UACE PHYSICS PAPER 2008 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	$1.2 \times 10^{-6}\Omega m$

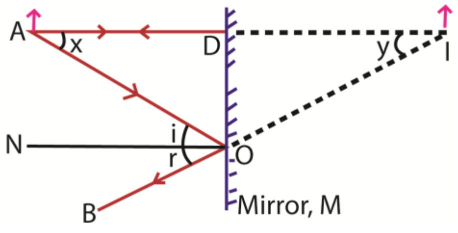
SECTION A

1. (a) (i) State the laws of reflection (02marks)

- Incident ray, refracted ray and the normal at the point of incidence all lie in the same plane
- Angle of reflection is equal to the angle of incidence

(ii) Show that the image formed in a plane mirror is as far behind the mirror as the object is in front. (04marks)

Consider an object A placed in front of a mirror **M**.



A ray AD from A incident normally on the mirror at D is reflected back along DA. The Ray AO is reflected along OB and appears to come from point I behind the mirror. The intersection **I** of the rays AD and BO is the image position.

From above angles,

x = i (alternating angles)

i = r (2^{nd} law of reflection)

r = y (corresponding angles)

Combining all the equations gives

x = i = r = y

⇨ angle x = angle y

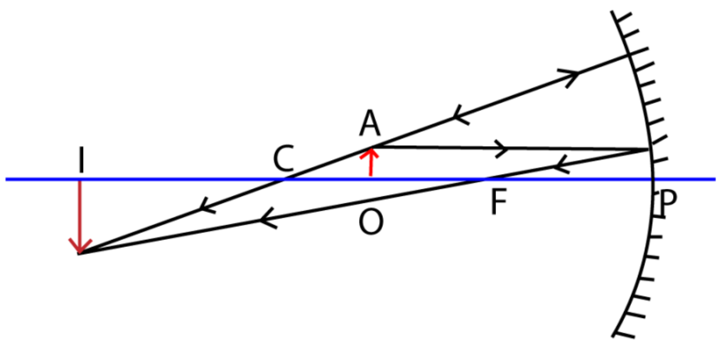
Tan x = tan y

$\therefore \quad \frac{DO}{AD} = \frac{DO}{DI}$

Thus AD = ID.

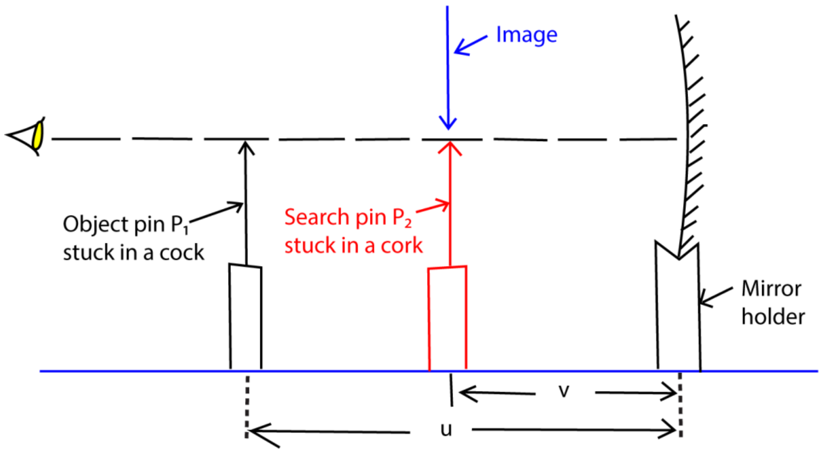
∴ The **image is as far behind the mirror as the object is in front**

(b) (i) Draw a ray diagram to show how a concave mirror forms a real image of a real object placed perpendicular to its principal axis. (01mark)



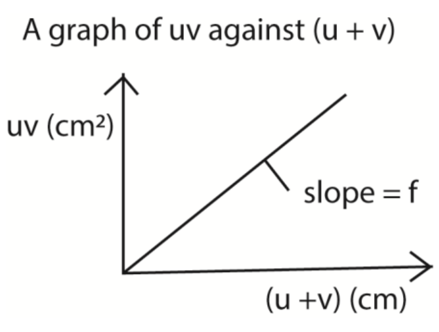
(ii) Describe an experiment, including a graphical analysis of the results to determine the focal length of a concave mirror using the No-parallax method. (06marks)

Experiment to determine focal length of concave mirror using no parallax method



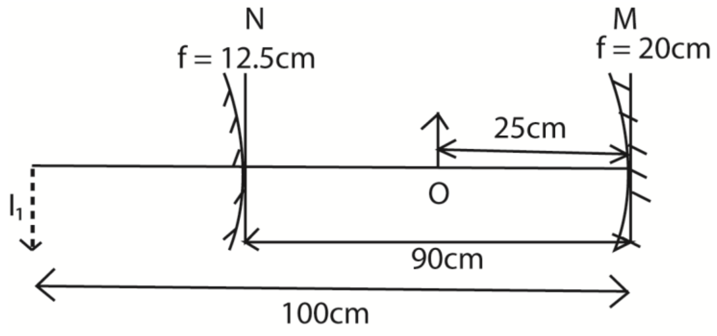
- An object pin $\mathbf{P_1}$ is placed at a distance **u** in front of a mounted concave mirror so that its tip lies along the axis of the mirror.
- A search pin $\mathbf{P_2}$ placed between the mirror and pin $\mathbf{P_1}$ is adjusted until it coincides with the image of pin $\mathbf{p_1}$ by no-parallax method.
- The distance **v** of pin $\mathbf{P_2}$ from the mirror is measured**.**
- The procedure is repeated for several values of **u** and the results are tabulated including values of **uv**, and **u+v.**

A graph of **uv** against **u+v** is plotted and the slope **s** of such a graph is equal to the focal length **f** of the mirror.



(c) A concave mirror M of focal length 20.0cmis placed 90cm in front of a convex mirror, N, of focal length 12.5cm. An object is placed on the common axis of M and N at a point 25.0 cm in front of M.

