UACE PHYSICS PAPER 2005 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	$1.2 \times 10^{-6}\Omega m$

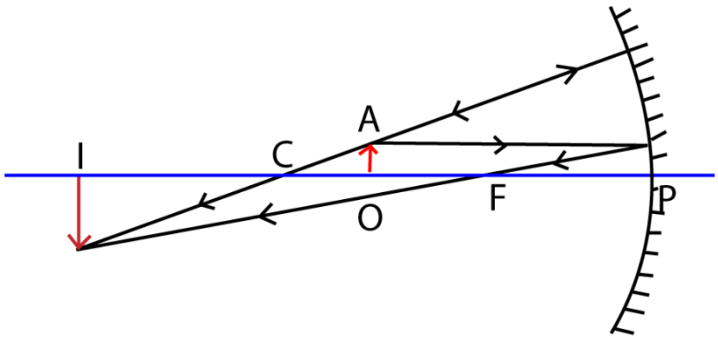
SECTION A

1. (a) Define the focal length of a concave mirror. (01mark)

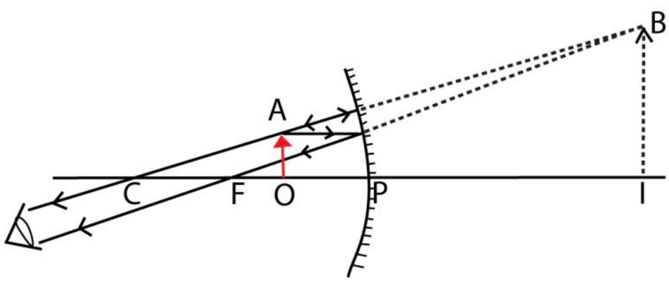
Focal length "f" of a concave mirror: it is the distance from the pole of the mirror to the point where paraxial rays incident and parallel to the principal axis converge after reflection by the mirror.

(b) An object is placed at a distance u from a concave mirror, the mirror forms an image of the object at a distance v. Draw diagrams to show the path of light rays when an image formed is

(i) real (02marks)

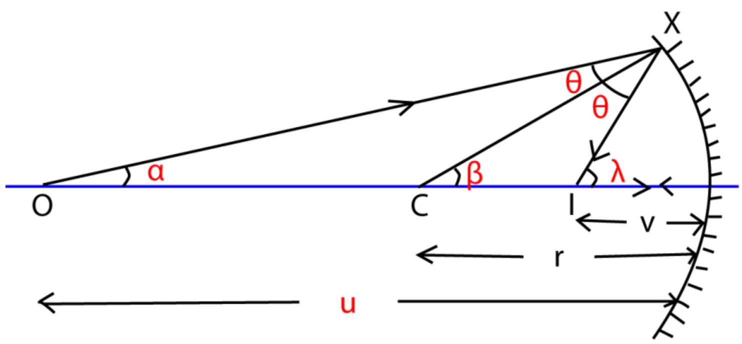


(ii) virtual (02marks)



(c) Use a geometrical diagram to derive the relation, $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$ (05marks)

Consider the incidence of ray **OX** on to a concave mirror from a point object **O** placed along the principal axis and then suddenly reflected in the direction XI making an angle ⍰ with the normal CX.



Ray OP strikes the mirror incident normally at P and thus reflected back along its own path. The

point of intersection I of the two reflected rays is the image position.
From Δ OXC; $\alpha + \theta = \beta$ ……………………………….. (i)
From Δ CXI; $\beta + \theta = \lambda$ ………………………………… (ii)
Eqn. (i) and (ii)
$\alpha + \lambda = 2\beta$ …………………………………………………. (a)
If X is close to P then.
$\alpha \approx \tan \alpha = \frac{XP}{u}$; $\beta \approx \tan \beta = \frac{XP}{r}$; $\lambda \approx \tan \lambda = \frac{XP}{v}$

Equation (a) becomes

$$\frac{XP}{u} + \frac{XP}{v} = \frac{2XP}{r}$$

$$\frac{1}{u} + \frac{1}{v} = \frac{2}{r}$$

But r = 2f

Thus, $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

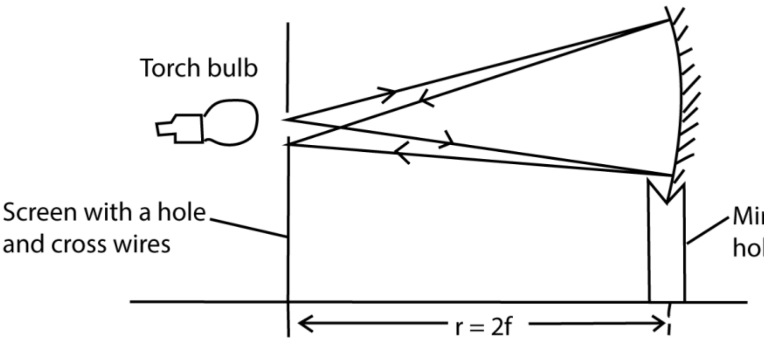
(d) A concave mirror of radius of curvature 40.0cm contains a liquid to a height 2.0cm. A pin clamped horizontally and viewed from above is observed to coincide with its image when it is 27.0 above the surface of the liquid. Calculate the refractive index of the liquid. (04marks)

R = 40.0cm, d = 2.0cm and h=27.0cm

$$n = \frac{R-d}{h} = \frac{40-2}{27} = 1.41$$

(e) You are provided with the following pieces of apparatus:

A screen with a cross wire, a lamp, a concave mirror, and a meter rule. Describe an experiment to determine the focal length of the concave mirror using the above apparatus.

