SAMPLE QUESTION PAPER

BLUE PRINT

Time Allowed : 3 hours **Maximum Marks :** 70

S. No.	Chapter	VSA/ AR/ Case Based (1 mark)	SA-I (2 marks)	SA-II (3 marks)	LA (5 marks)	Total
1.	Electrostatics	1(1)	1(2)	–	1(5)	**6(16)**
2.	Current Electricity	2(5)	–	1(3)	–	
3.	Magnetic Effects of Current and Magnetism	1(1)	2(4)	–	–	**8(17)**
4.	Electromagnetic Induction and Alternating Current	2(2)	1(2)	1(3)	1(5)	
5.	Electromagnetic Waves	2(2)	1(2)	–	–	**8(18)**
6.	Optics	2(5)	2(4)	–	1(5)	
7.	Dual Nature of Radiation and Matter	1(1)	–	1(3)	–	**6(12)**
8.	Atoms and Nuclei	2(2)	–	2(6)	–	
9.	Electronic Devices	3(3)	2(4)	–	–	**5(7)**
	Total	**16(22)**	**9(18)**	**5(15)**	**3(15)**	**33(70)**

Subject Code : **042**

PHYSICS

Time allowed : 3 hours ***Maximum marks : 70***

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

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

(iii) 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.

(iv) 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. From the information of energy bandgaps of diodes, how do you decide which can be light emitting diode?

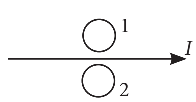
2. Which physical quantity in a nuclear reaction is considered equivalent to the *Q*-value of the reaction?

OR

Give the relation between radius of a nucleus and mass number *A*?

3. Define the term 'current sensitivity' of a moving coil galvanometer.

4. What is the direction of induced currents in metal rings 1 and 2 when current *I* in the wire is increasing steadily ?



OR

A long straight current carrying wire passes normally through the centre of circular loop. If the current through the wire increases, will there be an induced emf in the loop? Justify.

5. Two metals *A* and *B* have work functions 2 eV and 6 eV respectively. Which of the two metals have larger threshold frequency?

6. Give any one advantage of LEDs over conventional incandescent low power lamps.

7. What is the frequency of electromagnetic waves produced by oscillating charge of frequency υ?

OR

Name the part of electromagnetic spectrum whose wavelength lies in the range of 10^{-10} m. Give its one use.

8. Using the concept of force between two infinitely long parallel current carrying conductors, define one ampere of current.

9. Draw circuit diagram of a half wave rectifier.

OR

Draw I-V characteristic of a solar cell.

10. What is the Bohr's quantization condition for the angular momentum of an electron in the second orbit?

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) :** A single lens produces a coloured image of an object illuminated by white light.
Reason (R) : The refractive index of the material of lens is different for different wavelengths of light.

12. **Assertion (A) :** Net electric field insider a conductor is zero.
Reason (R) : Total positive charge equals to total negative charge in a charged conductor.

13. **Assertion (A) :** The electromagnetic waves are transverse in nature.
Reason (R) : Waves of wavelength 10 mm are radiowave and microwave.

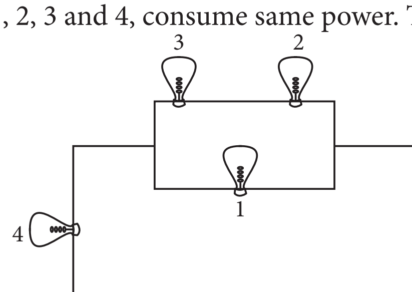
14. **Assertion (A) :** A copper sheet is placed in a magnetic field. If we pull it out of the field or push it into the field, we experience an opposing force.
Reason (R) : I According to Lenz's law eddy current produced in sheet opposes the motion of the sheet.

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.

15. Electric power is the rate at which an appliance converts electric energy into other forms of energy. Electric power is given by, $P = VI = I^2R = \frac{V^2}{R}$.

The given figure shows four bulbs 1, 2, 3 and 4, consume same power. The resistance of bulb 1 is 36 Ω.



(i) What is the resistance of the bulb 3?
(a) 4 Ω (b) 9 Ω (c) 18 Ω (d) 12 Ω

(ii) What is the resistance of bulb 4?
(a) 4 Ω (b) 8 Ω (c) 9 Ω (d) 18 Ω

(iii) If power of each bulb is 4 W, then the total current flowing through the circuit is
(a) 1 A (b) 2 A (c) 4 A (d) 12 A

(iv) What is the equivalent resistance of the circuit?
(a) 12 Ω (b) 8 Ω (c) 18 Ω (d) 16 Ω

(v) What is the voltage output of the battery, if the power of each bulb is 4 W?
(a) 16 V (b) 12V (c) 24V (d) 18V

16. Total internal reflection is the phenomenon that involves the reflection of all the incident light off the boundary. Light must travel from denser to rarer medium and angle of incidence in denser medium must be greater than critical angle (C) for the pair of media in contact. For internal reflection we can show that $\mu = \frac{1}{\sin C}$.

(i) Critical angle for glass air interface where μ of glass is 3/2 is
(a) 41.8° (b) 60° (c) 30° (d) 44.3°

(ii) Critical angle for water air interface is 48.6°. What is the refractive index of water?
(a) 1 (b) 3/2 (c) 4/3 (d) 3/4

(iii) Critical angle for air water interface for violet colour is 49°. Its value for red colour would be
(a) 49° (b) 50° (c) 48° (d) 52°

(iv) A point source of light is held at a depth h below the surface of water. If C is critical angle of air-water interface, the diameter of circle of light coming from water surface would be
(a) $2h \tan C$ (b) $h \tan C$ (c) $h \sin C$ (d) $h/\sin C$

(v) If the critical angle for total internal reflection from a medium to vaccum is 30°, then the velocity of light in the medium is,
(a) 3×10^8 m/s (b) 1.5×10^8 m/s (c) 6×10^8 m/s (d) $\sqrt{3} \times 10^8$ m/s

SECTION - C

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

17. The electric field intensity produced by the radiations coming from 100 W bulb at a 3 m distance is E. What is the electric field intensity produced by the radiations coming from 50 W bulb at the same distance ?

