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	2(2)	1(2)	2(6)	–	**7(16)**
2.	Current Electricity	1(1)	–	–	1(5)	
3.	Magnetic Effects of Current and Magnetism	1(4)	–	1(3)	–	**6(17)**
4.	Electromagnetic Induction and Alternating Current	1(1)	2(4)	–	1(5)	
5.	Electromagnetic Waves	2(2)	1(2)	–	–	**10(18)**
6.	Optics	4(7)	2(4)	1(3)	–	
7.	Dual Nature of Radiation and Matter	2(2)	–	1(3)	–	**8(12)**
8.	Atoms and Nuclei	3(3)	2(4)	–	–	
9.	Electronic Devices	–	1(2)	–	1(5)	**2(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. A copper wire of non-uniform area of cross-section is connected to a d.c. battery which physical quantity remains constant along the wire?

2. How is the radius of a nucleus related to its mass number A?

3. Let the wavelengths of the electromagnetic waves used quite often for

(i) killing germs in household water purifiers

(ii) remote sensing

(iii) treatment of cancer

be labelled as λ_1, λ_2, and λ_3. Arrange λ_1, λ_2 and λ_3 in increasing order.

OR

Why are microwaves considered suitable for radar systems used in aircraft navigation?

4. What is the maximum number of spectral lines emitted by a hydrogen atom when it is in the third excited state?

5. A proton and an electron have same kinetic energy. Which one has greater de-Broglie wavelength and why?

OR

Define the term 'stopping potential' in relation to photoelectric effect.

6. A 12 pF capacitor is connected to a 50 V battery. How much electrostatic energy is stored in the capacitor?

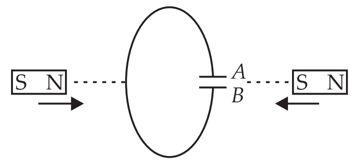
OR

Three capacitors of capacitances 2 pF, 3 pF and 4 pF are connected in parallel. What is the total capacitance of the combination.

7. What happens to a focal length of a convex lens, when it is immersed in water?

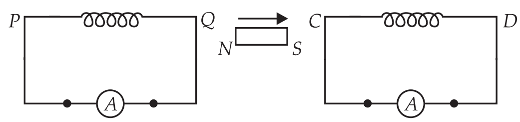
8. In Young's double slit experiment, the path difference between two interfering waves at a point on the screen is $\frac{5\lambda}{2}$, λ being wavelength of the light used. Which dark fringe will lie at this point?

9. Predict the polarity of the capacitor in the situation described below:



OR

A bar magnet is moved in the direction indicated by the arrow between two coils *PQ* and *CD*. Predict the direction of the induced current in each coil.



10. Draw graphs showing variation of photoelectric current with applied voltage for two incident radiations of equal frequency and different intensities. Mark the graph for the radiation of higher intensity.

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) :** When charges are shared between two bodies, there occurs no loss of charge, but there occur a loss of energy.
Reason (R) : In case of sharing of charges law of conservation of energy fails.

12. **Assertion (A) :** X-rays are used for studying the structure of crystals.
Reason (R) : The distance between the atoms of crystals is of the order of wavelength of X-rays.

13. **Assertion (A) :** X-rays, radio-waves, light waves and matter waves are all electromagnetic waves.
Reason (R) : Electromagnetic waves are longitudinal in nature.

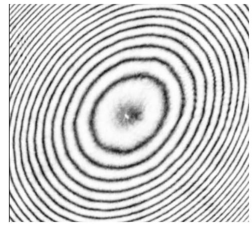
14. **Assertion (A) :** If refractive index of one medium is equal to refractive index of second medium, then beam does not bend at all.
Reason (R) : The bending of light does not depend on refractive indices of media.

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. Newton's rings is a phenomenon in which an interference pattern is created by the reflection of light between two surfaces: a spherical surface and an adjacent touching flat surface. It is named after Issac Newton, who investigated the effect in his 1704 treatise Opticks. When viewed with monochromatic light, Newton's rings

appear as a series of concentric, alternating bright and dark rings centred at the point of contact between the two surfaces. When viewed with white light, it forms a concentric ring pattern of rainbow colors, because the different wavelengths of light interfere at different thicknesses of the air layer between the surfaces.