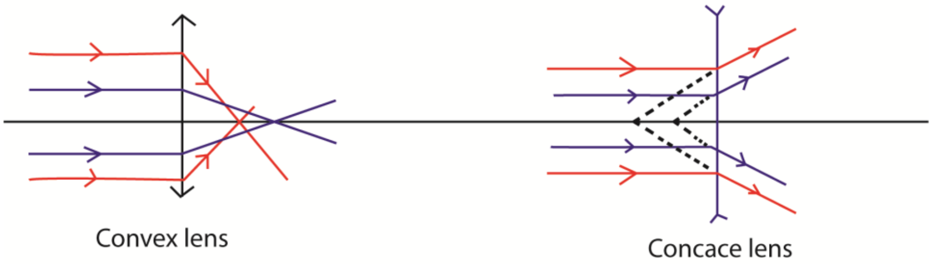


Align an illuminated bulb, a screen and a concave mirror mounted in a holder as shown above. The mirror position is adjusted to or from the screen until a sharp image of the cross-wire is formed on the screen besides the object. The distance **r** of the mirror from the screen is measured.
The required focal length $\mathbf{f} = \frac{\boldsymbol{r}}{\mathbf{2}}$

2. (a) (i) Explain the terms chromatic and spherical aberration in lenses. (04marks)

C***hromatic aberration*** (CA), also called chromatic distortion and spherochromatism, is a failure of a lens to focus all colors to the same point. It occurs due to dispersion since refractive index of the lens varies with the wave length of the color of light.

Spherical aberration



Spherical aberration occurs when the lens fails to focus all rays falling on it to the same point. Thus images formed by the lens at large apertures are therefore unsharp or blurred at the edges.

(ii) How are the aberrations in (a)(i) above minimized in reflecting telescope? (03marks)

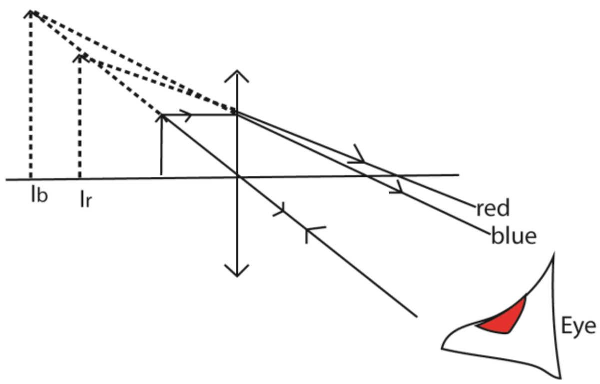
Correction of chromatic aberration

- 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.

(b) With the aid of a diagram, explain why the image seen in the magnifying glass is almost free from chromatic aberration when the eye is close to the lens. (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

(c) A converging lens is used to form an image of an object 1.2m away on the screen 0.05m from the lens.

(i) Find the focal length of the lens. (03marks)

Since the image is formed on a screen, then it is real, thus, v= 1.2m, u = 0.05m

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

$\frac{1}{0.05} + \frac{1}{1.2} = \frac{1}{f}$; f = 0.048m

(ii) If the lens is now used to form an image of a distant object, how far from the screen would the clear image be formed? (02marks)

For the distant object, the image is formed at F = 0.048

The distance from the screen = 0.05- 0.048 = 0.002m

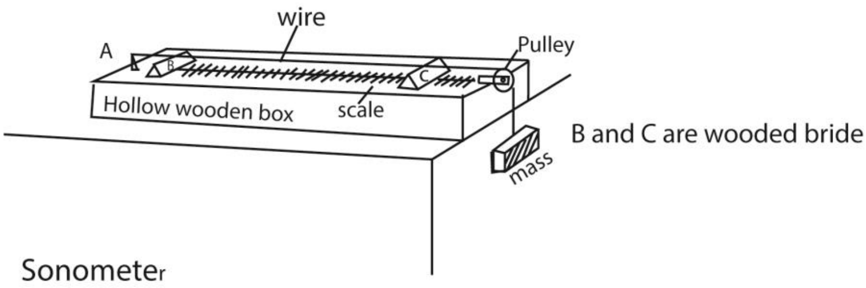
(iii) State the type of lens that should be placed close to the first lens in order to enable the image in (c)(ii) above be formed on the screen. (01mark)
Diverging lens

(iv) Calculate the focal length of the lens you have stated in (c)(iii) above. (03marks)
Let its focal length be f
Using $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f}$
$\frac{1}{0.05} = \frac{1}{0.048} + \frac{1}{f}$; f = -1.2m

3. (a) Distinguish between progressive and stationary waves. (04marks)

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 $\frac{2n\lambda}{2}$ apart are in phase

(b) Briefly describe an experiment to show that a wire under tension can vibrate with more than one frequency.