(i) Determine the distance from N of the image formed by reflection, first in M and then in N. (05marks)



For M

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

$\frac{1}{20} = \frac{1}{25} + \frac{1}{v}$; v = 100cm

For mirror N

u = -10cm, f = -12.5cm, v = ?

$\frac{-1}{12.5} = \frac{-1}{10} + \frac{1}{v}$; v = 50cm

So the distance of the final image from N is 50cm

(ii) find the magnification of the image formed in (c)(i) above (02marks)

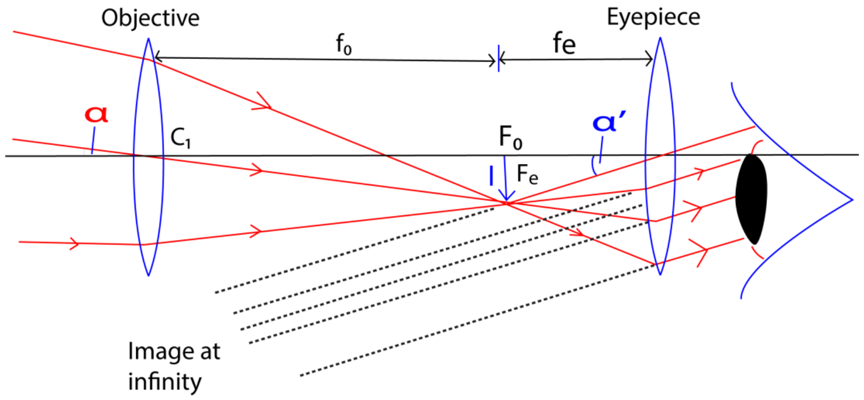
Let the magnification due to M and N be M_1 and M_2 respectively

$M_1 = \frac{100}{25} = 4$ and $M_2 = \frac{50}{10} = 5$

Resultant magnification, $M = M_1 \times M_2 = 4 \times 5 = 20$

2. (a) What is meant by reversibility of light as applied to formation of a real image by a convex lens? (02marks)
Reversibility of light is the phenomenon of light travelling along its original path when its direction of travel is reversed.

(b) (i) Draw a ray diagram to show the action of an astronomical telescope in normal adjustment. (03marks)



Telescope in nornal use

(ii) Derive the expression for magnifying power of the telescope in (b)(i) above in terms of the focal length, f_0 and f_e of the objective and eyepiece respectively.

For an aided eye (using the instrument)
For small angle, tanα' ≈ α' for small angle in radians
$\alpha' = \frac{h}{f_e}$ ………………………………………… (i)
Where, h, is the height of image I, f_e is the focal length of eye piece
For unaided eye
$\alpha = \frac{h}{f_0}$ …………………………………………. (ii)
f_0 is the focal length of objective lens
Combining equations (i) and (ii)
Magnifying power, $m = \frac{\alpha'}{\alpha} = \frac{h}{f_e} \div \frac{h}{f_o} = \frac{\boldsymbol{f_o}}{\boldsymbol{f_e}}$

(iii) The objective and eyepiece of an astronomical telescope have focal length of 75.0cm and 2.5cm respectively. Find the separation of the two lenses if the final image is 25cm from eyepiece. (04marks)

Action of eyepiece
f = 2.5cm, v = -25cm (image is virtual)

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

$\frac{1}{u} = \frac{1}{2.5} + \frac{1}{25}$; u = 2.3cm

Separation of lenses = f_0 + u = 75 + 2.3 = 77.3cm

(c) (i) What is the significance of the eye-ring of an astronomical telescope? (02marks)

The eye ring is the best position where the eye is placed to view the image clearly

(ii) State two advantages of a reflecting telescope over refractive telescope. (02marks)

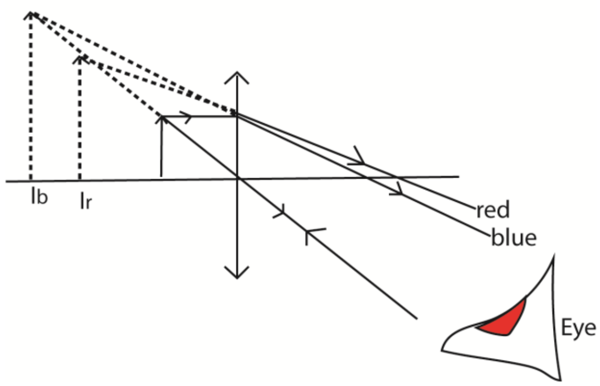
- has no spherical aberration

- has no chromatic aberration since there is no refraction

- high resolution since the objective lens can be made wider

- cheap since only one surface of objective requires grinding

(d) Explain why chromatic aberration is not observed in a simple microscope. (04marks)



In the lens the light rays from the object are dispersed to form colored images I_b and I_r due the different refractive indices; but when the eye is placed close to the lens, the mages subtend the same angle to the eye. The images overlap reducing chromatic aberration

3. (a) State three differences between sound and light waves. (03marks)

Mechanical wave	Electromagnetic waves
- Need material medium for propagation - Propagate at relatively low speed - Have longer wavelength - Are due to vibration or oscillation of particles in transmitting medium.	- Can propagate in vacuum - Propagate as very high speed - Shorter wavelength - Are due to vibration in electric and magnetic field

(b) Distinguish between free and damped oscillation? (02marks)

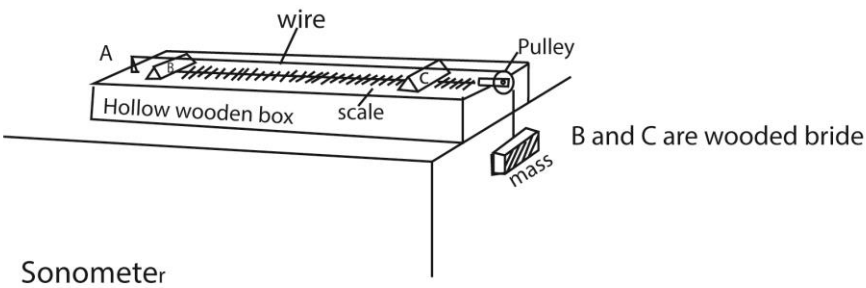
Free oscillation	Damped oscillation
- Amplitude is constant - Wave energy is constant	- Amplitude decreases with time - Wave energy decreases with time

(c) (i) What is meant by resonance? (02marks)

Resonance occurs when the forcing frequency in an oscillation is equal to natural frequency of the oscillating (vibrating) body. The body then oscillates (vibrates) with maximum or constant amplitude.

