnected from the battery and the dial turned to 0^0. Calculate the
(i) charge on capacitor. (03marks)
Charge on a capacitor Q = CV = $900 \times 10^{-12} \times 9 = 8.1 \times 10^{-9}$C
(ii) energy stored in the capacitor with the dial at 140^0. (03marks)
Energy = $\frac{1}{2}CV^2 = \frac{1}{2} x\ 900 x\ 10^{-12}\ x\ 9^2$ = 3.65×10^{-8}J
(iii) work required to turn the dial from 140^0 to 0^0 if the friction is neglected. (03marks)
Energy for C = 10pF;
Energy = $\frac{1}{2}CV^2 = \frac{1}{2} x\ 10 x\ 10^{-12}\ x\ 9^2$ = 4.05×10^{-10}J

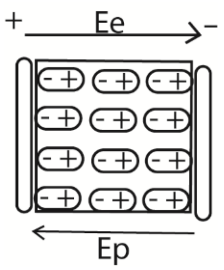
Work done = 3.65×10^{-8}J - 4.05×10^{-10}J   3.61 x 10-8J

(d) Describe an experiment to determine the effect of area of overlap on capacitance of a parallel plate capacitor (04marks)



- The reed switch repeatedly charges and discharges a pair of parallel plates through a sensitive galvanometer.
- The charge Q on the capacitor is proportional to current I
- With the p.d V and plate separation, d, kept constant, the current I is observed for different area overlap.
- The results I and A are tabulated and a plot of I against A gives a straight line showing that I is proportional to A and hence $C \propto A$

(e) Explain why the capacitance of a capacitor changes when a dielectric is placed between its plates. (04marks)



When a dielectric is placed between the plates of an insulated charged capacitor, it gets polarized with the sides near each plate bearing opposite charge to that on the plate.

These are bound charges which are not neutralized thus develop an electric field that oppose the applied electric field.

They lower electric field and voltage between the plates which increases capacitance of the capacitor.

END

END