- 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.

(c) A uniform wire of length 1.00m and mass 2.0 x 10^{-2}kg is stretched between two fixed points. The tension in the wire is 200N. The wire is plucked in the middle and released. Calculate the

(i) Speed of the transverse waves. (03marks)

L=1.0m, m = 2.0 x 10^{-2}kg. T= 200M

$V = \sqrt{\frac{T}{m}} = \sqrt{\frac{200}{2 \, x \, 10^{-2}}} = 100ms^{-1}$.

(ii) Frequency of the fundamental note (03marks)

$\lambda = 2L$ and $V = f\lambda$

$f = \frac{V}{\lambda} = \frac{100}{2 \, x \, 1} = 50Hz$

(d) (i) Explain how beats are formed. (02 marks)

When two notes of nearly equal frequencies are sounded together. At some instance waves from both sources arrive at some place in phase, reinforce and produce loud sound. At another instant, compression from one source arrive together with refraction from another and low sound or no sound at all is heard. The periodic rise and fall in loudness of sound is referred to as beats.

(ii) Derive an expression for the beats frequency. (03marks)

Let f_1 and f_2 be the frequencies of the two notes. Suppose notes of frequency f_1 make one cycle more than the other in time T. Number of cycles of f_1 is f_1T and that od f_2 is f_2T in time T.

$f_1T - f_2T = 1$

$(f_1 - f_2)T = 1$

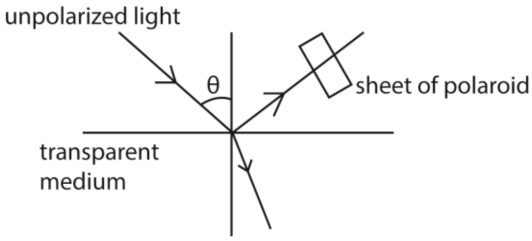
$(f_1\text{-}f_2) = \frac{1}{T} = f$

Therefore beat frequency = $(f_1\text{-}f_2)$

4. (a) Distinguish between longitudinal and transverse waves (02marks)

In transverse waves, the vibrations occur in a direction perpendicular to the wave while in longitudinal wave, the vibrations occur along the direction of a wave.

(b)(i) Describe the method of producing plane polarized light by reflection. (02marks)



- A narrow beam of unpolarized 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 gets cut off the observer as the Polaroid is rotated.
- The reflected ray is now completely polarized.

(iii) Mention two practical application of plane polarized light and describe one of them. (04marks)

- Reduce glare
- Measuring the concentration of sugars
- Holography
- Liquid crystal display

(c)(i) State the conditions necessary for formation of standing waves. (02marks)

When two wave trains of the same speed, same frequency and equal amplitude are moving in opposite direction

(ii) A Uniform tube, 50cm long is filled with water and vibrating tuning fork of frequency 512 Hz is sounded and held above it.

When the level of water is gradually lowered, the air column resonates with the tuning fork when the length is 12cm and again when it is 43.3cm.

Estimate the lowest frequency to which the air in the tube could resonate if the tube were empty.

Solution

L = 50cm = 0.5m; f = 512Hz, for L1 = 12cm= 0.12m and L2 = 43.3cm = 0.433m

Now $L_1 + c = \frac{\lambda}{4}$ ………………………………. (i)

$L_2 + c = \frac{3\lambda}{4}$ ……………………………… (ii)

$L_2 - L_1 = \frac{\lambda}{2}$

$\lambda = 2(L_2 - L_1) = 2(43.3 - 12) = 62.6cm = 0.626m$

also, v = fλ = 512 x 0.626 = 320.5ms^{-1}.

By substituting in eqn. (i)

12 + c = $\frac{0.626}{4}$

c = 0.0365cm

For open ended pipe, $f_0 = \frac{u}{\lambda} = \frac{u}{2(L+2c)} = \frac{320.2}{2(0.5+2\,x\,0.0365)}$ = 280Hz

For closed ended pipe, f0 = $\frac{v}{\lambda} = \frac{v}{4(L+c)} = \frac{320.2}{4(0.5+\,0.0365)}$ = 149.3Hz

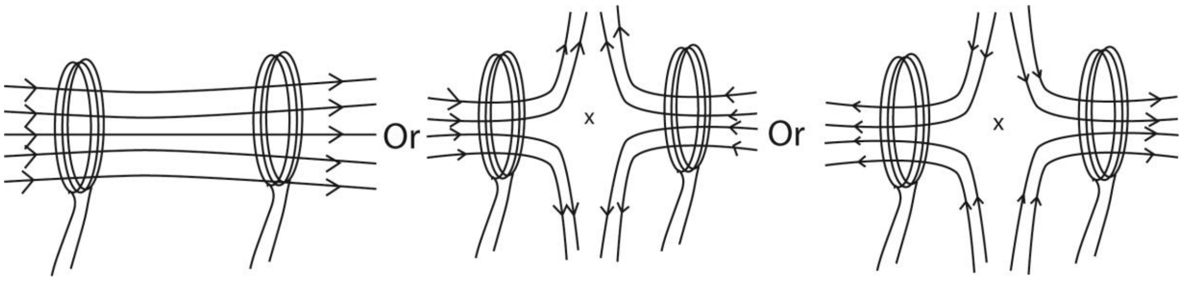
SECTION B

5. (a) Define magnetic flux density. (01mark)

Magnetic flux density is the force acting on a 1m long conductor carrying current of 1A in a direction perpendicular to magnetic field.