(ii) Describe with aid of diagram, an experiment to investigate the variation of frequency of stretched string with length. (06marks)

A sonometer below is used



Sonometer

- The wooden bridges B and C vary the effective length of the wire, L.
- Constant tension in the wire is maintained by the fixed mass
- A paper rider is place on the wire in the middle of BC and a sounding fork placed near it.
- The position of the bridge C is varied until sound is heard.
- The distance between the bridges L and the frequency, **f**, of the tuning fork is noted.
- The procedure is repeated for various tuning forks and values of L, **f** and $\frac{1}{L}$ are tabulated

- A plot of **f** against $\frac{1}{L}$ gives a straight line showing that the frequency of vibration of the wire is inversely proportional to length. I.e. frequency increases as length decreases.

(d) (i) Calculate the frequency of beats heard by stationary observer when a source of sound of frequency 80Hz is receding with a speed of 5.0ms^{-1} towards a vertical wall. (speed of sound in air = 340ms^{-1}) (05marks)

Solution

Apparent frequency of direct sound = $\frac{340}{340+5}\ x\ 80 = 78.8Hz$

Apparent frequency of reflected sound = $\frac{340}{340-5}\ x\ 80 = 81.2Hz$

Frequency of the beats heard = (81.2 – 78.8) = 2.4Hz

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

- Tuning musical instrument to a desired note
- Determining the unknown frequency of a note

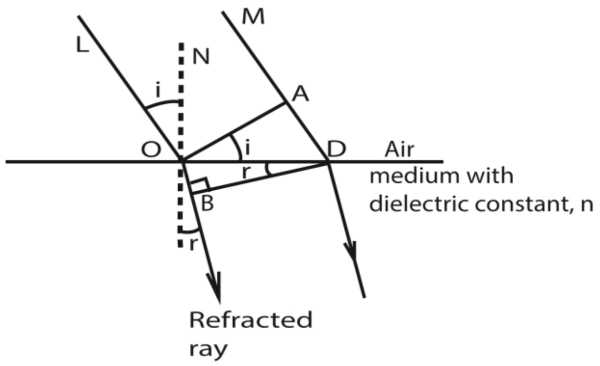
4. (a) State Huygens' Principle. (01 mark)

Every point on a wave front may be regarded as a source of secondary spherical wavelets which spread out with the wave velocity. The new wave front is the new envelope of these secondary wavelets.

(b) Monochromatic light propagating in air is incident obliquely onto a plane boundary with a dielectric of refractive index, n.

(i) Use Huygens' principle to show that speed, V, of light in the dielectric is given by V = $\frac{c}{n}$ where c is the speed of light. (06marks)

Consider a beam of parallel rays between LO and MD incident on the plane surface of the medium from air in the direction shown, and suppose that a plane wave front has reached the position OA at a certain instant,



In figure above, each point between O, D becomes a new centre of disturbance as the wave front advances to the surface of the medium, and the wave front changes in direction when the disturbance enters the medium.

Suppose that t is the time taken by the light to travel from A to D. The disturbance from O travels a distance OB, or Vt, in the medium in a time t, where v is the velocity of light in medium.

At the end of the time t, the wave fronts in the medium from the other secondary centres between O, D reach the surfaces of spheres to each of which DB· is a tangent.

Thus DB is the new wave front in the water, and the ray OB which is normal to the wave front is consequently the refracted ray.

Since c is the velocity of light in air, AD = ct.

Now

$$\frac{Sin\ i}{\sin r} = \frac{sin\ LON}{sin\ BOM} = \frac{sin\ AOB}{sin\ ODB}$$

$$n = \frac{Sin\ i}{\sin r} = \frac{AD}{OD} \div \frac{OB}{OD} = \frac{AD}{OD}\ x\ \frac{OD}{OB} = \frac{AD}{OB} = \frac{ct}{Vt} = \frac{c}{V}$$

$V = \frac{c}{n}$

(ii) If the wavelength of the light is 600nm in air, what will it be in a dielectric of refractive index 1.50? (04marks)

Let f_0 and f be frequencies of light in vacuum and in the medium, then

$f_0 = f$

$$\frac{c}{f_0} = \frac{V}{f}$$

But $\frac{\lambda_0}{\lambda} = \frac{c}{V} = n$

$$\lambda = \frac{\lambda_0}{n} = \frac{600}{1.5} = 400mm$$

(c) (i) What is meant by interference of waves? (01mark)

It is superposition of waves resulting into alternate regions of maximum and minimum intensity.

(iii) State the conditions necessary for interference fringes to be observed, (02mark)

- The wave trains must have nearly the same or equal amplitudes.
- There must be a constant phase relationship between the two wave trains.
- The source must be very close to each other.
- The screen must be very as far as possible from the sources.

(iv) Explain the term path difference with reference to interference of two wave-motions.

Path difference in difference in distances travelled by two wave trains from secondary sources to the point of overlap. Where they meet, the two waves superpose leading to reinforcement or cancellation. Where the path difference is an integral multiple of a wavelength, constructive interference takes place. Where the path difference is an odd multiple of half a wave length, destructive interference takes place.

