MODEL QUESTION PAPER (2020-21)

PHYSICS (THEORY)

MM: 70 Marks **Time : 3 hours**

General Instructions:

(1) All questions are compulsory. There are 33 questions in all.

(2) This question paper has five sections: Section A, Section B, Section C, Section D and Section E.

(3) Section A contains ten very short answer questions and four assertion reasoning MCQs of 1 mark each, Section B has two case based questions of 4 marks each, Section C contains nine short answer questions of 2 marks each, Section D contains five short answer questions of 3 marks each and Section E contains three long answer questions of 5 marks each.

(4) There is no overall choice. However internal choice is provided. You have to attempt only one of the choices in such questions.

SECTION–A

All questions are compulsory. In case of internal choices, attempt any one of them.

1. Write the necessary condition required for fusion reaction. **[1]**

2. Draw the pattern of electric field lines due to an electric dipole. **[1]**

OR

Define dielectric constant of a medium. What is it's S.I. unit ?

3. What is the ratio of radii of the orbits corresponding to first excited state and ground state in a hydrogen atom? **[1]**

4. Name two factors on which electrical conductivity of a pure semiconductor at a given temperature depends. **[1]**

5. Two wires one of copper and other of manganin have same resistance and equal length. Which wire is thicker and why ? **[1]**

OR

Define the term 'relaxation time' in a conductor.

6. Explain why current flows through an ideal capacitor when it is connected to an a.c. source but not when it is connected to a d.c. source in a steady state. **[1]**

7. What is the magnitude of magnetic force per unit length on a wire carrying a current of 8A and making an angle of 30° with the direction of a uniform magnetic field of 0.15 T? **[1]**

8. Must every magnetic configuration have a north pole and a south pole? What about the field due to a toroid? **[1]**

9. Name the electromagnetic radiations used for (a) water purification, and (b) eye surgery. **[1]**

OR

How are electromagnetic waves produced by accelerating charges?

10. Define the term 'wave front'. **[1]**

For question numbers 11, 12, 13 and 14, two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false and R is also false

11. **Assertion(A) :** Critical angle is maximum for red colour in water air system for visible light. **[1]**

Reason(R) : Because $\sin\theta_c = \frac{1}{\mu}$, μ (Refractive index of red colour) is minimum for visible light.

12. **Assertion(A) :** Conductivity of a semiconductor increases on doping. **[1]**
Reason(R) : Doping raises the temperature of semiconductor.

13. **Assertion(A) :** Parallel plate capacitor is connected across battery through a key. A dielectric slab of constant K is induced between the plates. The energy which is stored becomes K times. **[1]**
Reason(R) : The surface density of charge on the plate remains constant or unchanged.

14. **Assertion(A) :** When wheatstone bridge is balanced the current through the cell depends on the resistance of galvanometer. **[1]**
Reason(R) : In a balanced condition current through the galvanometer is very high.

SECTION – B

Questions 15 and 16 are Case Study based questions and are compulsory. Attempt any 4 sub parts from each question. Each question carries 1 mark.

Faraday Cage:

15. A Faraday cage or Faraday shield is an enclosure made of a conducting material. The fields within a conductor cancel out with any external fields, so the electric field within the enclosure is zero. These Faraday cages act as big hollow conductors you can put things in to shield them from electrical fields. Any electrical shocks the cage receives, pass harmlessly around the outside of the cage. **[4]**

(i) Which of the following material can be used to make a Faraday cage?
(a) Plastic (b) Glass (c) Copper (d) Wood

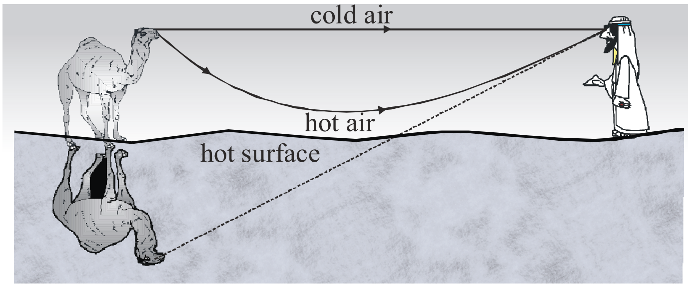
(ii) Example of a real-world Faraday cage is
(a) car (b) plastic box (c) lightning rod (d) metal rod

(iii) What is the electrical force inside a Faraday cage when it is struck by lightning?
(a) The same as the lightning (b) Half that of the lightning
(c) Zero (d) A quarter of the lightning

(iv) An isolated point charge +q is placed inside the Faraday cage. Its surface must have charge equal to-
(a) Zero (b) +q (c) –q (d) +2q

(v) A point charge of 2C is placed at centre of Faraday cage in the shape of cube with surface of 9 cm edge. The number of electric field lines passing through the cube normally will be-
(a) 1.9105 Nm^2/C entering the surface (b) 1.9105 Nm^2/C leaving the surface
(c) 2.0105 Nm^2/C leaving the surface (d) 2.0105 Nm^2/C entering the surface

16. **Mirage** :



Mirage is caused due to total internal reflection in deserts and other hot regions where, refractive index of air near the surface of earth becomes lesser than that above it due to heating of the earth. Light from distant objects approach the surface of earth with successively increasing incident angle (i), till incident angle (i) > critical angle (θ_C) so that total internal reflection (TIR) takes place so that inverted images appear along with the objects as shown in figure. **[4]**

(i) For the total internal reflection, which of the following statement is correct ?
(a) Light travels from denser to rarer medium.
(b) Light travels from rarer to denser medium.
(c) Light travels in air only.
(d) Light travels in water only.