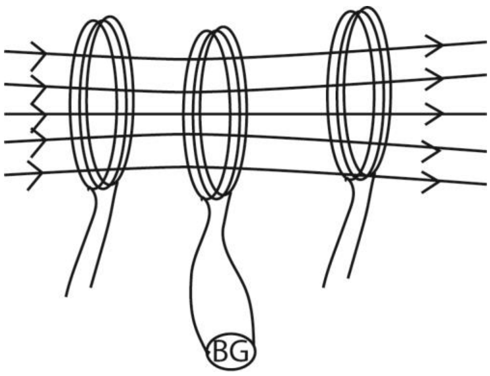
(b) Two identical circular coils are placed coaxially at distance equal to the radius of each coil.

(i) Sketch the magnetic field pattern which results when equal current are passed through the coils. (02marks)



(ii) Describe how you would investigate the variation of magnetic flux density with distance along the axis of the coils. Draw a sketch graph to show the expected results. (06marks)

Solution



- A search coil is connected in series with a ballistic galvanometer, B.G.
- The search coil is placed such that its plane is parallel to those of the coils.
- 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.

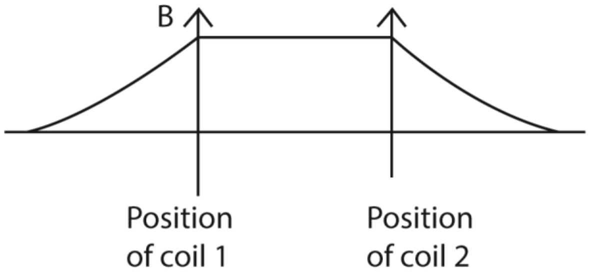
- The magnetic flux density B is now calculated from B = $\frac{CVR\theta}{NA\theta'}$

Where A = the area of the coil,

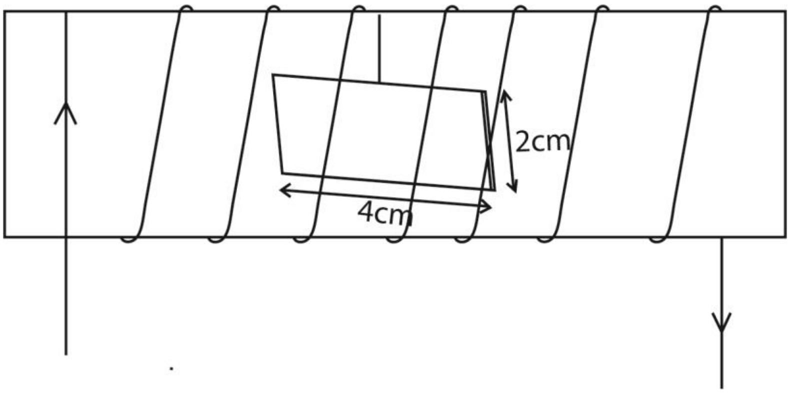
N = the number of turns in the coil and;

R = the resistance of the coil circuit.

- The procedure is repeated for different distances, X, from the coils
- A graph of B against X is plotted.



(c) A small rectangular coil of 10turns and dimensions 4cm by 2cm is suspended inside a long solenoid of 1000 turns per meter so that its plane lies along the axis of the solenoid as shown in the figure below. The coil is connected in series with solenoid.



The coil deflects through 300 when a current of 2.0A is passed through the solenoid. Find the torsion constant of the suspension. (05mark)

n = 1000, I = 2A, N = 10 A = 4 x 2 x 10^{-4} = 8 x 10^{-4} m^2

Magnetic flux density in the center of the coil, B = $\mu_0 nI$

= 4π x 10^{-7} x 1000 x 2

= 2.512 x 10^{-3}

Deflection torque = τ = BANI

This torque is equal to opposing, t' = Cθ where C is the torsion constant.

At equilibrium

BANI = Cθ

C = $\frac{BANI}{\theta} = \frac{2.512 \, x \, 10^{-3} \, x \, (\, 8 \, x \, 10^{-4}) x \, 10 \, x \, 2}{\pi/6}$ = 7.68 x 10^{-5}Nmrad^{-1}

(d) A moving coil galvanometer reads 15mA when it is connected in series with a source of e.m.f of negligible internal resistance is replaced with one of resistance 100Ω.

The galvanometer reads 10mA when the 100Ω resistor is replaced with one of resistance 200Ω. Find the

(i) Resistance of the galvanometer

Let r be the resistance of the galvanometer
From V = (R + r)I
V = 15 x 10^{-3} (100 + r) = 10 x 10^{-3} (200 + r)
r = 100Ω

(ii) E.m.f of the source.