(d) Two glass slide in contact at one end are separated by a wire of diameter 0.04mm at the other end to form a wedge. Fringes are observed when light of wavelength 5.0×10^{-7}m is incident normal to the slides. Find the number of fringes which can be observed. (03marks)

Solution

$2t = \rho\lambda$

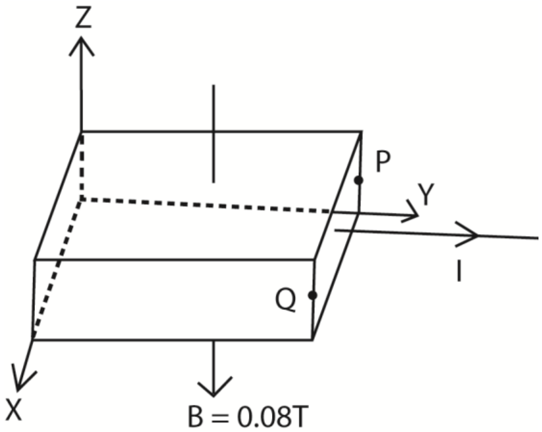
$\rho = \frac{2t}{\lambda} = \frac{2\ x\ 0.04\ x\ 10^{-3}}{5\ x\ 10^{-7}} = 160$

SECTION B

5. (a)(i) What is a magnetic field? (01marks)

Magnetic field is a region of space in which a magnetic dipole experiences a force.

(b)



A magnetic field of flux density 0.08T is applied to a metal strip currying current, I, as shown above

(i) Account for the occurrence of potential difference (p.d) between points P and Q.

When a current begins flowing in the y-direction, by Fleming's left hand rule, a magnetic force acts on the conduction electrons in the direction PQ.

The electrons are deflected towards P, since there is high concentration of negative charge on side P and positive charge on side Q, a p.d develops between sides P and Q.

(ii) Calculate the electric field intensity between P and Q if the drift velocity of the conduction electrons is 4.0×10^{-4}m/s (03marks)

In equilibrium, electric force on electrons = magnetic force on the electron

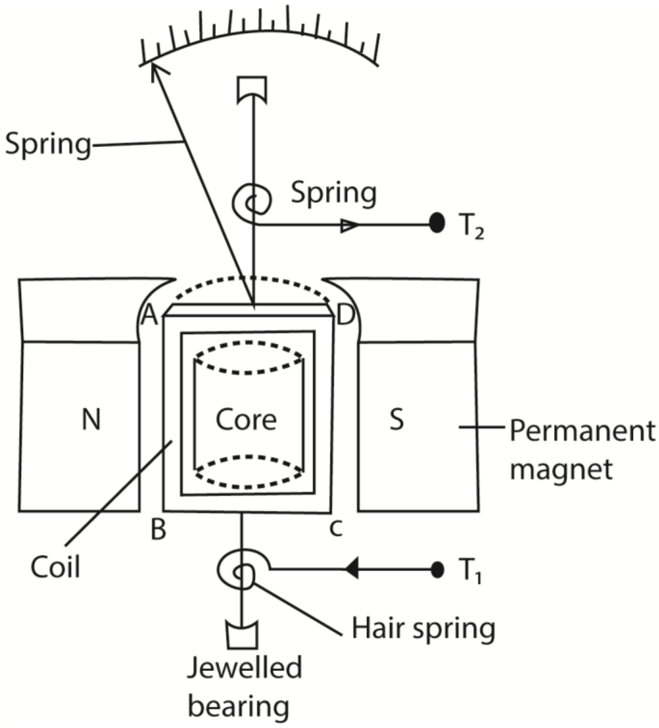
i.e. eE = VeB

∴ E = BV

$= 0.08 \times 4 \times 10^{-4}$

$= 3.2 \times 10\text{-}5\text{Vm}^{-1}$

(c)(i) Describe with the aid of a diagram the structure and mode of action of moving coil galvanometer. (03marks)



Structure

- It consist of a rectangular coil of fine insulated copper wire wound on an aluminium frame to provide electromagnetic damping.
- The coil together with the frame of aluminium are mounted over a soft iron cylindrical core and freely pivoted on jeweled bearing to minimize friction at contact.
- The suspension torsion wire suspending the coil is attached to a pair of control hair springs T_1 and T_2 for feeding current in and out of the coil and control rotation of the coil.
- The coil is then suspended between concave pieces of a strong magnet to provide magnetic field.

  Mode of action
- Current I to be measured is passed into the coil via hair spring T_1.
- The current then causes the coil to experience a deflection torque, r = NABI due to a couple force causing rotation in a radial magnetic field.
- The coil turns with the pointer through angle θ until stopped by restoring torque, r = kθ provided by a pair of hair springs T_1 and T_2.
- At equilibrium, NABI = Kθ
- ∴ current I = $\left(\frac{k}{NAB}\right)\theta$
- I ∝ θ, hence the instrument has a linear scale

  Where B = magnetic field strength between the poles of the magnets
  A = area of the plane of the coil
  N = number of turns of the coil
  k = torsion constant of suspension wire

(ii) Explain how the design of the moving coil galvanometer can be modified to produce a ballistic galvanometer. (03marks)

The light metal former is replaced by a heavy insulating former. The former is an insulator to minimize eddy currents. The former is made heavy and the suspension fine to achieve a longer period of oscillation.

(b) A flat circular coil X of 30 turns and mean diameter 30cm is fixed in a vertical plane and carries a current of 3A.