OR

What are the radio waves? How are these waves produced?

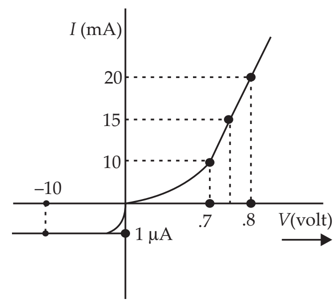
18. In what way is diffraction from each slit related to the interference pattern in a double-slit experiment?

19. Write the four important properties of the magnetic field lines due to a bar magnet.

OR

A conducting rod of length 2 m is placed on a horizontal table in north-south direction. It carries a current of 5 A from south to north. Find the direction and magnitude of the magnetic force acting on the rod. Given that the Earth's magnetic field at the place is 0.6×10^{-4} T and angle of dip is $\frac{\pi}{6}$.

20. The V-I characteristic of a diode is shown in the figure. Find the ratio of forward to reverse bias resistance.



21. Explain briefly how the phenomenon of total internal reflection is used in fibre optics.

22. Show that the capacitance of a spherical conductor is $4\pi\varepsilon_0$ times the radius of the spherical conductor.

OR

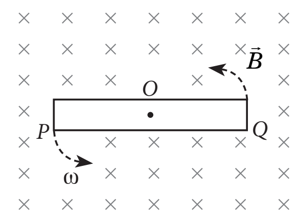
Two charges 2 μC and –2 μC are placed at points A and B 6 cm apart.

(a) Identify an equipotential surface of the system.

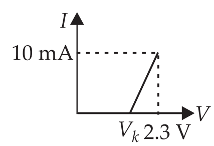
(b) What is the direction of the electric field at every point on this surface?

23. A proton and a deuteron, each moving with velocity $\vec{v}$ enter simultaneously in the region of magnetic field $\vec{B}$ acting normal to the direction of velocity. Trace their trajectories establishing the relationship between the two.

24. A metallic rod PQ of length l is rotated with an angular velocity ω about an axis passing through its mid-point (O) and perpendicular to the plane of the paper, in uniform magnetic field $\vec{B}$, as shown in the figure. What is the potential difference developed between the two ends of the rod, P and Q?



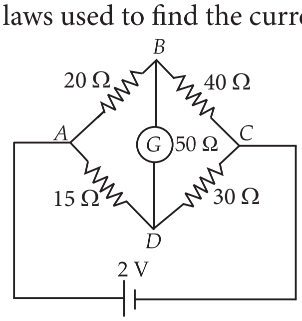
25. Find the resistance of a germanium junction diode whose $V – I$ is shown in figure. (V_k = 0.3 V)



SECTION - D

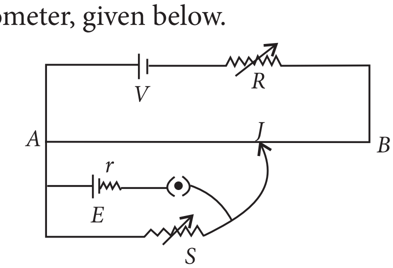
All questions are compulsory. In case of internal choices, attempt any one.

26. The given figure shows a network of resistances. Name the circuit so formed. What is the current flowing in the arm BD of this circuit? State the two laws used to find the current in different branches of this circuit.



OR

State working principle of potentiometer. Explain how the balance point shifts when value of resistor R increases in the circuit of potentiometer, given below.



27. Write three characteristic properties of nuclear force.

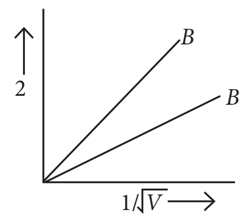
28. Radiations of frequency 10^{15} Hz are incident on two photosensitive surfaces *A* and *B*. Following observations are recorded.

Surface *A* : No photo-emission takes place.

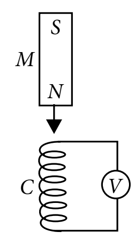
Surface *B* : Photo-emission takes place but photo-electrons have zero energy. Explain the above observations on the basis of Einstein's photoelectric equation. How will the observation with surface *B* change when the wavelength of incident radiation is decreased?

OR

The two lines *A* and *B* shown in the graph represent the de-Broglie wavelength (λ) as a function of $1/\sqrt{V}$ (V is the accelerating potential) for two particles having the same charge. Which of the two represents the particle of heavier mass?



29. Figure shows a bar magnet *M* falling under gravity through an air cored coil C. Plot a graph showing variation of induced emf (e) with time (t). What does the area enclosed by the e-t curve depict?



30. Derive an expression for the total energy of the electron in hydrogen atom, using Rutherford's model of the atom. Also, explain the significance of total negative energy possessed by the electron?

SECTION - E

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

31. (a) In a series *LCR* circuit connected across an ac source of variable frequency, obtain the expression for its impedance and draw a plot showing its variation with frequency of the ac source.

(b) What is the phase difference between the voltages across inductor and the capacitor at resonance in the *LCR* circuit ?

(c) When an inductor is connected to a 200 V dc voltage, a current of 1 A flows through it. When the same inductor is connected to a 200 V, 50 Hz ac source, only 0.5 A current flows. Explain, why ? Also, calculate the self inductance of the inductor.

OR

(a) A lamp is connected in series with a capacitor. Predict your observations for d.c. and a.c. connections. What happens in each case if the capacitance of the capacitor is reduced?

(b) A coil of 0.01 henry inductance and 1 ohm resistance is connected to 200 volt, 50 Hz ac supply. Find the impedance of the circuit and time lag between maximum alternating voltage and current.