(ii) If the critical angles for TIR from a medium to vacuum is 30°, the velocity of light in the medium :-
(a) 3×10^8 m/s (b) 0.5×10^8 m/s (c) 1.5×10^8 m/s (d) 0.2×10^8 m/s

(iii) Critical angle of light passing from glass to air is minimum for
(a) red (b) green (c) yellow (d) violet

(iv) Mirage is phenomenon due to :-
(a) Reflection of light (b) Refraction of light
(c) Total internal reflection of light (d) Diffraction of light

(v) If critical angle for a material to air is 30° the refractive index of the material will be?
(a) 1.0 (b) 1.5 (c) 2.0 (d) 2.5

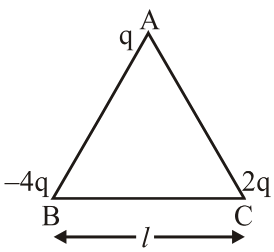
SECTION–C

All questions are compulsory. In case of internal choices, attempt anyone.

17. Find the ratio of the potential differences that must be applied across the series and parallel combination of two capacitors C_1 and C_2 with their capacitances in the ratio 1 : 2 so that the energy stored in the two cases becomes the same. **[2]**

OR

Three point charges q, –4q and 2q are placed at the vertices of an equilateral triangle ABC of side 'l' as shown in the figure. Obtain the expression for the magnitude of the resultant electric force acting on the charge q.



18. Define the following : **[2]**

(i) Root mean square value of A.C.

(ii) Quality factor in electrical resonance.

19. The number density of free electrons in a copper conductor estimated is 8.5×10^{28} m^{-3}. How long does an electron take to drift from one end of a wire 3.0 m long to its other end? The area of cross-section of the wire is 2.0×10^{-6} m^2 and it is carrying a current of 3.0 A. **[2]**

20. Explain briefly the process of emission of light by a Light Emitting Diode (LED) **[2]**

21. A long solenoid with 15 turns per cm has a small loop of area 2.0 cm^2 placed inside the solenoid normal to its axis. If the current carried by the solenoid changes steadily from 2.0 A to 4.0 A in 0.1 s, what is the induced emf in the loop while the current is changing ? **[2]**

OR

(i) Define mutual inductance.

(ii) A pair of adjacent coils has a mutual inductance of 1.5 H. If the current in one coil changes from 0 to 20A in 0.5 s, what is the change of flux linkage with the other coil?

22. Draw the intensity pattern for single slit diffraction and double slit interference. Hence, state two differences between interference and diffraction patterns. **[2]**

23. What is the reason to operate photodiode in reverse bias?

A p-n photodiode is fabricated from a semiconductor with a band gap of range of 2.5 to 2.8 eV. Calculate the range of wavelengths of the radiation which can be detected by the photodiode. **[2]**

24. The focal lengths of an objective lens and eyepiece are 192 cm and 8 cm respectively in a small telescope. Calculate it's magnifying power and the separation between the two lenses. **[2]**

25. In the magnetic meridian of a certain place, the horizontal component of the earth's magnetic field is 0.26G and the dip angle is 60°. What is the magnetic field of the earth at this location? **[2]**

OR

Name the elements of the earth's magnetic field. Define any two of them.

SECTION -D

All questions are compulsory. In case of internal choices, attempt any one.

26. Two identical cells of emf 1.5 V each joined in parallel to supply energy to an external circuit consisting of two resistances of 7 Ω each joined in parallel. A very high resistance voltmeter reads the terminal voltage of cells to be 1.4 V. Calculate the internal resistance of each cell. **[3]**

OR

A storage battery of emf 8.0 V and internal resistance 0.5Ω is being charged by a 120 V dc supply using a series resistor of 15.5Ω. What is the terminal voltage of the battery during charging? What is the purpose of having a series resistor in the charging circuit?

27. What is the effect on the interference fringes in Young's double slit experiment due to each of the following operations ? Justify your answer. **[3]**

(a) The screen is moved away from the plane of the slits.

(b) The separation between slits is increased.

(c) The source slit is moved closer to the plane of double slit.

28. State two important properties of photon which are used to write Einstein's photoelectric equation. Define (i) stopping potential and (ii) threshold frequency, using Einstein's equation and drawing necessary plot between relevant quantities. **[3]**

OR

Define the term 'cut off frequency" in photoelectric emission. The threshold frequency of a metal is f. When the light of frequency 2f is incident on the metal plate, the maximum velocity of photo-electrons is v_1. When the frequency of the incident radiation is increased to 5f, the maximum velocity of photo-electrons is v_2. Find the ratio $v_1 : v_2$.