(i) In an interference experiment the ratio of amplitudes of coherent waves is $\frac{a_1}{a_2} = \frac{1}{3}$. The ratio of maximum and minimum intensities of fringes will be

(a) 4 (b) 9 (c) 2 (d) 18

(ii) Two coherent sources of intensity 10 W/m^2 and 25 W/m^2 interfere to from fringes. Find the ratio of maximum intensity to minimum intensity.

(a) 15.54 (b) 16.78 (c) 19.72 (d) 18.39

(iii) Which of the following does not show interference?

(a) Soap bubble (b) Excessively thin film (c) A thick film (d) Wedge shaped film

(iv) In a Young's double-slit experiment, the slit separation is doubled. To maintain the same fringe spacing on the screen, the screen-to-slit distance D must be changed to

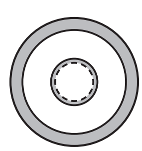
(a) $2D$ (b) $4D$ (c) $D/2$ (d) $D/4$

(v) Two slits in Young's double slit experiment have widths in the ratio 81 : 1. The ratio of the amplitudes of light waves is

(a) 3 : 1 (b) 3 : 2 (c) 9 : 1 (d) 6 : 1

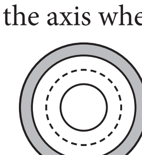
16. Consider a coaxial cable which consists of an inner wire of radius a surrounded by an outer shell of inner and outer radii b and c respectively. The inner wire carries an electric current i_0 and the outer shell carries an equal current in opposite direction. Assume that the current density is uniform in the inner wire and also uniform in the outer shell.

(i) Find the magnetic field at a distance x from the axis where, $x < a$



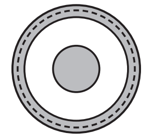
(a) $\frac{\mu_0 i_0 x}{2\pi a^2}$ (b) $\frac{\mu_0 i_0 x}{2\pi a}$ (c) $\frac{2\mu_0 i_0}{a}$ (d) $\frac{\mu_0^2 i_0^2}{2a}$

(ii) Find the magnetic field at a distance x from the axis where, $a < x < b$



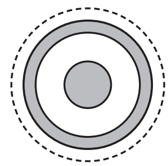
(a) $\frac{\mu_0 i_0}{2\pi x}$ (b) $\frac{\mu_0 i_0}{2\pi a}$ (c) $\frac{\mu_0 i_0}{2\pi b}$ (d) $\frac{\mu_0 i_0}{2\pi(a-b)}$

(iii) Find the magnetic field at a distance x from the axis where, $b < x < c$



(a) $\frac{\mu_0 i_0 (c^2 - b^2)}{2\pi x(c^2 - x^2)}$ (b) $\frac{\mu_0 i_0 (c^2 - x^2)}{2\pi x(c^2 - b^2)}$ (c) $\frac{\mu_0 i_0 (c^2 - a^2)}{2\pi x(c^2 - x^2)}$ (d) 0

(iv) Find the magnetic field at a distance x from the axis where, $x > c$



(a) $B\pi x$ (b) $2B\pi x$ (c) $4B\pi x$ (d) 0

(v) If instead of coaxial cable, we have a hollow copper pipe carrying current, then produced magnetic field will be

(a) both inside and outside the pipe (b) outside the pipe only

(c) inside the pipe only (d) neither inside nor outside the pipe.

SECTION - C

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

17. When an ac source is connected across an inductor, show on a graph the nature of variation of the voltage and the current over one complete cycle.

OR

An alternating current generator has an internal resistance R_g and an internal reactance X_g. It is used to supply power to a passive load consisting of a resistance R_g and a reactance X_L. For maximum power to be delivered from the generator to the load, the value of X_L is equal to

18. Identify the electromagnetic waves whose wavelengths vary as

(a) 10^{-12} m $< \lambda < 10^{-8}$ m (b) 10^{-3} m $< \lambda < 10^{-1}$ m

Write one use for each.