32. Use Huygen's principle to explain the formation of diffraction pattern due to a single slit illuminated by a monochromatic source of light.

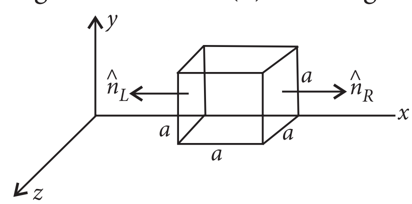
When the width of the slit is made double the original width, how would this affect the size and intensity of the central diffraction band?

OR

Using Huygens' principle, draw a diagram to show propagation of a wavefront originating from a monochromatic point source.

33. (a) Using Gauss's law, derive expression for intensity of electric field at any point near the infinitely long straight uniformly charged wire.

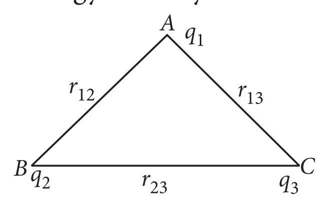
(b) The electric field components in the following figure are $E_x = \alpha x$, $E_y = 0$, $E_z = 0$; in which $\alpha = 400$ N/C m. Calculate (i) the electric flux through the cube, and (ii) the charge within the cube, assume that $a = 0.1$m.



OR

(a) Define electrostatic potential at a point. Write its SI unit.

Three charges q_1 , q_2 and q_3 are kept respectively at points A, B and C as shown in figure. Write the expression for electrostatic potential energy of the system.



(b) Depict the equipotential surfaces due to

(i) an electric dipole

(ii) two identical negative charges separated by a small distance

SOLUTIONS

1. Diodes with bandgap energy in the visible spectrum range can function as LED.

2. Q-value is the difference in initial mass energy and energy associated with mass of products or total kinetic energy in the process.

OR

The volume of the nucleus is directly proportional to the number of nucleons (mass number) constituting the nucleus.

$\frac{4}{3}\pi R^3 \propto A$ Where $R \to$ radius

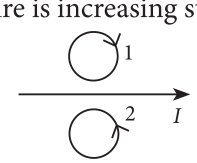
$R \propto A^{1/3}$ $A \to$ Mass number

$R = R_0 A^{1/3}$

3. Current sensitivity : It is defined as the deflection of coil per unit current flowing in it, *i.e.*,

$$I_S = \frac{\theta}{I} = \frac{NAB}{k}$$

4. The direction of induced current in metal ring 1 is clockwise. In metal ring 2 is anticlockwise when current I in the wire is increasing steadily.



OR

The magnetic lines of force due to current are parallel to the plane of the loop. So angle between magnetic field and area vector is 90°. Hence, the flux linked with the loop is zero. Hence, there will be no induced emf in the loop.

5. $W_0 = h\upsilon_0$

So metal B of larger work function 6 eV has larger threshold frequency υ_0.

6. LEDs are extremely energy efficient. They consume upto 90% less power than conventional incandescent low power lamps.

7. Frequency of the electromagnetic waves produced will be equal to the frequency υ of the oscillating charge.

OR

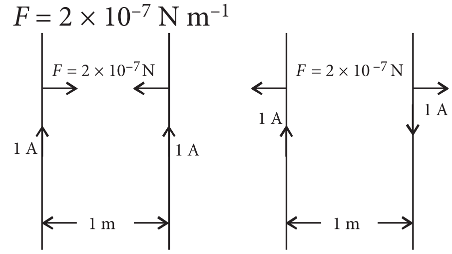
The wavelength range of 10^{-10} m, lies in X-ray region of the electromagnetic spectrum. X-rays are used as a diagnostic tool in medicine and as a treatment for certain forms of cancer.

8. One ampere is the value of steady current which when maintained in each of the two very long, straight, parallel conductors of negligible cross-section and placed one metre apart in vacuum, would produce on each of these conductors a force of attractive or repulsive nature of magnitude 2×10^{-7} N m^{-1} on their unit length.

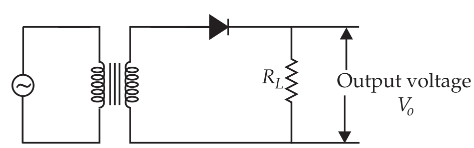
Force between two straight parallel current carrying conductors, $F = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{r}$

when $I_1 = I_2 = 1$ A, $r = 1$ m, then

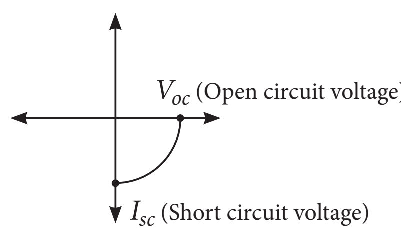
$F = 2 \times 10^{-7}$ N m^{-1}



9.



OR



10. $mvr = 2h/2\pi$ or $mvr = h/\pi$

11. (a) : Due to the variation of the refractive index of the material of the lens, the focal length also varies accordingly. Now as white light is composed of different colours of light, each colour will produce its own image based on the focal length for that colour. This particular phenomenon for a single lens is known as chromatic aberration.

12. (c)

13. (c) : Wavelength of 10 mm lies in infrared region.

14. (a) : When we pull a copper plate out of the magnetic field or push it into the magnetic field, magnetic flux linked with the plate changes. As a result of this eddy currents are produced in the plate which oppose its motion (according to Lenz's law).

15. (i)(b) : The Bulbs 2 and 3 are in series, current through them is same.

$\therefore\ I_2 = I_3 = I_b$(say)

Now, Bulb 1 and combination of 2 and 3 are in parallel,

$\therefore\ V_1 = (V_2 + V_3) = V$(say)

Since, all bulbs consumes same power.