29. Given the value of the ground state energy of hydrogen atom as –13.6 eV, find out its kinetic and potential energy in the ground and second excited states. **[3]**

30. Differentiate between nuclear fission & fusion. Give an example of each. Which of the above reactions take place in nuclear reactor ? **[3]**

OR

From the relation $R = R_0A^{1/3}$, where R_0 is a constant and A is the mass number of a nucleus, shows that the nuclear matter density is nearly constant. (i.e. independent of A).

SECTION – E

All questions are compulsory. In case of internal choices, attempt any one.

31. (a) Write an expression of magnetic moment associated with a current (I) carrying circular coil of radius r having N turns. **[5]**

(b) Consider the above mentioned coil placed in YZ plane with its centre at the origin. Derive expression for the value of magnetic field due to it at point (x, 0, 0).

OR

(a) Define current sensitivity of a galvanometer. Write its expression.

(b) A galvanometer has resitances G and shows full scale deflection for current Ig.

(i) How can it be converted into an ammeter to measure current up to $I_0(I_0 > I_g)$?

(ii) What is the effective resistance of this ammeter ?

32. (i) Draw a labelled diagram of a step-down transformer. State the principle of its working.

(ii) Express the turn ratio in terms of voltages.

(iii) Find the ratio of primary and secondary currents in terms of turn ratio in an ideal transformer.

(iv) How much current is drawn by the primary of a transformer connected to 220 V supply when it delivers power to a 110 V – 550 W refrigerator ? **[5]**

OR

A 2 μF capacitor, 100 Ω resistor and 8 H inductor are connected in series with an AC source.

(i) What should be the frequency of the source such that current drawn in the circuit is maximum, What is this frequency called ?

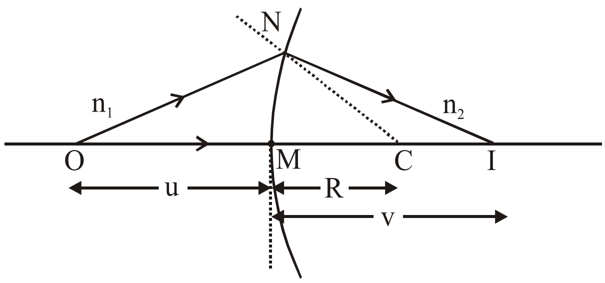
(ii) If the peak value of e.m.f. of the source is 200 V, find the maximum current.

(iii) Draw a graph showing variation of amplitude of circuit current with changing frequency of applied voltage in a series LCR circuit for two different values of resistance R_1 and R_2 $(R_1 > R_2)$.

33. A point object O on the principal axis of a spherical surface of radius of curvature R separating two media of refractive indices n_1 and n_2 forms an image 'I' as shown in the figure. **[5]**

Prove that

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$



OR

(a) Derive the relation $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$

Where f_1 and f_2 are focal lengths of two thin lenses and f is the focal length of the combination in contact.

(b) Draw the ray diagram of an compound microscope, when the final image is formed at the least distance of distinct vision. Write the formula for magnifying power in the above noted case.

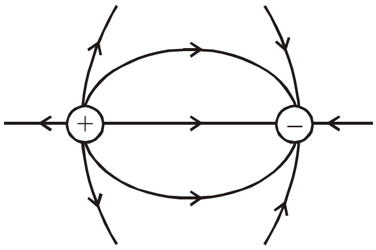
MODEL PAPER (SOLUTIONS) 2020-21

(PHYSICS)

SECTION – A

1. (i) Nuclear fusion will occur when the kinetic energy of colliding nuclei is enough to overcome the strong electrostatic forces of repulsion between the protons. For this, high temperature is required.

(ii) The density of nuclei should also be very high to increase the number of collisions. **[1]**

2. 
[1]

OR

Dielectric constant (or relative permittivity) of a medium is the ratio of the absolute permittivity of a medium to the permittivity of free space.

$$K \ (\text{or } \varepsilon_r) = \varepsilon/\varepsilon_0$$

Value of K is more than 1 for any dielectric medium. As it is a ratio so it has no unit.

3. $r_n \propto n^2 \Rightarrow r_2 / r_1 = 4/1$ **[1]**

4. (i) Band gap (ii) Biasing. **[1]**

5. Manganin is an alloy of copper with manganese and nickel. Since the manganese and nickel have resistivity greater than copper, the pure copper has lower resistivity as compared to alloy manganin. For the same resistance and equal length manganin wire is thicker than copper. [$\because \rho \propto A$] **[1]**

$$R = \rho\frac{\ell}{A}$$

OR

Relaxation time is the time interval between two successive collisions of electrons in a conductor, when current flows.

6. When AC is connected to capacitor, due to continous change of polarity of the applied voltage there will be continuous change of polarity of capacitor plates. This causes the charge to flow (dq/dt) across capacitor. **[1]**

In steady state, capacitor acts as open circuit as reactance offered by it to flow of dc ($f = 0$) is infinite.