Substituting for r,
V = 15 x 10^{-3} (100 + 10) = 3,0V

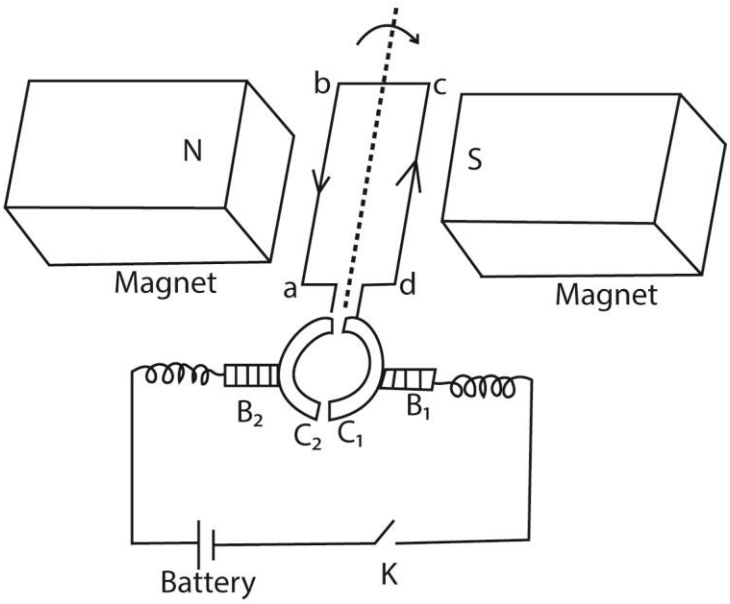
6. (a) State the laws of electromagnetic induction (02marks)

Faraday's law of electromagnetic induction states that magnitude of induced in a circuit is directly proportional to the rate of change of magnetic flux linkage in the circuit.
Lenz's Laws states that the direction of the induced current is such as to oppose the change causing it.

(b) A coil of 100turns is wound round the middle of a long solenoid of 500 turns per meter and radius 8.0cm
A sinusoidal current I = 10sin(120πt), amperes, is passed through the solenoid winding. Find the amplitude of e.m.f induced across the terminals of the coil. (05mark)

Solution
$|E| = \frac{d(N\phi)}{dt} = N\frac{d(BA)}{dt}$
But B = $\mu_0 nI$
$\therefore |E| = NA\mu_0 n \frac{d}{dt}(10sin120\pi t)$
$= NA\mu_0 n\,.\,120\pi\,.\,cos120\pi t$
Amplitude of induced e.m.f, E_0 = $NA\mu_0 n\,.\,120\pi$
= 100 x (π x 8^2 x10^{-4}) x 4π x 10^{-7} x 500 x 120 π
= 4.75V

(c)(i) With the aid of labelled diagram, describe the structure and action of a simple d.c. motor. (07marks)



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 Vis 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 term back e.m.f in a motor and derive its relation to the efficiency of the motor. (03marks)

When the armature coil of a motor rotates in magnetic field, an, e.m.f is induced in the coil. The induced e.m.f opposes the applied p.d. and is therefore a back e.m.f.

If V, E and r are applied p.d, induced e.m.f and resistance to the armature coil respectively, then the current flowing in the coil is given by

I = $\frac{V-E}{r}$

=> V- E = Ir

Multiplying through by I

VI = EI + I^2r

Since I^2r is the power dissipated as heat in the armature, EI is the mechanical power output and VI is the power supplied.

Efficiency of the motor, η = $\frac{EI}{VI}\ x\ 100\%$

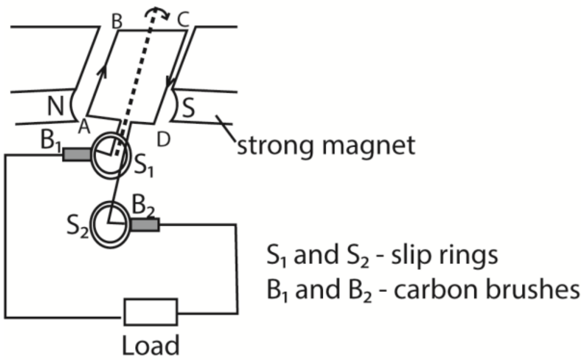
$= \frac{E}{V}\ x\ 100\%$

(d) Briefly explain one application of eddy currents (03marks)

- Damp and slow down the oscillation of a pointer of the galvanometer.
- Melting of metals in induction furnace
- Electric brakes

7. (a) (i) Describe with the aid of a diagram, the structure and mode of operation of a.c. generator. (05marks)

Solution



How it works

- The coil is rotated in a magnetic field, the magnetic field linked with it changes and hence e.m.f is led away by means of slip rings which press slightly against the carbon brushes.
- Applying Fleming's right hand rule, the induced current enters the coil AB and leave the coil via CD.
- Starting with the coil in the vertical position, the magnetic flux linking it is maximum and hence no induced e.m.f.
- The induced e.m.f increases with the position of the coil in the magnetic field until it becomes maximum with the coil in horizontal position and then decrease to zero as the coil rotates to the vertical position
- The force acting on the sides of the coil change as the coil passes over the position and hence he current flowing in the coil reverses. Hence an alternating e.m.f or current flows through the load.