Another coil Y of 2cm x 2cm and having 2000 turns is suspended in a vertical plane at the center of the circular coil. Initially the planed of the two coils coincides. Determine the torque on the coil Y when a current of 2.0A is passed through it. (04marks)

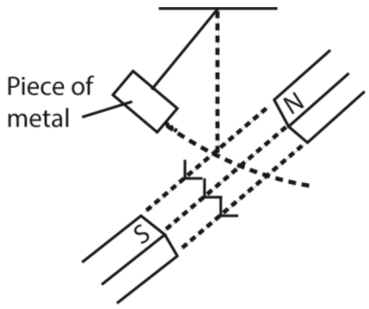
Magnetic flux density at the center of the larger coil B = $\frac{\mu_0 NI}{2R}$

Initial torque on the small coil, τ = NBIAcosθ

$= 200 \times \left(\frac{4 \times 3.14 \times 10^{-4} \times 30 \times 3}{2 \times 15 \times 10^{-2}}\right) \times 2 \times 4 \times 10^{-4} \cos 90^0$

= 0

6. (a)(i) Describe an experiment to demonstrate the damping effect of eddy current, (04marks)



A metal plate is suspended in a magnetic field so that its lane is perpendicular to the magnetic field. The plane is set to oscillate such that its plane cuts the magnetic field, and the time taken for the oscillation to die out is noted.
The experiment is repeated without a magnetic field.
It is noted that in absence of magnetic field when no eddy currents are induced oscillations take longer to stop.

(ii) Give two practical applications of this effect. (01mark)

- damping of moving coil meters
- melting metals in induction furnaces
- breaking in electric train
- speedometer

(b) What is meant by:

(i) self induction? (01mark)

Self-induction is a type of electromagnetic induction where by an e.m.f is induced in a coil due to change in the current flowing in the same coil.

(ii) mutual induction? (01mark)

Mutual induction is a type of electromagnetic induction where by change in current in one coil or induces e.m.f in the neighboring coil or circuit.

(c) Discuss the factors which determine the maximum e.m.f generated by a dynamo. (04mark)

Induced e.m.f, $E = 2\pi fNBA\sin 2\pi ft$

Maximum e.m.f, $E_0 = 2\pi fNBA$

Thus maximum e.m.f increases with increase in

frequency or angular velocity
number of turns in the coil
area of the coil
magnetic flux density.

(d) A transformer has 2000 turns in the primary coil. The primary coil is connected to a 240V mains. A 12 V, 36W lap is connected to the secondary coil. If the efficiency of the transformer is 90%, determine the

(i) number of turns in the secondary coil (02marks)

$N_S = \frac{V_S}{V_P}\ x\ N_P = \frac{12}{240}\ x2000 = 100$

(ii) current flowing in the primary coil (03marks)

$I_sV_s = 0.9I_pV_p$

$I_p = \frac{I_SV_S}{0.9V_p} = \frac{36}{0.9\ x\ 240} = 0.167A$

(e) Explain any two factors which lead to energy losses in the transformer.

- Hysteresis – energy spend in turning the magnetic domains, dissipated as heat.
- Eddy currents- Eddy currents circulating in metal dissipate heat by I^2R mechanism
- Flux leakage- all the magnetic flux associated with the primary does not pass through secondary coil
- Resistance of winding lead to I^2R heat loss minimized by use of thick copper wires

7. (a) (i) Define root mean square value of alternating current. (01mark)

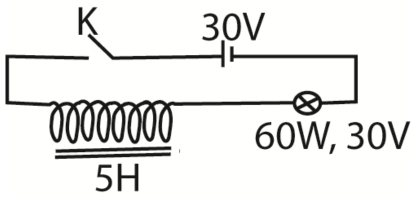
Root mean square value of an alternating current is the value of steady current that dissipates heat at the same rate as alternating current.

(ii) A resistor of 400Ω is connected to 240V a.c. supply. What is the peak value of current flowing through the resistor? (03marks)

From $V_{r.m.s} = I_{r.m.s}\ x\ R$

$I_{r.m.s} = \frac{V_{r.m.s}}{R} = \frac{240}{400} = 0.6A$

(b)



A 60W, 30V bulb, and a coil of inductance 5H are connected in series to a battery of 30V as shown above.

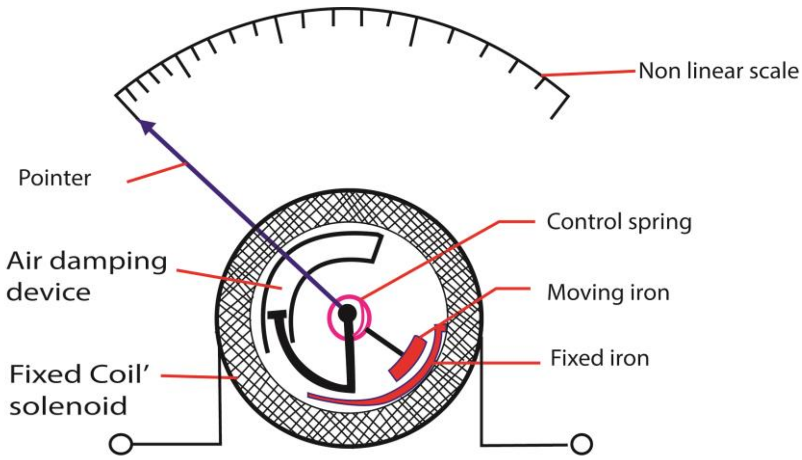
(i) What is observed when switch K is closed and when it is opened? (02marks)

When the switch is closed, the bulb increases slowly to full brightness. When the switch is opened, the bulb dims gradually until it goes off.

(ii) Explain your observation in (b)(i) (04marks)

When the switch is closed, a large back e.m.f is induced in the coil which opposes the flow of current in the circuit. Due to low current the bulb produces dim light. The rate of change of current reduces gradually and the back e.m.f reduces to zero. This leads to maximum current in the circuit causing the bulb to light brightest.
When the switch is opened, the decaying magnetic field in the coil induces an e.m.f in the circuit which tend to reinforce the decaying current. The glow of the bulb gradually reduces before going off.

(c) With the aid of a labelled diagram, describe how a repulsive type of moving iron ammeter works. (05marks).