19. Obtain approximately the ratio of the nuclear radii of the gold isotope $^{197}_{79}\text{Au}$ and the silver isotope $^{107}_{47}\text{Ag}$.

OR

Why do stable nuclei never have more protons than neutrons?

20. The value of ground state energy of hydrogen atom is –13.6 eV. Find the energy required to move an electron from the ground state to the first excited state of the atom.

21. Laser light of wavelength 630 nm incident on a pair of slits produces an interference pattern in which the bright fringes are separated by 7.2 mm. Calculate the wavelength of another source of laser light which produces interference fringes separated by 8.1 mm using same pair of slits.

22. What is the net flux of the uniform electric field in previous question through a cube of side 20 cm oriented so that its faces are parallel to the coordinate planes?

OR

The dimensions of an atom are of the order of an Angstrom. Thus there must be large electric fields between the protons and electrons. Why, then is the electrostatic field inside a conductor zero?

23. A fish in a water tank sees the outside world as if it (the fish) is at the vertex of a cone such that the circular base of the cone coincides with the surface of water. Given the depth of water, where fish is located, being 'h' and the critical angle for water-air interface being 'i_c', find out by drawing a suitable ray diagram the relationship between the radius of the cone and the height 'h'.

24. A lamp is connected in series with a capacitor. Predict your observations when the system is connected first across a dc and then an ac source. What happens in each case if the capacitance of the capacitor is reduced?

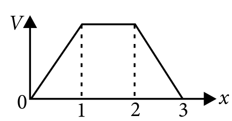
25. How do you obtain steady d.c. output from the pulsating voltage ?

SECTION - D

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

26. At a certain location in Africa, a compass points 12° west of the geographic north. The north tip of the magnetic needle of a dip circle placed in the plane of magnetic meridian points 60° above the horizontal. The horizontal component of the earth's field is measured to be 0.16 G. Specify the direction and magnitude of the earth's field at the location.

27. The electric potential as a function of distance 'x' is shown in the figure. Draw a graph of the electric field E as a function of x.



OR

An infinitely large thin plane sheet has a uniform surface charge density $+\sigma$. Obtain the expression for the amount of work done in bringing a point charge q from infinity to a point, distant r, in front of the charged plane sheet.

28. **(a)** (i) Draw a neat labelled ray diagram of an astronomical telescope in normal adjustment.
(ii) Explain briefly its working.

(b) An astronomical telescope uses two lenses of powers 10 D and 1 D. What is its magnifying power in normal adjustment?

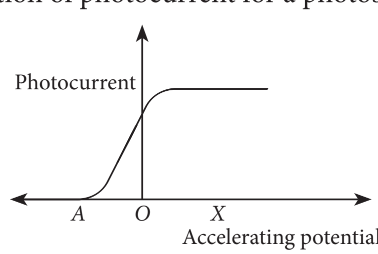
OR

Draw a neat labelled diagram of a compound microscope. Obtain the expression for total magnification on when the image is formed at infinity.

29. **(a)** Obtain the expression for the torque $\vec{\tau}$ experienced by an electric dipole of dipole moment $\vec{p}$ in a uniform electric field, $\vec{E}$.

(b) What will happen if the field were not uniform?

30. The following graph shows the variation of photocurrent for a photosensitive metal:



(a) Identify the variable X on the horizontal axis.

(b) What does the point A on the horizontal axis represent?

(c) Draw this graph for three different values of frequencies of incident radiation υ_1, υ_2 and υ_3 ($\upsilon_1 > \upsilon_2 > \upsilon_3$) for same intensity.

(d) Draw this graph for three different values of intensities of incident radiation I_1, I_2 and I_3 ($I_1 > I_2 > I_3$) having same frequency.

SECTION - E

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

31. (a) State the working principle of a potentiometer. Draw a circuit diagram to compare emf of two primary cells. Drive the formula used.

(b) Which material is used for potentiometer wire and why ?