(ii) Explain the structural modifications needed to convert an a.c generator to a d.c generator. (02marks)

To convert an a.c. generator to d.c. generator, the ends of the rectangular coil are connected to commentators instead of a pair of slip rings (b)(i) Define the terms peak value and root mean square (r.m.s) value of alternating voltage (02marks)

Root mean square value is the value of direct current which dissipates heat in a given resistor at the same rate as the a.c.

(ii) An electric kettle draws 1.5 x 10^3W from a 240V mains supply. Find the peak value of the current drawn by the kettle, if the voltage is sinusoidal. (03marks).

P = 1.5 x 10^3W, $V_{r.m.s}$ = 240V

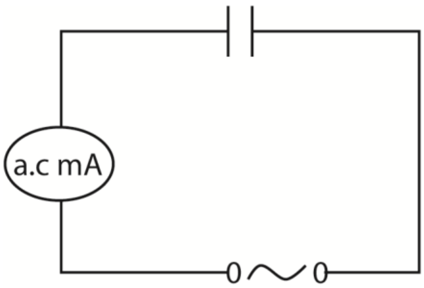
P = $I_{r.m.s}$ x $V_{r.m.s}$

$I_{r.m.s} = \frac{1.5 \ x\ 10^3}{240}$ = 6.25A

$I_0 = \sqrt{2} x\ I_{r.m.s} = \sqrt{2}\ x\ 6.25$ = 8.84A

(c) An alternating voltage of 12V and variable frequency, f, is connected in series with a capacitor of capacitance, C.

(i) Explain why current apparently flows through the capacitor. (05marks)



During the first quarter cycle, the capacitor charges in one direction until the p.d. between the plates is equal to supply voltage.

In the second quarter a cycle, the supply voltage decreases and the p.d between the capacitor plates drives charge in opposite direction.

The charge gets depleted from the plates but the flow of charge continues in the same direction, thus charging in opposite sense.

In the fourth quarter cycle, voltage begins to decrease and capacitor drives charge in the circuit in opposite direction.

The process is repeated many times per second such that the millimeter shows continuous flow of current.

(ii) Calculate the value of the current in the circuit when f and C are 1kHz and 0.5µF respectively. (03marks)

From $\frac{V_{r.m.s}}{I_{r.m.s}} = \frac{1}{2\pi f C}$

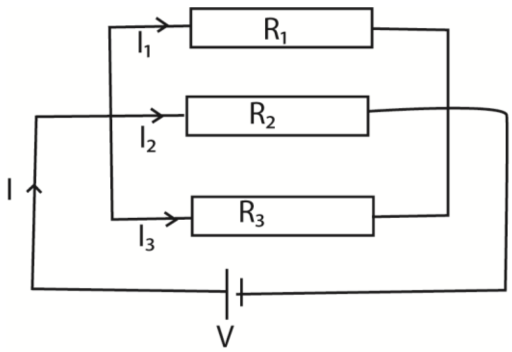
$I_{r.m.s} = V_{r.m.s} x\ 2\pi f C = 12\ x\ 2\pi\ x\ 1000\ x\ 0.5\ x\ 10^{-6}$ = 3.77 x 10^{-2}A

SECTION C

8. (a) (i) Define a volt. (01mark)

A volt is the potential difference between two points if work done to transfer1C of charge from one of the point to the other is 1J

(ii) Derive the formula for the combined resistance of three resistors in parallel. (04marks)



The p.d across each resistor is the same and equal to V

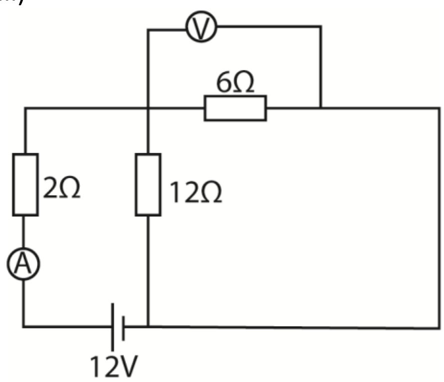
By conservation of current at the junction, $I = I_1 + I_2 + I_3$

From Ohm's law:$\frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$ where R is the equivalent resistance in the circuit

Dividing throughout by V

$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

(iii)



In the circuit above, has negligible internal resistance. Find the ammeter and voltmeter readings (04marks)