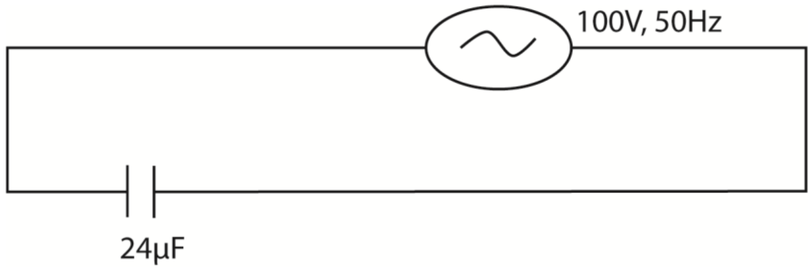
When a current is passed through the coil, the iron rods magnetize in the same poles adjacent to each other in whatever the direction of current. Hence they repel and the pointer move in the same direction until it is stopped by the restoring spring.

Since the magnetic force is proportional to the square of the average current, hence, the deflection is proportional to the square of average current.

Advantage: it measured both direct and alternating current.

Disadvantage: it has nonlinear scale

(d)

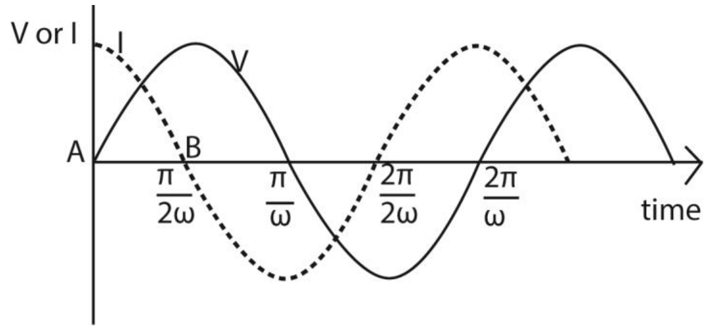


A 100V, 50Hz a.c. supply is connected across a capacitor of 24μF as shown in figure above,

(i) Calculate the reactance of the circuit (03marks)

Capacitive reactance, Xc = $\frac{1}{2\pi f C}$ = $\frac{1}{2\pi \; x \; 50 \; x \; 24 \; x \; 10^{-6}}$ = 132.6Ω

(ii) Sketch graphs to show the time-dependence of supplied voltage and the current in the circuit. (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.

SECTION C

8. (a)(i) State Coulomb's law of electrostatics (01mark)

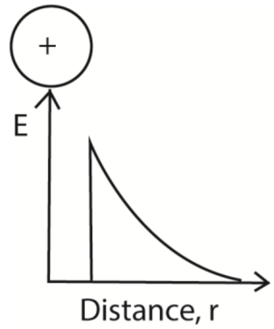
The force between two point charges is directly proportional to the product of the magnitude of charges and inversely proportional to the square of their distance apart

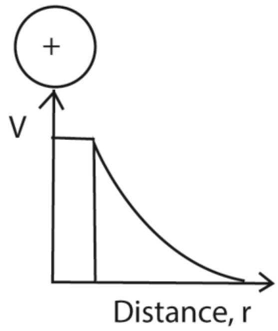
(ii) Define the terms electric field intensity and electric potential at a point. (02marks)

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

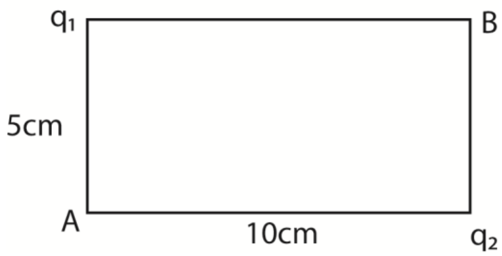
Electric potential at a point is the work done to move 1C of positive charge from infinity to that point against electrostatic repulsion.

(b) Sketch graphs of variation of electric potential and electric field intensity with distance from the center of a charged conducting sphere. (02marks)





(c) Charges q_1 and q_2 of -5.0µF and +2.0µF respectively are placed at two opposite corners of a rectangle of sides5cm and 10 cm as shown below.



Calculate the

(i) Electric potential at A (04marks)

$V_1 = \frac{kq_1}{r_1} = \frac{9\,x\,10^9\,x{-5}\,x\,10^{-6}}{0.05}$ = -9 x 10^6V

$V_{21} = \frac{kq_2}{r_2} = \frac{9\,x\,10^9\,x\,2\,x\,10^{-6}}{0.1}$ = 1.8 x 10^5V

V = V1 + V2 = -9 x 10^6V + 1.8 x 10^5V = -8.82 x 10^6V

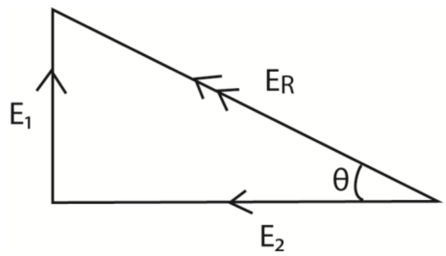
(ii) Electric field intensity at A (05marks)