(c) How can the sensitivity of a potentiometer be increased ?

OR

(a) State Kirchhoff's rules for an electric network.

(b) Using Kirchhoff's rules, obtain the balance condition in terms of the resistances of four arms of Wheastone bridge.

32. (a) Using phasor diagram for a series LCR circuit connected to an ac source of voltage $V = V_0 \sin \omega t$, derive the relation for the current flowing in the circuit and the phase angle between the voltage across the resistor and the net voltage in the circuit.

(b) Draw a plot showing the variation of the current I as a function of angular frequency 'ω' of the applied ac source for the two cases of a series combination of (i) inductance L_1, capacitance C_1 and and resistance R_1 and (ii) inductance L_2, capacitance C_2 and resistance R_2 where $R_2 > R_1$. Write the relation between L_1, C_1 and L_2, C_2 at resonance. Which one, of the two, would be better suited for fine tuning in a receiver set? Give reason.

OR

(a) Write the function of a transformer. State its principle of working with the help of a diagram. Mention various energy losses in this device.

(b) The primary coil of an ideal step up transformer has 100 turns and transformation ratio is also 100. The input voltage and power are respectively 220 V and 1100 W. Calculate

(i) number of turns in secondary
(ii) current in primary
(iii) voltage across secondary
(iv) current in secondary
(v) power in secondary

33. Explain the term 'depletion layer' and 'potential barrier' in a p-n junction diode. How are the (i) width of depletion layer, and (ii) value of potential barrier affected when the p-n junction is forward biased?

OR

(a) Photo diodes are used to detect

(b) What is the function of a photodiode ?

(c) Explain, with the help of a circuit diagram, the working of a photodiode. Write briefly how it is used to detect the optical signals.

SOLUTIONS

1. Electric current remains constant along the wire.

2. 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. (i) UV-radiation (λ_1)

(ii) Microwaves (λ_2),

(iii) γ-rays (λ_3)

In the order of increasing wavelength :

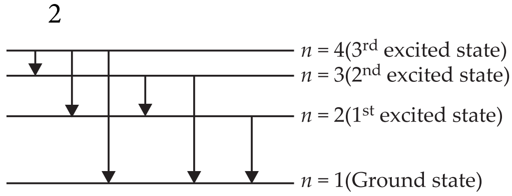
$$\lambda_3 < \lambda_1 < \lambda_2$$

OR

Microwaves have wavelengths of the order of a few millimetres. Due to their short wavelengths, these are not diffracted (bent) much by objects of normal dimensions. So they can be used to transmit signal in a particular direction as required in a radar system.

4. Number of spectral lines obtained due to transition of electron from $n = 4$ (3rd excited state) to $n = 1$ (ground state) is

$$N = \frac{(4)(4-1)}{2} = 6$$



These lines correspond to Lyman series.

5. We know the relation $\lambda = \frac{h}{p}$,

kinetic energy, $K = \frac{p^2}{2m}$

Then, $\lambda = \frac{h}{\sqrt{2mK}}$; $K_p = K_e \Rightarrow \lambda \propto \frac{1}{\sqrt{m}}$

$\therefore\ m_p >> m_e\ \therefore\ \lambda_p << \lambda_e$

Hence for same kinetic energy wavelength associated with electron will be greater.

OR

For a given frequency of incident radiation stopping potential is that minimum negative potential given to anode for which the photoelectric current becomes zero. It is denoted by V_s. For a given frequency of the incident radiation, the value of stopping potential is different for different metals but it is independent of the intensity of the incident light.

6. $U = \frac{1}{2}CV^2 = \frac{1}{2}\times 12\times 10^{-12}\times 50^2$

$= 15000 \times 10^{-12}$ or $U = 1.5 \times 10^{-8}$ J.

OR

$C = C_1 + C_2 + C_3 = 2 + 3 + 4$ or $C = 9$ pF

7. Focal length f of a convex lens is related to its refractive index as

$$f \propto \frac{1}{\mu - 1}$$

As ${}^w\mu_g < {}^a\mu_g$, so focal length of the convex lens will increase when it is immersed in water.