Effective resistance R = 2 + $\frac{6\ x\ 12}{6\ + 12}$= 6Ω

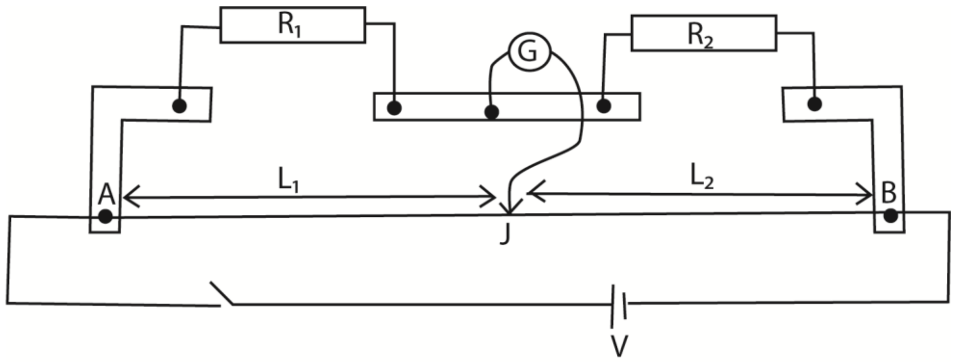
Current through 2Ω resistor = $\frac{V}{R} = \frac{12}{6} = 2A$

Hence ammeter reading = 2A

Effective resistance of 6Ω and 12Ω = $\frac{6\ x\ 12}{6+12}$ = 4Ω

V = IR = 2 x 4 = 8V

(b) (i) Draw a labelled diagram of a meter bridge and derive the relation for balance. (05marks)



- At balance, current passing through G is zero
- This implies that p.d across R_1 = p.d across AJ
- Let I_1 and I_2 be current through R_1 and AJ respectively, and k the resistance per unit length of wire AB
- The $I_1R_1 = I_1kL_1$…………………. (i)
- Also Ig = 0, I_1 passes through R_2 and I_2 passes through JB and p.d across R_2 = p.d across JB
- Then $I_1R_2 = I_2kL_2$…………………(ii)
- Dividing (i) by (ii)

$$\frac{R_1}{R_2} = \frac{L_1}{L_2}$$

(ii) Explain why the balance point should be close to the middle of the wire (02marks)

- When the length measured is big, percentage error is negligible
- When the balance point is close to the middle the end errors are minimized

(c) A coil of a wire has resistance of 30Ω at 200C and 34.5Ω at 600C. Calculate its temperature coefficient of resistance. (04marks)

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

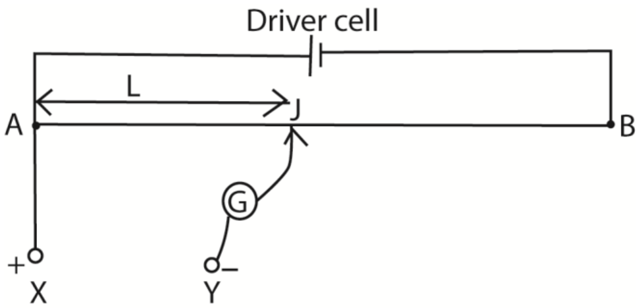
$30.0 = R_0(1 + 20\alpha)$……………. (i)

$34.5 = R_0(1 + 60\alpha)$…………… (ii)

From (i) and (ii)

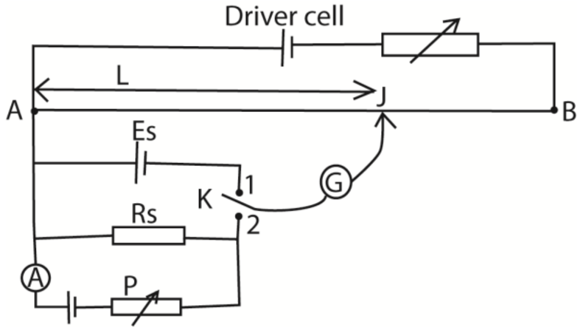
$\alpha = 4.05 \times 10^{-3}K^-1$

9. (a) Explain the principle of a slide wire potentiometer. (03marks)



- The driver cell maintains a steady current through a uniform resistance wire AB.
- The p.d per unit length of the wire is therefore constant.
- At balance, when G shows no deflection, the p.d across length AJ = test p.d
  i.e. V = kL

(b)(i) Using a labelled diagram, describe how an ammeter is calibrated using a slide wire potentiometer. (06marks)



- Es and Rs are standard e.m.f and standard resistance
- Switch K is connected to position 1 and jockey tapped at different positions along wire AB until the galvanometer shows no deflection.
- The balance length Ls is measured.
- Switch K is connected to position 2 and the resistance P adjusted to obtain a suitable reading Ir on the ammeter A.
- The balance length L and ammeter reading Ir are recorded.
- The procedure is repeated for the different setting of P, and corresponding values of L and Ir tabulate including values of $I_a = \frac{E_s}{L_s}\, x\, \frac{L}{Rs}$
- A graph of Ia against Ir constitutes the calibration curve of the ammeter.