As $$X_C = \frac{1}{2\pi fC} = \infty$$

7. $i = 8A$, $\theta = 30°$, $B = 0.15T$, $F/\ell = ?$ **[1]**

$F = i \, \ell \, B \sin\theta$

$F/\ell = i B \sin\theta = 8 \times 0.15 \sin 30° = 1.20 \times 1/2 = 0.6$ N/m

8. Not necessarily. True only if the source of the field has a net non-zero magnetic moment. This is not so for a toroid or even for a straight infinite conductor. **[1]**

9. (a) Water purification → Ultraviolet radiation **[1]**

(b) Eye surgery → Ultraviolet radiation [LASIK LASER]

OR

An accelerated charge produces an oscillating electric field in space which produces an oscillating magnetic field, which is again a source of oscillating electric field and so as a result electro magnetic wave is produced.

10. Locus of all the points vibrating in the same phase is called wave front. **[1]**

11. (a) **[1]**

12. (c) **[1]**

13. (c) **[1]**

14. (d) **[1]**

SECTION – B

15. (i) c, (ii) a, (iii) c, (iv) c, (v) b **[4 × 1 = 4]**

16. (i) a, (ii) c, (iii) d, (iv) c, (v) c **[4 × 1 = 4]**

SECTION – C

17. Let $C_1 = x$ and $C_2 = 2x$ **[2]**

equivalent capacitance in series combination

$$C_S = \frac{C_1C_2}{C_1+C_2} = \frac{x \times 2x}{x+2x} = \frac{2x}{3} \qquad \therefore C_S = \frac{2x}{3}$$

equivalent capacitance in parallel combination

$C_P = C_1 + C_2 = x + 2x = 3x$

Now given that energy stored in series combination = Energy stored in parallel combination

$$\frac{1}{2}C_sV_1^2 = \frac{1}{2}C_PV_2^2$$

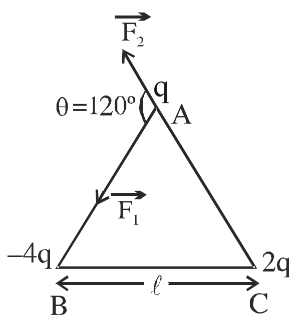
$$\frac{1}{2}\times\left(\frac{2x}{3}\right)V_1^2 = \frac{1}{2}\times 3x \times V_2^2$$

$$\Rightarrow \boxed{\frac{V_1}{V_2} = \frac{3}{\sqrt{2}}}$$

OR

Force on charge q due to the charge 4 q

$$F_1 = \frac{1}{4\pi\epsilon_0}\left(\frac{4q^2}{\ell^2}\right), \text{ along AB}$$



Force on the charge q due to the charge 2 q

$$F_2 = \frac{1}{4\pi\epsilon_0}\left(\frac{2q^2}{\ell^2}\right), \text{ along CA}$$

F_1 and F_2 are inclinded to each other at an angle of 120º

Hence, resultant electric force on charge q

$$F = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$

$$= \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos 120^\circ}$$

$$= \sqrt{F_1^2 + F_2^2 - F_1F_2}$$

$$= \left(\frac{1}{4\pi\epsilon_0}\frac{q^2}{\ell^2}\right)\sqrt{16+4-8}$$

$$= \frac{1}{4\pi\epsilon_0}\left(\frac{2\sqrt{3}q^2}{\ell^2}\right)$$

18. **(i) Root mean square value of alternating current :** It is equal to that value of steady current which when passed through same resistance for same time then same amount of heat get produced.

(ii) Quality factor in electrical resonance : It is that factor which represents the sharpness of resonance of series LCR circuit. It is given by - **[2]**

$$\boxed{Q = \frac{1}{R}\sqrt{\frac{L}{C}}}$$

19. Using $V_d = \frac{I}{neA}$, We get **[2]**

$$V_d = \frac{3}{(8.5\times10^{28})(1.6\times10^{-19})(2\times10^{-6})} = 1.1 \times 10^{-4} \ \text{m s}^{-1}$$

Time taken, $t = \frac{l}{V_d} = \frac{3}{1.1\times10^{-4}} = 2.72 \times 10^4$ s

20. A light-emitting diode (LED) is a heavily doped p–n junction diode that emits light when forward biased. When a suitable voltage is applied, electrons recombine with holes thereby releasing energy in the form of photons $\leq E_g$. **[2]**

21. Here, number of turns per unit length, **[2]**

$n = N/l = 15$ turns/cm $= 1500$ turns/m

$A = 2\ \text{cm}^2 = 2 \times 10^{-4}\ \text{m}^2$

$dI/dt = (4-2)/0.1$ or $dI/dt = 20\ \text{As}^{-1}$

$$|e| = \frac{d\phi}{dt} = \frac{d}{dt}(BA) \qquad \left[\because B = \frac{\mu_0 NI}{l}\right]$$

$$|e| = \frac{Ad}{dt}\left(\mu_0\frac{NI}{l}\right) = A\mu_0\left(\frac{N}{l}\right)\frac{dI}{dt}$$

$$|e| = (2\times10^{-4}) \times 4\pi \times 10^{-7} \times 1500 \times 20\ \text{V}$$

$$|e| = 7.5 \times 10^{-6}\ \text{V}$$

OR

(i) **Mutual Inductance** : It is numerically equal to the magnetic flux linked with one coil (secondary coil) when a unit current flows through the other coil (primary coil).