$\therefore\ P_2 = P_3 \Rightarrow I_b^2 R_2 = I_b^2 R_3 \Rightarrow R_2 = R_3$

So, $V_2 = V_3 = \dfrac{V}{2}$

Now, $P_1 = \dfrac{V_1^2}{R_1} = \dfrac{V^2}{36}$ and $P_3 = \dfrac{V_3^2}{R_3} = \dfrac{V^2}{4R_3}$

$\because\ P_1 = P_3$

$\therefore\ \dfrac{V^2}{36} = \dfrac{V^2}{4R_3} \Rightarrow R_3 = 9\Omega$

(ii) (a) : Total current through R_1, $I_a = \dfrac{R_2 + R_3}{R_1 + (R_2 + R_3)} I$

$= \dfrac{18}{36+18} = \dfrac{18}{54} I = \dfrac{I}{3}$

Also, $I_4 = I$

Since, $P_1 = P_4 \Rightarrow I_a^2 R_1 = I_4^2 R_4 \Rightarrow \left(\dfrac{I}{3}\right)^2 \times 36 = I^2 R_4$

Which implies sign $R_4 = 4\ \Omega$

(iii)(a) : Gives that $P_4 = 4$W

$P_4 = I_4^2 R_4$

or $P_4 = I^2 R_4$ $\qquad (\because I_4 = \text{I})$

or $I = 1$A

(iv)(d) : $R_{eq.} = R_4 + \dfrac{R_1(R_2 + R_3)}{R_1 + R_2 + R_3} = 4 + \dfrac{36(9+9)}{36+9+9} = 16\Omega$

(v) (a) : $\varepsilon = I\,R_{eq.} = 16$ V

16. (i)(a) : $\sin C = \dfrac{1}{\mu} = \dfrac{1}{3/2} = \dfrac{2}{3} = 0.6667$

$C = \sin^{-1}(0.6667) = 41.8°$

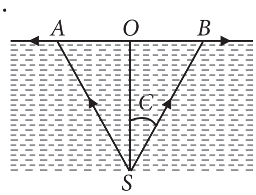
(ii) (c) : $\mu = \dfrac{1}{\sin C} = \dfrac{1}{\sin 48\cdot 6} = \dfrac{1}{0\cdot 75} = \dfrac{4}{3}$

(iii)(c): From $\mu = \dfrac{1}{\sin C}$, $\sin \text{C} = \dfrac{1}{\mu}$

As $\quad \mu_v < \mu_r \therefore C_v > C_r$

The correct alternative may be (c).

(iv)(a) : $SO = h$



When angle of incidence is slightly greater than C, light undergoes total internal reflection.

$\therefore$ Diameter of circle of light coming from water surface

$= 2r = 2\,(OB) = 2\,OS \tan C = 2\,h \tan C$

(v) (b) : $\mu = \dfrac{1}{\sin C} = \dfrac{1}{\sin 30°} = 2$

$\therefore\ v = \dfrac{3\times 10^8}{2} = 1\cdot 5\times 10^8$ m/s

17. Electric field intensity on a surface due the incident radiation is

$$E = \frac{U}{At} = \frac{P}{A} \qquad \left(\because\ \frac{U}{t} = P\right)$$

$\therefore\ E \propto P$ (for the given area of the surface)

$\therefore\ \dfrac{E'}{E} = \dfrac{P'}{P} = \dfrac{50}{100} = \dfrac{1}{2}$

$E' = \dfrac{E}{2}$

OR

Radio waves are the electromagnetic waves of frequency ranging from 500 kHz to about 1000 MHz. These waves are produced by oscillating electric circuits having inductor and capacitor.

18. In double slit experiment, an interference pattern is observed by waves from two slits but as each slit provide a diffraction pattern of its own, thus the intensity of interference pattern in Young's double slit experiment is modified by diffraction pattern of each slit.

19. Properties of magnets

(i) Attractive property : When a magnet is dipped into iron filings, it is found that the concentration of iron filings is maximum at the ends. It means attracting power of the magnet is maximum at two points near the ends and minimum at the centre. The places in a magnet where its attracting power is maximum are known as poles while the place of minimum attracting power is known as the neutral region.

(ii) Directive property : When a magnet is suspended, its length becomes parallel to N-S direction. The pole at the end pointing north is known as north pole while the other pointing south is known as south pole.

(iii) Magnetic poles always exist in pairs *i.e.*, an isolated magnetic pole does not exist.

(iv) Like poles repel each other and unlike poles attract each other.

OR

Given Earth's magnetic field,

$B = 0.6 \times 10^{-4}$ T,

$\theta = \dfrac{\pi}{6} = 30°, I = 5\,\text{A}$ and $l = 2$ m.

The horizontal component of earth's magnetic field,

$B_H = B\cos\theta$

$= 0.6\times 10^{-4} \times \dfrac{\sqrt{3}}{2} = 3\sqrt{3}\times 10^{-5}$ T

$\therefore$ Magnetic force $= BIl = 3\sqrt{3}\times 10^{-5} \times 5 \times 2$

$= 3\sqrt{3}\times 10^{-4}$ N

20. Forward bias resistance,

$R_1 = \dfrac{\Delta V}{\Delta I_{\text{for}}} = \dfrac{0.8 - 0.7}{(20-10)\times 10^{-3}} = \dfrac{0.1}{10\times 10^{-3}} = 10$

Reverse bias resistance, $R_2 = \dfrac{10}{1\times10^{-6}} = 10^7$

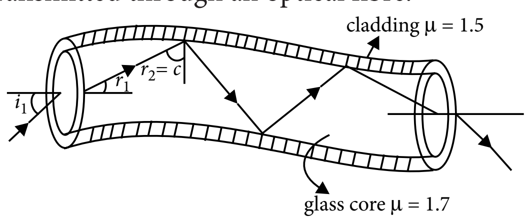
then, the ratio of forward to reverse bias resistance,

$$\frac{R_1}{R_2} = \frac{10}{10^7} = 10^{-6}$$

21. Optical fibre is made up of very fine quality glass or quartz of refractive index about 1.7.

A light beam incident on one end of an optical fibre at appropriate angle refracts into the fibre and undergoes repeated total internal reflection.