E = $\frac{kQ}{r^2}$

$E_1 = \frac{9\,x\,10^9\,x\,5\,x\,10^{-6}}{0.05^2}$ = 1.8 x 10^7NC^{-1}

$E_2 = \frac{9\,x\,10^9\,x\,2\,x\,10^{-6}}{0.1^2}$ 1.8 x 10^6NC^{-1}

E is a vector quantity so E_1 and E_2 is added to give resultant intensity E_R



$E_R = \sqrt{E_1^2 + E_2^2}$

$= \sqrt{(1.8 \; x \; 10^7)^2 + (1.8 \; x \; 10^6)^2}$ = 1.81 x $10^7 NC^{-1}$

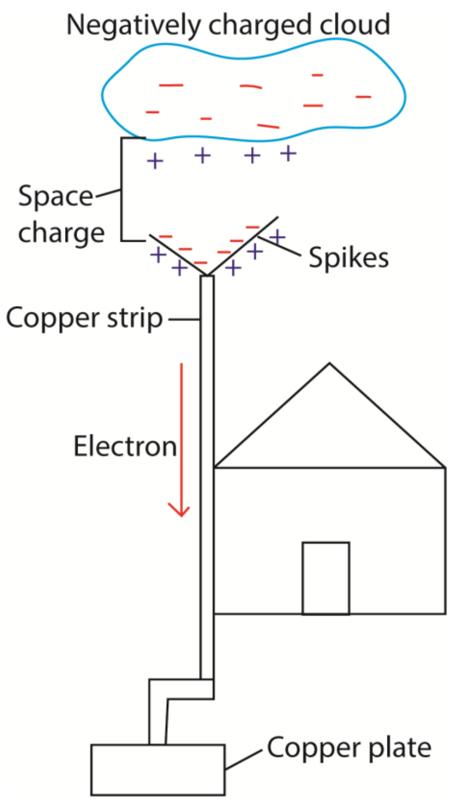
θ = $\tan^{-1}\left(\frac{1.8 \; x \; 10^7}{1.8 \; x \; 10^6}\right)$= 84. 289^0

Therefore the resultant electric field intensity at A is 1.81 x 107NC^{-1} at an angle of 84.289^0

(d) (i) What is meant by corona discharge? (02marks)

The high electric field intensity at the sharp points of charged conductor ionizes air around it. The ions of opposite charge are attracted to the sharp point partially neutralizes the charges at the pointed end of the conductor. The apparent loss of charges from the sharp end of the conductor in this way is called corona discharge.

(ii) Explain how the lightning conductor works (04marks)



Action

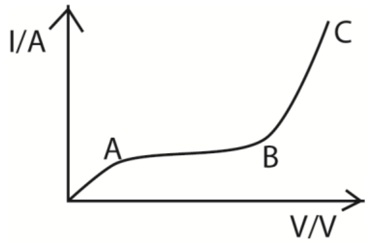
(i) When a negatively charged cloud passes over lightning conductor, it induces positive charges on the spikes by repelling electrons to the grounds through copper conductor.

(ii) A high electric field concentration of positive ions on the spikes ionizes air around it causing positively charged ions and negatively ions.

(iii) The negatively charged ions are attracted and discharged at the spikes while the positively charged ions are repelled to form a space charges which neutralizes the negative charge on the cloud. In this way the harmful effect of the cloud is reduced.

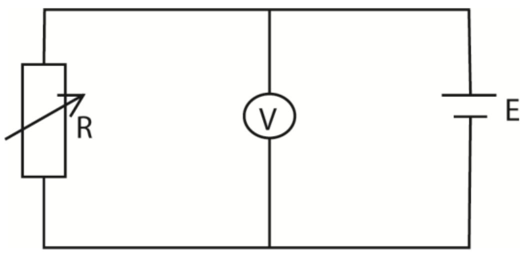
9. (a) Define current density and the ohm and state their units. (03marks)
   - Current density is the amount of current flowing through a conductor of cross section area $1m^2$
   - The Ohm is the resistance of a conductor if the current of 1A flows through it when the potential difference across it is 1V. Unit is Ω.

(b) (i) sketch the current versus voltage characteristic for a gas discharge tube (01mark)



(ii) Explain the main features of the graph in (b)(i) above. (03marks)
- OA – very little current detected due to photoelectric effect on the cathode releasing electrons
- AB – current increases slowly because anode begins to attract electrons
- BC - current increases exponentially because anode accelerates electrons that collide with and cause ionization of gas atoms thereby producing a large volume of conducting electrons.

(c)



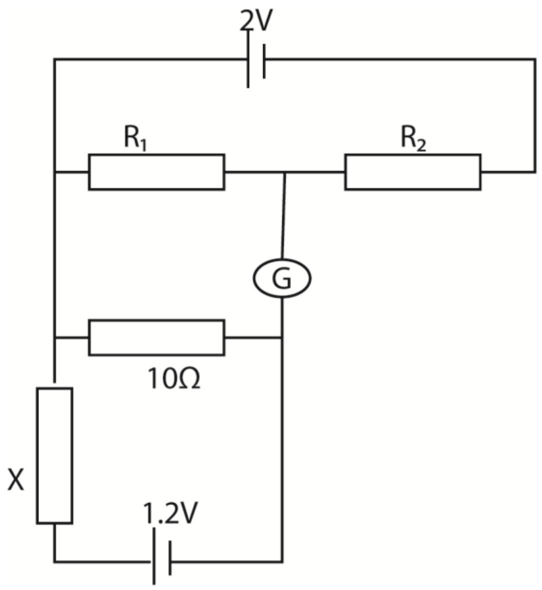
The figure above shows a cell of e.m.f, E and internal resistance, r, connected to a voltmeter, V, and variable resistor R.

Explain how the value of V varies with R. (04marks)

From $V_{AB} = IR$

When R increases, v increases and when R decreases also V decreases

(d)



In the figure above, R1 and R2 are resistors of 10Ω and 90Ω respectively. If the cells have negligible internal resistances, find the value of X for which G shows no deflection. (04marks)

Current flowing in the driver circuit

Id = $\frac{2}{10+90} = \frac{2}{100} = 0.02A$

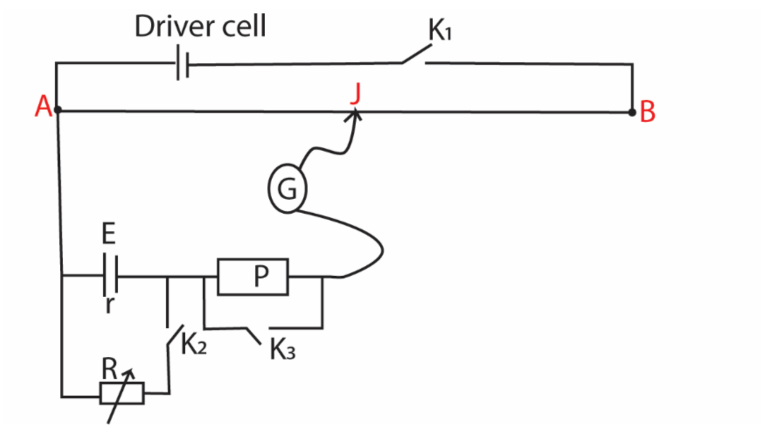
Current flowing in the test circuit, I1 = $\frac{1.2}{x+10}$

p.d across the 10Ω resistor = $\frac{1.2}{x+10}\ x\ 10 = 0.2$

x = 50Ω

(e) Describe how the internal resistance of a cell can be measured using a slide wire potentiometer. (05marks)