(ii) Magnetic flux

$\phi_1 = MI_1$

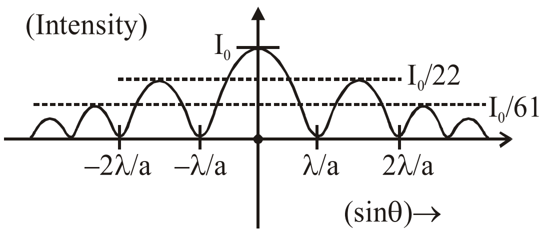
As $I_1 = 0$

$\therefore$ $\phi_1 = 0$

$\phi_2 = MI_2 = 1.5 \times 20 = 30$

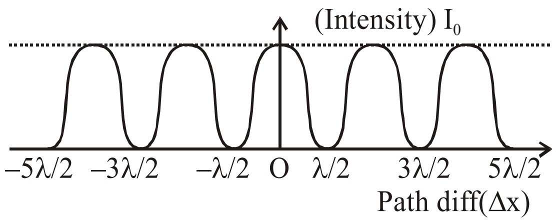
Change in flux $d\phi = \phi_2 - \phi_1 = 30 - 0 = 30$ weber.

22. **[2]**



Diffraction

(1) Intensity decreases rapidly
(2) Fringes are of unequal width.



Interference

(1) Intensity remains constant most of the time
(2) Fringes are of equal width.

23. It is much easier to detect optical signal in reverse bias of photodiode because fractional change in conc. of minority charge carriers is very higher as compare to majority carriers. **[2]**

From, $\lambda = \dfrac{12400}{\Delta E_{(ev)}}$ Å

$$= \frac{12400}{0.3} = 41400\text{Å}$$

24. $f_o = 192$ cm and $f_e = 8$ cm **[2]**

Magnifying power

$$M = \frac{f_0}{f_e} = \frac{192}{8} \Rightarrow M = 24$$

Distance between two lenses -

$L = f_o + f_e$

$L = 192 + 8$

$L = 200$ cm

25. Given $B_H = 0.26$ G **[2]**

$$\cos 60° = \frac{B_H}{B}$$

$$B = \frac{B_H}{\cos 60°} = \frac{0.26}{(1/2)} = 0.52\text{G}$$

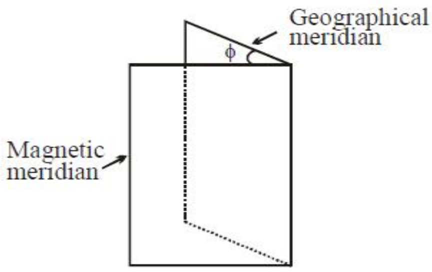
OR

Earth's magnetic components :-

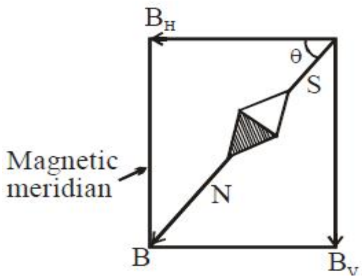
(1) Declination Angle (2) Dip Angle or Angle of inclination

(3) Horizontal Component of earth's magnentic field

(1) Angle of declination (ϕ) :- It is the acute angle between magnetic meridian and geographical meridian at a given place.



(2) Dip Angle(θ) :- It is direction horizontal resultant magnetic field of earth in magnetic meridian. Dip angle at magnetic pole of earth is 90° and at magnetic equator it is 0°.



B ⇒ resultant magnetic field of earth's magnetism

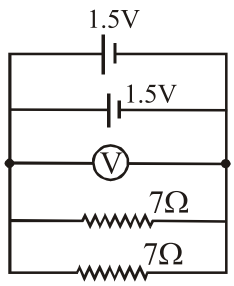
B_H ⇒ Horizontal component

B_V ⇒ Vertical component

SECTION – D

26. A high resistance voltmeter means that no current flow through the voltmeter (practically very less current). When two batteries are connected in parallel, then **[3]**

$$E_{eq} = \frac{E_1r_2 + E_2r_1}{r_1 + r_2}$$



Here $r_1 = r_2 = r$

$E_1 = E_2 = 1.5V$ (given)

$$E_{eq} = \frac{1.5 \times r + 1.5 \times r}{2r}$$

$E_{eq} = 1.5$ V

Now $\left.\begin{array}{l} R_1 = 7\Omega \\ R_2 = 7\Omega \end{array}\right]$ given

So $$\frac{1}{R_{eq}} = \left(\frac{1}{7} + \frac{1}{7}\right)\Omega$$

$$R_{eq} = \frac{7}{2} = 3.5\Omega$$

$\because \quad I = \dfrac{\text{terminal voltage}}{\text{equivalent resistance}}$

V = terminal voltage = 1.4 (given) = voltmeter reading

So $\quad I = \dfrac{1.4}{3.5} = 0.4\ A$

Now $\quad V = E_{eq} - I \times r_{eq}$

$1.4 = 1.5 - 0.4 \times r_{eq}$

$0.4 \times r_{eq} = 0.1$

$r_{eq} = 0.25\ \Omega$

As $r_{eq} = r/2 \qquad \left(\because \dfrac{1}{r_{eq}} = \dfrac{1}{r} + \dfrac{1}{r}\right)$

So r of each cell = 0.5Ω

OR

During charging,

V= E + I (r + R)

$I = \dfrac{E - V}{r + R} = \dfrac{120 - 8}{0.5 + 15.5} = \dfrac{112}{16} = 7A$

Terminal Voltage,

= 8 + 7 × 0.5 = 11.5 V

The series resistor limits the current drawn from the external source. In its absence, the current will be dangerously high.