This is because the angle of incidence is greater than critical angle. The beam of light is received at other end of fibre with nearly no loss in intensity. To send a complete image, the image of different portion is send through separate fibres and thus a complete image can be transmitted through an optical fibre.



22. The potential at any point on the surface of the conductor having radius r and charge q is given by

$$V = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{r}$$

where $\varepsilon_0 = 8.854 \times 10^{-12}\ C^2\ N^{-1}\ m^{-2}$

The capacitance of the spherical conductor situated in vaccum is given by

$$C = \frac{q}{V} = \frac{q}{\frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{r}}$$

$C = 4\pi\varepsilon_0 r$

Hence, the capacitance of an isolated spherical conductor situated in vaccum is $4\pi\varepsilon_0$ times its radius.

OR

(a) Since it is an electric dipole, so a plane normal to AB and passing through its mid-point has zero potential everywhere.

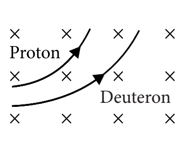
(b) Normal to the plane in the direction AB.

23. Charge on deuteron (q_d) = charge on proton (q_p)

Radius of circular path $r \propto m \left(\because qvB = \dfrac{mv^2}{r}\right)$

(For constant velocity v)

$$\frac{r_d}{r_p} = \frac{m_d}{m_p}$$

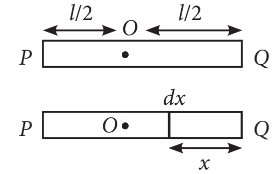


$\because\ m_d = 2m_p$

$\Rightarrow r_d = 2r_p$ or $r_d : r_p = 2 : 1$

24. Consider a small element 'dx' on the rod, then the induced EMF on the element 'dx',

$d\varepsilon = (\vec{v}\times\vec{B})dx = vBdx = B\omega x dx$



$\therefore$ The total EMF induced,

$$\varepsilon = \int d\varepsilon = \int_{-\frac{l}{2}}^{\frac{l}{2}} B\omega x dx = \frac{B\omega}{2}[x^2]_{-\frac{l}{2}}^{\frac{l}{2}} = \frac{1}{2}B\omega l^2$$

25. From graph,

Resistance of the germanium junction diode,

$$R = \frac{\Delta V}{\Delta I} = \frac{2.3\ V - 0.3\ V}{10\ mA - 0} = \frac{2\ V}{10\times10^{-3}\ A} = 0.2\ k\Omega$$

26. This circuit is called Wheatstone bridge. Wheatstone bridge is balanced when

$$\frac{\text{Resistance in branch } AB}{\text{Resistance in branch } BC} = \frac{\text{Resistance branch } AD}{\text{Resistance in branch } CD}$$

or $\dfrac{20}{40} = \dfrac{15}{30}$ or $\dfrac{1}{2} = \dfrac{1}{2}$

No current flows through the arm BD containing galvanometer, as B and D are at same potential. Two laws used to find the current in different branches of this circuit are:

(i) Kirchhoff's junction rule : It states that at any junction in an electrical circuit, sum of incoming currents is equal to sum of outgoing currents.

(ii) Kirchhoff's loop rule : It states that in any closed loop in a circuit, algebraic sum of applied emf's and potential drops across the resistors is equal to zero.

OR

Principle of potentiometer : When a constant current flows through a wire of uniform area of cross-section, the potential drop across any length of the wire is directly proportional to the length.

Let resistance of wire AB be R_1 and its length be l then current drawn from driving cell

$$I = \frac{V}{R+R_1}$$

and hence potential drop across the wire AB will be,

$$V_{AB} = IR_1 = \frac{V}{R+R_1}\times\frac{\rho l}{a}$$

where a is the area of cross-section of the wire AB.

$$\therefore \frac{V_{AB}}{l} = \frac{V\rho}{(R+R_1)a} = \text{constant} = k$$

Where R increases, current and potential difference across wire AB will be decreased and hence potential gradient k will also be decreased. Thus the null point or balance point will shift to right (towards, B) side.

27. Properties of nuclear force are :

(i) Nuclear forces are short range forces and are strongly attractive within a range of 1 fermi to 4.2 fermi.

(ii) Nuclear forces above 4.2 fermi are negligible, whereas below 1 fermi, they become repulsive in nature. It is this repulsive nature below 1 fermi, which prevents the nucleus from collapsing under strong attractive force.

(iii) Nuclear forces are charge independent. The same magnitude of nuclear force act between a pair of protons, pair of proton and neutron and pair of neutrons. The attractive nuclear force is due to exchange of π mesons (π^0, π^+, π^-) between them.

28. By Einstein's photoelectric equation

$$\frac{1}{2}mv_{max}^2 = h\nu - W_0$$

So, no emission of photo-electrons takes place at surface A, because the work function W_0 of surface A is more than the energy $h\upsilon$ of photons of incident radiations of frequency 10^{15} Hz.

However, for surface B, photoemission takes place but photoelectrons have zero energy,

So, $\frac{1}{2}mv_{max}^2 = 0$ or $h\upsilon - W_0 = 0$

$W_0 = h\upsilon$

or $h\nu_0 = h\upsilon$

or $\upsilon_0 = \upsilon = 10^{15}$ Hz

i.e., 10^{15} Hz is the threshold frequency for surface B.