(ii) What is the advantage of the potentiometer over an ordinary voltmeter in measurement of voltages? (02marks)

- It does not draw any current from the p.d thus gives accurate results.
- It can measure a wide range of p.d since the length of the slide wire can be adjusted

(c) Two cells A and B connected in series, give a balance length of 758mm along a potentiometer wire. When cell B is reversed, the balance length falls to 123mm. If the e.m.f of cell A is 1.5V, calculate the e.m.f of cell B. (04marks)

V ∝ L => V = kL where k is constant

$E_A + E_B$ = 0.758k ………………….. (i)

E_A = 0.123k ……………………….. (ii)

But E_A = 1.5 => k = $\frac{1.5}{0.123}$

Substituting into eqn. (i)

$E_B = \left(0.758\, x\, \frac{1.5}{0.123}\right) - 1.5 = 7.74V$

(d) The resistance of a nichrome element of an electric fire is 50.9Ω at 20.0^{0}C. When operating on a 240V supply, the current flowing through it is 4.17A. Calculate the steady temperature reached by the electric fire if the temperature coefficient of resistance of nichrome is 1.7 x $10^{-4}K^{-1}$

From R = $\frac{V}{I}$ => R = $\frac{240}{4.17}$ = 57.55Ω

But $R_\theta = R_0(1+ \alpha\theta)$,

50.9 = R_0 (1 + 1.7 x 10^{-4} x 20)

R_0 = 50.72Ω

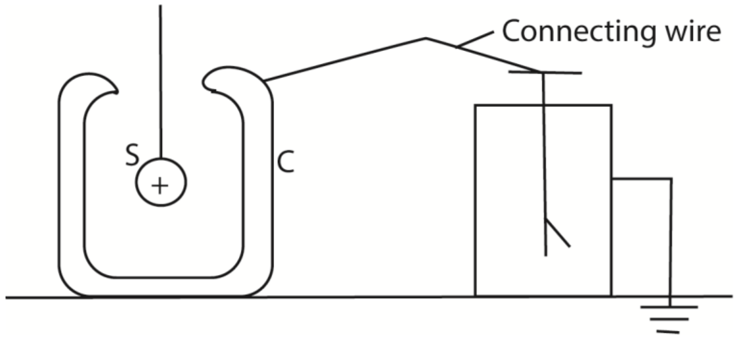
57.55 = 50.72 (1 + 1.7 x $10^{-4}\theta$)

θ = 792.1^0

10. (a) Explain the meaning of an equipotential surface as applied to electric field. (02marks)

An equipotential surface in one on which electric potential is the same at all points. The electric field lines are perpendicular to the surface and therefore work done to move 1C charge along the surface is equal to zero.

(b) With the aid of a diagram, describe an experiment to show that excess charge resides only on the outside surface of a hollow conductor. (05marks)

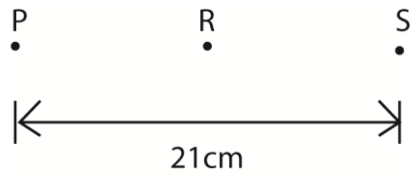


- A positive charge metal sphere S is lowered into a metal can using an insulating thread.
- The leaf of the electroscope diverges.
- The sphere S is withdrawn from C, and the leaf of electroscope collapses.
- When the sphere is lowered into C again, the leaf of the electroscope diverges by the same amount as before.
- S is then made to touch the inner surface of C, and then withdrawn. The divergence remains the same.
- When S s tested for charge, it is found to have lost all the charge. Hence there is no charge inside C but since the electroscope leaf is diverged, charge exist on the outside of C.

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

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

(d)



Two point charges P and S of -17.6μC and -9.0μC respectively are placed in a vacuum at a distance of 21cm apart. When a third charge, R, is placed midway between P and S as shown above, the net force on S is zero.

(i) Determine the charge on R (05marks)

F = $\frac{kQ_1.Q_2}{r^2}$

$F_P = \frac{k\,x\,17.6\ x\,10^{-6}\,x\,9\,x\,10^{-6}}{0.21^2}$

$F_R = \frac{k\,x\,Q\,x\,9\,x\,10^{-6}}{0.105^2}$

FP = FR

$$\frac{k\,x\,17.6\ x\,10^{-6}\,x\,9\,x\,10^{-6}}{0.21^2} = \frac{k\,x\,Q\,x\,9\,x\,10^{-6}}{0.105^2}$$

$$Q = \frac{17.6\,x\,10^{-6}}{0.21^2}\ x\ 0.105^2 = 4.4\ x\ 10^{-6}C$$

(ii) Calculate electric potential at position of R (05marks)

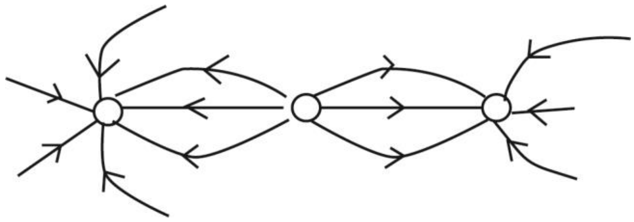
$V = \frac{kQ}{r}$

$V_p = \frac{9\ x\ 10^9\ x{-17.6}\ x\ 10^{-6}}{0.105}$ = -1.51 x 10^6V

$V_s = \frac{9\ x\ 10^9\ x{-9}\ x\ 10^{-6}}{0.105}$ = -0.77 x 10^6V

Total electric potential = -1.51 x 10^6 + -0.77 x 10^6V = 2.28 x 10^6V

(iii) Sketch the electric field lines corresponding to the charge distribution (02marks)



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