27. Fringe width in young's double slit experiment is given by $\boxed{\beta = \dfrac{\lambda D}{d}}$ **[3]**

λ = wavelength of light

d = separation between slits

D = distance between screen and plane of the slits.

(a) When D is increased, β also increases. Thus the size of each fringe increases. There will be lesser dark and bright fringes on the screen.

(b) If the separation between slits is increased, fringe width decreases $\boxed{\beta \propto \dfrac{1}{d}}$.

Thus, the size of each fringe decreases.

(c) For interference fringes to be seen, the condition $\dfrac{s}{S} < \dfrac{\lambda}{d}$ should be satisfied. As the

$$\begin{cases} s \Rightarrow \text{ size of slit} \\ S \Rightarrow \text{ distance between source slit and plane of the two slits} \end{cases}$$

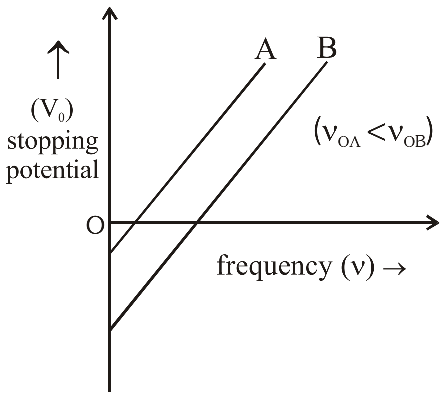
If the source slit is moved towards or closer to the double slit then the above condition is not satisfied. As a result, interference fringes will overlap and interference pattern will be less sharp & have low intensity.

28. (i) Energy of a photon is proportional to the freq. of light. ($\because E = h\nu$) **[3]**

(ii) Photons are quanta or discrete carriers of energy.

Stopping potential :- In experiment of photoelectric effect, the value of negative potential of anode at which photoelectric current reduces to zero is called stopping potential for the given freq. of incident radiation.

Threshold freq. :- For a given material, there exist a certain min. frequency below which no photoelectron can come out from the metal surface. This is called threshold ferquency.



OR

Cut off frequency – The min. freq. of light which can emit photoelectrons from a material is known as cut-off frequency.

From eq. $KE_{max} = h\nu - h\nu_0$

$$\frac{1}{2}mv_1^2 = hf \qquad ....(1)$$

$$\frac{1}{2}mv_2^2 = 4hf \qquad ....(2)$$

$$\therefore \quad \frac{v_1^2}{v_2^2} = \frac{1}{4} \Rightarrow \frac{v_1}{v_2} = \frac{1}{2}$$

29. Ground state energy of hydrogen atom as –13.6 eV, **[3]**

$$E_n = \text{Total energy} = -\frac{13.6 \text{ eV}}{n^2}$$

$$\text{K.E.} = \frac{Rhc}{n^2}, \qquad \text{P.E.} = = \frac{-2Rhc}{n^2}$$

$\Rightarrow$ In ground state, $(n = 1)$

$R = 1.097 \times 10^7 m^{-1}$ (Rydberg's constant)
$h = 6.6 \times 10^{-34} J-s$ (Planck's constant)
$c = 3 \times 10^8 m/s$

$$\text{K.E.} = \frac{Rhc}{n^2} = Rhc$$

& P.E. = –2Rhc

⇒ In second excited state, (n = 3)

$$\text{K.E.} = \frac{Rhc}{9} \quad \& \quad \text{P.E.} = \frac{-2Rhc}{9}$$

30. **(i) Nuclear fission :** Nuclear fission is the phenomenon of splitting of a heavy nucleus (usually A > 230) into two or more lighter nuclei. **[3]**

Ex. $_{92}U^{235} + {}_0n^1 \rightarrow {}_{92}U^{236} \rightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3{}_0n^1 + Q$

(ii) Nuclear fusion : The process of combining of two lighter nuclei to form one heavy nucleus is called nuclear fusion.

Ex. $4{}_1H^1 \rightarrow {}_2He^4 + 2{}_1e^0 + 2\nu + 26.7\ \text{MeV}$

* Nuclear reactor is based on controled chain reaction.

OR

$$\text{Density of nucleus matter} = \frac{\text{Mass of nucleus}}{\text{Volume of nucleus}}$$

$$\rho = \frac{mA}{\frac{4}{3}\pi R^3}, \qquad [\, R = R_0 A^{1/3}$$

$$\rho = \frac{3m}{4\pi R_0^3}$$

$$\rho = \frac{A \times 1.66 \times 10^{27} \text{kg}}{\frac{4}{3} \times 3.14 \times \left(1.2 \times 10^{-15}\right)^3 A} \approx 10^{17}\ \text{kg/ m}^3$$

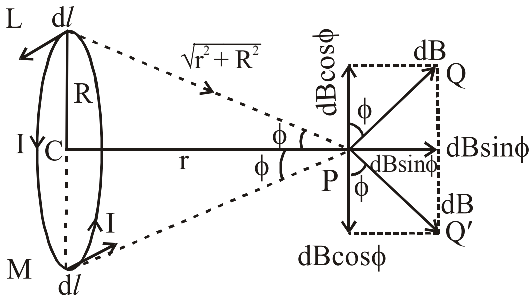
It is clear that the density of nucleus is constant.