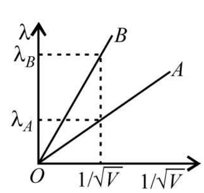
If the wavelength of incident radiation is decreased, then the frequency and hence energy $h\upsilon$ of photons of incident radiations will increase, due to which photo electrons emitted will have same kinetic energy

$(i.e., \frac{1}{2}mv_{max}^2 > 0)$

OR

As $\lambda = \frac{12.27}{\sqrt{V}}$ Å,

So $\lambda \propto \frac{1}{\sqrt{V}}$



At same V, $\lambda_B > \lambda_A$

or $\frac{h}{m_B v_B} > \frac{h}{m_A v_A}$ or $m_A v_A > m_B v_B$

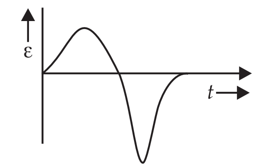
or $m_A\sqrt{\frac{2qV}{m_A}} > m_B\sqrt{\frac{2qV}{m_B}}$ or $\sqrt{m_A} > \sqrt{m_B}$

or $m_A > m_B$

So line A represents particle of heavier mass.

29. Induced emf $\propto$ rate of change of magnetic flux. Therefore, as the magnet approaches coil, the induced emf first increases, becomes maximum and then decreases to zero.

When the bar magnet crosses the coil, then the induced emf changes direction, increases, becomes maximum and finally decreases to zero. The graph is shown in figure.



As $\varepsilon = -\frac{d\phi}{dt}$

$d\phi = \varepsilon dt$ (numerically)

$\phi = \int \varepsilon dt$

Accordingly the area under ε-t curve represents the change in flux.

30. Energy of electron in n^{th} orbit hydrogen atom

An electron revolving in an orbit of H-atom, has both kinetic energy and electrostatic potential energy.

Kinetic energy of the electron revolving in a circular orbit of radius r is $E_K = \frac{1}{2}mv^2$

Since, $\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2}$

$\therefore \quad E_K = \frac{1}{2}\times\frac{1}{4\pi\varepsilon_0}\frac{e^2}{r}$ or $E_K = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{2r}$

Electrostatic potential energy of electron of charge $-e$ revolving around the nucleus of charge $+e$ in an orbit of radius r is

$E_P = \frac{1}{4\pi\varepsilon_0}\frac{+e\times -e}{r}$ or $E_P = \frac{-1}{4\pi\varepsilon_0}\frac{e^2}{r}$

So, total energy of electron in orbit of radius r is

$E = E_K + E_P$ or $E = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{2r} - \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r}$

or $E = \frac{-1}{4\pi\varepsilon_0}\frac{e^2}{2r}$

Putting $r = \frac{n^2h^2\varepsilon_0}{\pi me^2}$, we get

$$E = \frac{-1}{4\pi\varepsilon_0}\frac{e^2}{2\left(\frac{n^2h^2\varepsilon_0}{\pi me^2}\right)} \quad \text{or} \quad E = -\frac{me^4}{8\varepsilon_0^2n^2h^2}$$

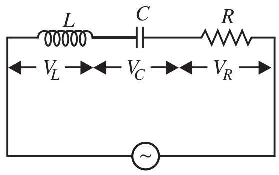
or $E_n = -\frac{13.6}{n^2}$ eV

The –ve sign of the energy of electron indicates that the electron and nucleus together form a bound system, *i.e.*, electron is bound to the nucleus.

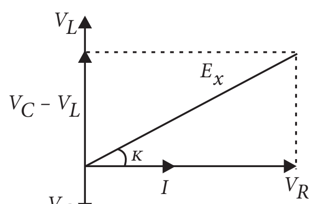
31. (a) : AC circuit containing inductor, capacitor and resistor in series [Series LCR circuit]

If I is the current in the circuit containing inductor of inductance L, capacitor of capacitance C and resistor of resistance R in series, then the voltage drop across the inductor is

$V_L = I \times X_L$



which leads current I by phase angle of $\pi/2$, and voltage drop across the capacitor is $V_C = I \times X_C$



Phasor diagram

which lags behind current I by phase angle of $\pi/2$, and voltage drop across the resistor is $V_R = I\,R$,

which is in phase with current I. So the net voltage E, across the circuit is

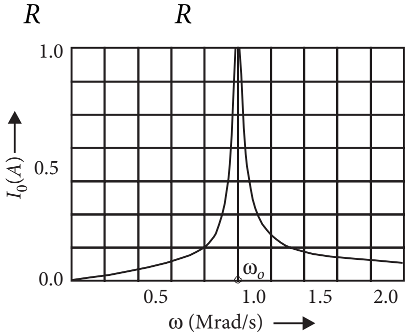
$$E = \sqrt{V_R^2 + (V_L - V_C)^2}$$

or $E = I\sqrt{R^2 + (X_L - X_C)^2}$

or $E = IZ$

where Z is the effective resistance offered by ac circuit containing inductor, capacitor and resistor in series, known as impedance in series LCR circuit. Hence in series LCR circuit, phase difference ϕ between the current I and the voltage E is

$$\tan\phi = \frac{X_L - X_C}{R} = \frac{\left(\omega L - \frac{1}{\omega C}\right)}{R}$$



With increase in ω, current first increases (upto ω_0) and then decreases.

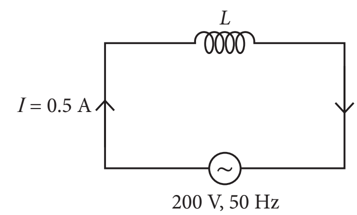
(b) At resonance, $X_L = X_C$

$$\therefore\ \tan\phi = \frac{X_L - X_C}{R} = 0$$

$\therefore\ \phi = 0°$

$\therefore$ There is no phase difference between voltage across inductor and capacitor at resonance in the LCR circuit.

(c) Whenever an inductor is connected to an a.c. source then it produces inductive reactance as impedance, that reduces the amount of current flowing through it. When inductor is connected to d.c. voltage, current flow in a circuit is 1 A and when in same inductor is connected to a.c. source, current will be reduced so, we can say that power consumption is more in case of d.c. circuit.