Experiment to determine internal resistance of a cell



P = protective resistor

R= variable resistor

G = center zero galvanometer

E = dry cell whose internal resistance is required

J = jockey

Procedure

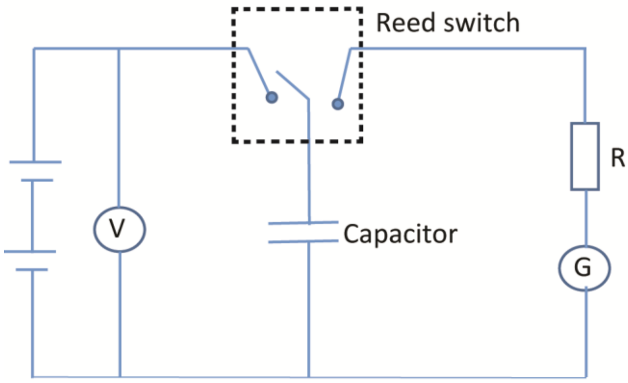
(a) The dry cell is first balanced against the slide wire as follows:
K_1 is closed while K_2 and K_3 are left open, the jockey is placed in different places on the slide wire until the galvanometer shows no deflection. K_3 in the closed and the actual balance length L_o is noted.
At balance
$E = kL_0$ ....(i) where k is the p.d per cm

(b) The variable resistor is adjusted to a suitable value and the p.d across it is balanced against the slide wire as follows
With K_1 and K2 closed, K_3 open, an approximate balance length is obtained. K_3 is then closed and actual balance length, L is obtained.
At balance
IR = kL ....(ii) where I is current flowing through the resistor

The experiment is repeated for different values of R and corresponding lengths, L are recorded.
The results tabulated including values of $\frac{1}{R}$ and $\frac{1}{L}$
A plot of $\frac{1}{R}$ against $\frac{1}{L}$ give a straight line with intercept = $\frac{-1}{r}$ or r = $\frac{intercept}{slope}$

10. (a) (i) Define capacitance and state its units (02marks)
Capacitance of a capacitor is the ratio of the magnitude of charge on either plate of the capacitor to the potential difference between the plates.

(ii) With the aid of a labelled diagram, describe an experiment to measure capacitance of a capacitor. (05marks)



- The setup is shown above
- The is closed and the reading of current I and voltage V are noted at known frequency, f of the reed switch.
- The capacitance of a capacitor, C = $\frac{I}{fV}$

(b) A capacitor is charged by a 30V d.c supply. When the capacitor is fully charged, it is found to carry charge of 5.0μC. Calculate the:

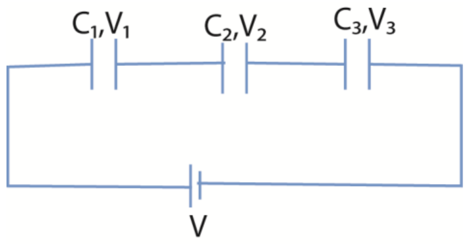
(i) capacitance of the capacitor. (02marks)

C = $\frac{Q}{V} = \frac{5\ x\ 10^{-6}}{30}$ = 1.67 x 10^{-7}F

(ii) energy stored in the capacitor (03marks)

Energy = $\frac{1}{2}CV^2 = \frac{1}{2}\ x\ 1.67\ x\ 10^{-7}\ x\ 30^2$ = 7.5 x 10^{-5}J

(c) Derive the expression for effective capacitance of three capacitors C_1, C_2 and C_3 respectively connected in series. (04marks)



The charge on each of the capacitor is the same equal to Q

Total voltage V = $V_1 + V_2 + V_3$

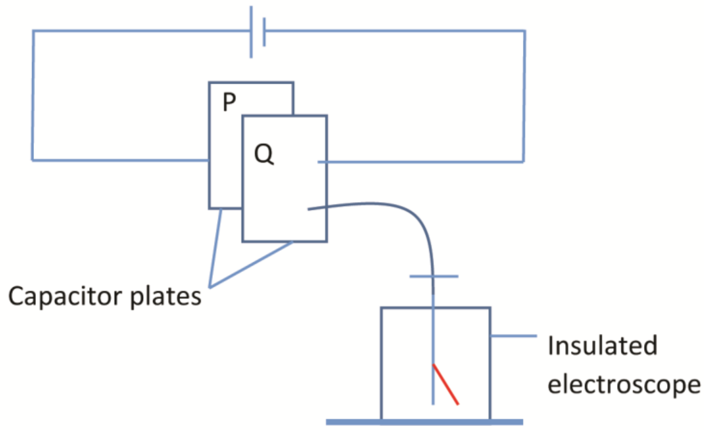
$$= \frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3} = Q\left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right)$$

But $\frac{V}{Q} = \frac{1}{C}$ where C is the resultant capacitance.

$$\therefore \frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

(d) Describe briefly an experiment to show the effect of varying the distance of separation of the plates of a capacitor on capacitance. (04marks)

END



The plate P is then slid back and separation between the plates is increased by moving P away from Q. The divergence of the leaf is observed to decrease. Since divergence of the leaf is proportional to charge on the plates, which in turn is proportional to capacitance C, then C is reduced. This shows that $C \propto 1/d$.

END