SECTION – E

31. (a) Magnetic moment of current carrying circular coil. **[5]**

$\boxed{M = NIA}$ $[A = \pi r^2]$

(b) Let us consider a circular loop of radius R with centre C. Let the plane of the coil be perpendicular to the plane of the paper and current I be flowing in the direction shown. Suppose P is any point on the axis at distance r from the centre.



Let us consider a current element dl on top (L) where, current comes out of paper normally whereas at bottom (M) enters into the plane paper normally.

Here $\quad LP = MP = \sqrt{r^2 + R^2}$

Now, magnetic field at P due to current at L accroding to Biot-Savart Law,

$$dB = \frac{\mu_0}{4\pi} \frac{Idl \sin 90^\circ}{\left(r^2 + R^2\right)}$$

Where, $\quad$ R = radius of circular loop

r = distance of point P from centre along the axis.

dBcosϕ components balance each other and net magnetic field is given by integration of dBsinϕ component.

$$B = \oint dB \sin\phi = \oint \frac{\mu_0}{4\pi}\left[\frac{Idl}{r^2 + R^2}\right] \cdot \frac{R}{\sqrt{r^2 + R^2}} \qquad \left[\because \sin\phi = \frac{R}{\sqrt{r^2 + R^2}} \text{ in } \Delta PCM\right]$$

$$= \frac{\mu_0}{4\pi} \frac{IR}{(r^2 + R^2)^{3/2}} \oint dl$$

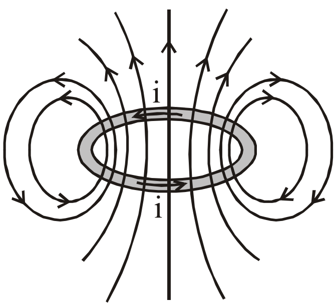
$$B = \frac{\mu_0}{4\pi} \frac{IR}{(r^2 + R^2)^{3/2}} (2\pi R)$$

$$B = \frac{\mu_0 IR^2}{2\left(r^2 + R^2\right)^{\frac{3}{2}}}$$

For N turns,

$$\boxed{B = \frac{\mu_0 NIR^2}{2\left(r^2 + R^2\right)^{\frac{3}{2}}}}$$

Magnetic field due to circular wire carrying current I.



OR

(a) Current sensitivity (CS)

Deflection per unit current in a galvanometer is called current sensitivity.

$$CS = \frac{\phi}{I}$$

$$\boxed{CS = \frac{NAB}{K}}$$

$N \Rightarrow$ No. of turns in a coil.

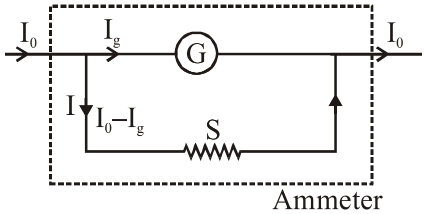
$A \Rightarrow$ Area of coil

$B \Rightarrow$ Magnetic field

$K \Rightarrow$ Torsional constant of spring.

(b) (i) To convert galvanometer into an ammeter to measure current up to I_0. We connect a small resistance (S) in parallel to a galvanometer.

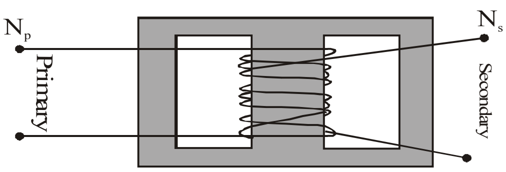
In parallel, $(I_0 - I_g)S = I_g G$



$$\boxed{S = \frac{I_g G}{I_0 - I_g}}$$

(ii) Effective resistance of this ammeter $\boxed{R_A = \frac{GS}{G+S}}$

32. (i) **[5]**



$N_s < N_p$

Principle: Transformer works on principle of mutual induction , in which an EMF is induced in the secondary coil by the change in magnetic flux in primary coil.

Working : When alternating current source is connected to the ends of primary coil, the current changes continuously in the primary coil, due to which magnetic flux linked with the secondary coil changes continuously. Therefore, the alternating emf of same frequency is developed across the secondary terminals.