Here, $I = 0.5$ A, $V = 200$ V, $\upsilon = 50$ Hz

$\therefore$ Inductive reactance, $X_L = \omega L = 2\pi\upsilon L$

Also, $I = \dfrac{V}{X_L}$ or $0.5 = \dfrac{200}{2 \times 3.14 \times 50 \times L}$

$$\Rightarrow\ L = \frac{200}{0.5 \times 2 \times 3.14 \times 50} = 1.27\text{ H}$$

OR

(a) Here, combination of lamp and capacitor is a series LCR circuit. Capacitor offers infinite resistance for d.c. For d.c.,

$$X_C = \frac{1}{2\pi\upsilon C} = 0,\ X_C = \infty$$

On switching d.c. on after a fraction of second the capacitor gets charged fully and then no current flows. For a.c. circuit, capacitor offers finite resistance.

$$X_C = \frac{1}{2\pi\upsilon C},\ X_L = 2\pi\upsilon L,\ Z = \sqrt{R^2 + (X_L - X_C)^2}$$

reducing C will increase Z and thus reduce the current.

(b) $L = 0.01$ H, $R = 1\ \Omega$, $E = 200$ V, $\upsilon = 50$ Hz.

$X_L = 2\pi\upsilon l = 2 \times (3.14) \times 50 \times 0.01 = 3.14\ \Omega$.

$$Z = \sqrt{R^2 + X_L^2} = \sqrt{(1)^2 + (3.14)^2}$$

$$= \sqrt{10.86} = 3.3\ \Omega$$

$$\tan\phi = \frac{X_L}{R} = \frac{3.14}{1} = 3.14$$

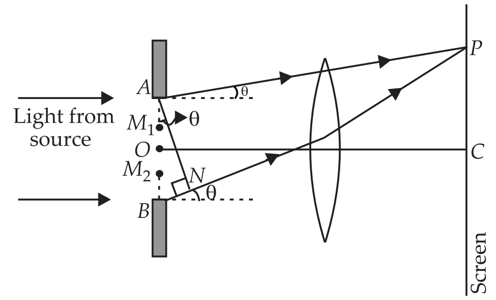
$$\phi = \tan^{-1}(3.14) = 72° = 72 \times \frac{\pi}{180}\text{ rad}$$

$$= 0.4\,\pi\text{ rad}$$

Time lag, $\Delta t = \dfrac{\phi}{\omega} = \dfrac{0.4\,\pi}{100\,\pi} = 0.004$ s

$(\omega = 2\pi\upsilon = 100\,\pi\text{ rad s}^{-1})$

32.



Consider a parallel beam of monochromatic light is incident normally on a single slit AB of width a as shown in the figure. According to Huygens principle every point of slit acts as a source of secondary wavelets spreading in all directions. The mid point of the slit is O. A straight line through O perpendicular to the slit plane meets the screen at C. At the central point C on the screen, the angle θ is zero. All path differences are zero and hence all the parts of the slit contribute in phase. This gives maximum intensity at C.

Consider a point P on the screen.

The observation point is now taken at P.

Secondary minima : Now we divide the slit into two equal halves AO and OB, each of width $\frac{a}{2}$. For every point, M_1 in AO, there is a corresponding point M_2 in OB, such that $M_1M_2 = \frac{a}{2}$. The path difference between waves arriving at P and starting from M_1 and M_2 will be $\frac{a}{2}\sin\theta = \frac{\lambda}{2}$.

$\therefore \quad a\sin\theta = \lambda$

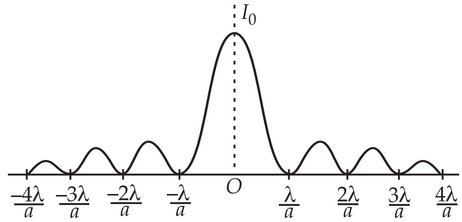
In general, for secondary minima

$a\sin\theta = n\lambda$ where $n = \pm1, \pm2, \pm3$......

Secondary maxima : Similarly it can be shown that for secondary maxima

$$a\sin\theta = (2n+1)\frac{\lambda}{2} \quad \text{where } n = \pm1, \pm2........$$

The intensity pattern on the screen is shown in the given figure.



Width of central maximum $= \frac{2D\lambda}{a}$

When width of slit (a) is doubled, central maximum width is halved. Its area becomes $(1/4)^{\text{th}}$. Hence intensity of central diffraction band becomes 4 times.

OR

Propagation of wavefront from a point source : Huygen's principle is useful for determining the position of a given wavefront at any time in future if we know its present position. The principle may be stated in three parts as follows :

(i) Every point on a given wavefront may be regarded as a source of new disturbance.

(ii) The new disturbances from each point spread out in all directions with the velocity of light and are called the secondary wavelets.

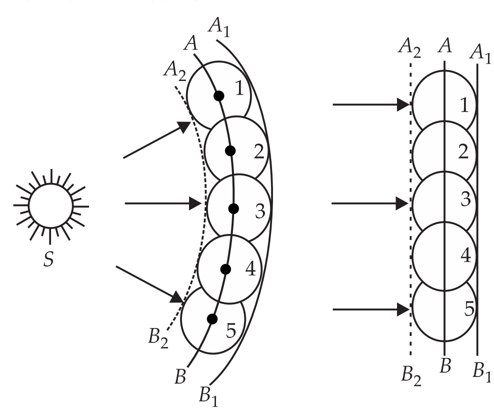
(iii) The surface of tangency to the secondary wavelets in forward direction at any instant gives the new position of the wavefront at that time. Let us illustrate this principle by the following example :

Let AB shown in figure (i) be the section of a wavefront in a homogeneous isotropic medium at $t = 0$. We have to find the position of the wavefront at time t using Huygens' principle. Let v be the velocity of light in the given medium.

(a) Take the number of points, 1, 2, 3,... on the wavefront AB. These points are the sources of secondary wavelets.

(b) At time t the radius of these secondary wavelets is vt. Taking each point as centre, draw circles of radius vt.

(c) Draw a tangent A_1B_1 common to all these circles in the forward direction.



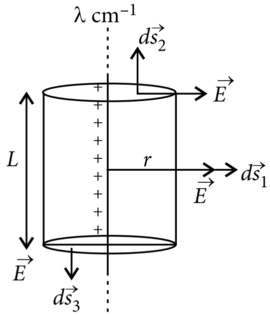
(i) (ii)

This gives the position of new wavefront at the required time t.

The Huygens' construction gives a backward wavefront also shown by dotted line A_2B_2 which is contrary to observation. The difficulty is removed by assuming that the intensity of the spherical wavelets is not uniform in all directions; but varies continuously from a maximum in the forward direction to a minimum of zero in the backward direction.

The directions which are normal to the wavefront are called rays, *i.e.*, a ray is the direction in which the disturbance is propagated.

33. (a)



Net charge = $q = \lambda L$

where, λ = line charge density.

According to Gauss's law, $\oint \vec{E}\cdot d\vec{s} = \frac{1}{\varepsilon_0}(q)$

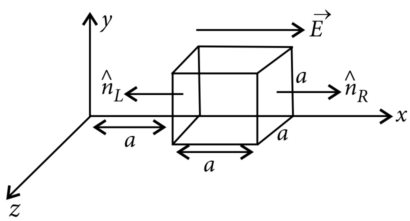
$$\int \vec{E}\cdot d\vec{s}_1 + \int \vec{E}\cdot d\vec{s}_2 + \int \vec{E}\cdot d\vec{s}_3 = \frac{1}{\varepsilon_0}(\lambda L)$$

$$\int Eds_1 \cos 0° + \int Eds_2 \cos 90° + \int Eds_3 \cos 90° = \frac{\lambda L}{\mu_0}$$

$$E\int ds_1 = \frac{\lambda L}{\varepsilon_0} \quad \text{or} \quad E\times 2\pi r L = \frac{\lambda L}{\varepsilon_0}$$

$\Rightarrow \quad E = \frac{\lambda}{2\pi\varepsilon_0 r}$. In vector form, $\vec{E} = \frac{\lambda}{2\pi\varepsilon_0}\hat{r}$

(b)



$\because \quad E_x = \alpha x = 400x$

$\quad E_y = E_z = 0$

Hence flux will exist only on left and right faces of cube as $E_x \neq 0$.

$$\therefore \quad \vec{E}_L \cdot a^2(\hat{n}_L) + \vec{E}_R \cdot a^2 \hat{n}_R = \frac{1}{\varepsilon_0}(q_{in}) = \phi$$

$$-E_L \cdot a^2 + a^2 E_R = \phi_{\text{Net}}$$

$\phi_{Net} = -(400a)a^2 + a^2(400 \times 2a)$

$\quad = -400a^3 + 800a^3 = 400a^3 = 400 \times (0.1)^3$

$\phi_{\text{Net}} = 0.4 \text{ N m}^2 \text{ C}^{-1}$

$\because \ \phi_{\text{Net}} = \frac{1}{\varepsilon_0}\{q_{in}\}$

$\therefore \quad q_{in} = \varepsilon_0\, \phi_{\text{Net}} = 8.85 \times 10^{-12} \times 0.4 = 3.540 \times 10^{-12}$ C

OR

(a) Electrostatic potential : Work done by an external force in bringing a unit positive charge from infinity to a point in the region of another charge particle is equal to the electrostatic potential at that point.

SI unit : J/C or volt.

Let no source charge be present in the system initially and hence no potential at any point.

Now the charge q, is brought at point A from infinite

Work done to bring charge q_1 at A

$\quad W_1 = q_1 V_A$

or $\ W_1 = 0 \qquad$ ...(i) $\qquad [\because \ V_A = 0]$

Due to presence of q_1 a potential develops at point B

i.e., $V_B = \frac{1}{4\pi\varepsilon_0}\frac{q_1}{r_{12}}$

Work required to bring a charge q_2 from ∞ to B

$W_2 = q_2 V_B$; $W_2 = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_{12}} \qquad$ ...(ii)

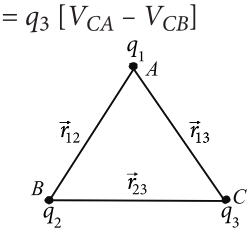
Total work done to form the system of two point charges or the potential energy of the system of charges is then given by

$$U = W_1 + W_2 = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_{12}}$$

Work done in bringing the charge q_3 from ∞ to point C is

$W_3 = q_3 [V_C - V_\infty] = q_3 [V_C - 0] = q_3 [V_{CA} - V_{CB}]$

$$= q_3 \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1}{r_{13}} + \frac{q_2}{r_{23}}\right]$$

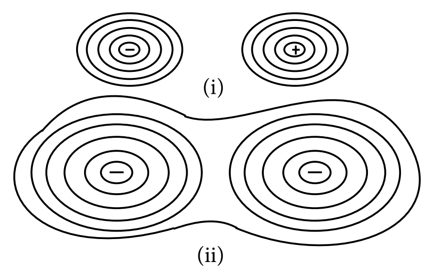


$$\text{or} \quad W_3 = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1 q_3}{r_{13}} + \frac{q_2 q_3}{r_{23}}\right]$$

So work done to form system of three point charges or the potential energy of system of three point charges is $U = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1 q_2}{r_{12}} + \frac{q_2 q_3}{r_{23}} + \frac{q_1 q_3}{r_{13}}\right]$

Here it is important to note that potential energy is not localised but it is distributed all over the field.

(b)



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