(ii) $\frac{N_S}{N_P} = \frac{V_S}{V_P}$ $\qquad \left\{ \frac{N_S}{N_P} = \text{turn ratio} \right.$

(iii) For ideal transformer

Output power = Input power

$V_S I_S = V_P I_P$

$\frac{V_S}{V_P} = \frac{I_P}{I_S}$ $\qquad \left\{ \frac{V_S}{V_P} = \frac{N_S}{N_P} \right.$

$$\boxed{\frac{N_S}{N_P} = \frac{I_P}{I_S}}$$

(iv) Given $V_P = 220$ V

$V_S = 110$ V

$P = 550$ W

$I_P = ?$

$$I_P = \frac{\text{Power}}{\text{Primary Voltage}} = \frac{P}{V_P}$$

$$I_P = \frac{550}{220} = 2.5 \text{ A}$$

OR

(i) Source frequency, when current is maximum is given by

$$f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{8\times 2\times 10^{-6}}} \quad \{L = 8H \text{ and } C = 2\mu F$$

$$f = \frac{1}{2\pi\times 4\times 10^{-3}}$$

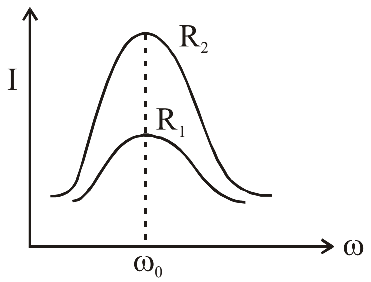
$f = 39.80$ Hz

The frequency at which current maximum, is called resonant frequency.

(ii) given $E_0 = 200V$, $R = 100\Omega$

$$I_{max} = \frac{E_0}{R} = \frac{200}{100} = 2A$$

(iii)



33. (a) & (b) Assumptions :- **[5]**

– Aperature of the spherical refracting surface is small.

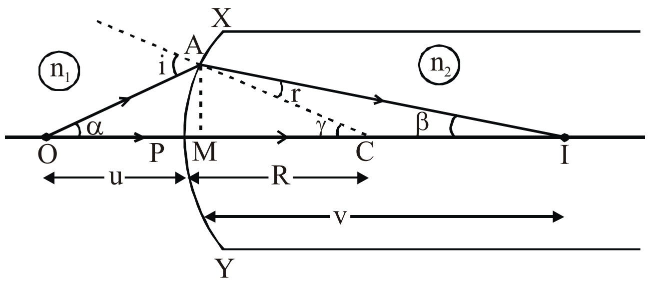
– Object is a point object & lies on the pricipal axis.

– Incident ray, refracted ray & normal to the spherical surface makes small angles with PA.

Let XPY = convex spherical refracting surface.

O = point object in rarer medium

I = real image in denser medium



From ΔAOC, $i = \alpha + \gamma$

From ΔAIC, $\gamma = r + \beta \Rightarrow r = \gamma - \beta$

From snell's law, $\frac{\sin i}{\sin r} = \frac{n_2}{n_1} \Rightarrow n_1 \sin i = n_2 \sin r$

Since the angles are small, $\therefore\ n_1 i = n_2 r$

Substituting for i & r, in the above eqn, we get

$$\boxed{n_1(\alpha + \gamma) = n_2(\gamma - \beta)}$$

or $$n_1\left\{\frac{AM}{PO} + \frac{AM}{MC}\right\} = n_2\left\{\frac{AM}{MC} - \frac{AM}{MI}\right\}$$

Since the aperature is small,

$\therefore$ MC = PC, MI = PI

$$\therefore \left\{\frac{n_1}{PO} + \frac{n_1}{PC}\right\} = \left\{\frac{n_2}{PC} - \frac{n_2}{PI}\right\}$$

Acc. to sign convention, PO = –u, PC = R, PI = v

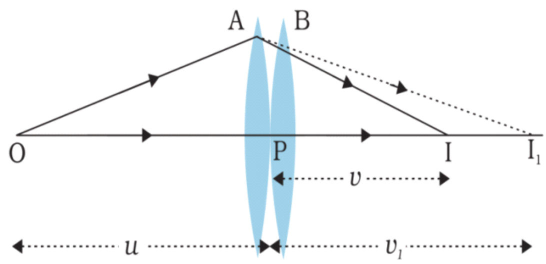
$$\therefore \left\{\frac{n_1}{-u} + \frac{n_1}{R}\right\} = \left\{\frac{n_2}{R} - \frac{n_2}{v}\right\}$$

or $$\boxed{\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}}$$

OR

(a) Combination of thin lenses in contact -

Image I_1 made up by lens L_1 is work as a object for lens L_2 which made up final image I.



f_1 Focal length of lens L_1

$f_2 \Rightarrow$ Focal length of lens L_2

For lens L_1

Using lens formula

$$\frac{1}{v_1} - \frac{1}{(-u)} = \frac{1}{f_1}$$

$$\frac{1}{v_1} + \frac{1}{u} = \frac{1}{f_1} \qquad \ldots\ldots(1)$$

For lens L_2

Using lens formula

$$\frac{1}{v} - \frac{1}{v_1} = \frac{1}{f_2} \qquad \ldots\ldots(2)$$

eq^n (1) + eq^n (2)

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f_1} + \frac{1}{f_2} \qquad \ldots\ldots(3)$$

If the two lens system is regarded as equivalent to a single lens of focal length f.

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \qquad \ldots\ldots(4)$$

From eq^n (4) & eq^n (3)

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} \qquad \ldots\ldots(5)$$

equivalent focal length

$$f = \frac{f_1 f_2}{(f_1 + f_2)} \qquad \ldots\ldots(6)$$

(b) Magnifying power, M= $\frac{v_0}{u_0}\left(1 + \frac{D}{f_e}\right) = -\frac{L}{f_0}\left(1 + \frac{D}{f_e}\right)$