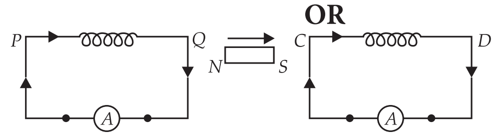
8. For destructive interference, $\Delta x = \left(n + \frac{1}{2}\right)\lambda$

$\Rightarrow \left(n + \frac{1}{2}\right)\lambda = \frac{5}{2}\lambda \Rightarrow n = 2$

$\therefore$ The second dark fringe will be at this point.

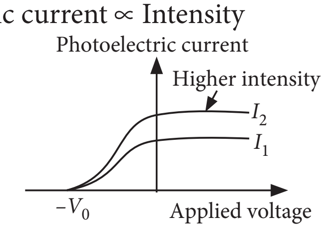
9. Polarity of plate A will be positive with respect to plate B in the capacitor, as induced current is in clockwise direction

OR



10. For a given frequency,

Photoelectric current $\propto$ Intensity



According to Lenz's law, direction of current in loop PQ is from P to Q and in loop CD is from C to D.

11. (c) : Energy conservation does not fail during sharing of charges between two bodies. Some energy is lost in the form of heat or light or sparking.

12. (a) : The distance between the atoms of crystals is of the order of wavelength of X-rays. When they fall on a crystal, they are diffracted. The diffraction pattern is helpful in the study of crystal structure.

13. (d) : Electromagnetic waves are transverse in nature. X-rays, radio waves and light waves are transverse in nature and are part of the electromagnetic spectrum. Matter waves are not transverse.

14. (c) : Since $\mu_1 = \mu_2$

From Snell's law, $\dfrac{\sin i}{\sin r} = \dfrac{\mu_2}{\mu_1} = 1 \Rightarrow \sin i = \sin r \Rightarrow i = r$

Therefore, the light beam does not bend at all.

15. (i) (a) : $\dfrac{I_{\max}}{I_{\min}} = \dfrac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = \dfrac{(1+3)^2}{(1-3)^2} = \dfrac{16}{4} = \dfrac{4}{1} = 4$

(ii) (c) : Given $I_1 = 10$ W/m^2 and $I_2 = 25$ W/m^2

$$\frac{I_1}{I_2} = \frac{a_1^2}{a_2^2} = \frac{10}{25} \Rightarrow \frac{a_1}{a_2} = \frac{3.16}{5} \text{ or } a_1 = \frac{3.16}{5} a_2 = 0.6324 a_2$$

$$\frac{I_{\max}}{I_{\min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = \frac{[0.6324 a_2 + a_2]^2}{[0.6324 a_2 - a_2]^2} = 19.724$$

(iii) (b) : In an excessively thin film, the thickness of the film is negligible. Thus the path difference between the reflected rays becomes $\lambda/2$. Which produces a minima.

(iv) (a) : Since, $\beta = \dfrac{\lambda D}{d}$ for $d = 2d$, $\beta' = \dfrac{\lambda D'}{2d} = \beta$(Gives)

$\therefore \quad D_1 = 2D$

(v) (c) : Width ratio, $\dfrac{\beta_1}{\beta_2} = \dfrac{I_1}{I_2} = \dfrac{81}{1}$

$\therefore$ Amplitude ratio, $\dfrac{A_1}{A_2} = \sqrt{\dfrac{I_1}{I_2}} = \sqrt{\dfrac{81}{1}} = 9 : 1$

16. A cross section of the cable is shown in figure. Draw a circle of radius x with the centre at the axis of the cable. The parts a, b, c and d of the figure correspond to the four parts of the problem. By symmetry, the magnetic field at each point of a circle will have the same magnitude and will be tangential to it, The circulation of B along this circle is, therefore, $\oint \vec{B} \cdot d\vec{l} - = B 2\pi x$ in each of the four parts of the figure.

(i) (a) : The current enclosed within the circle in part a is $\dfrac{i_0}{\pi a^2} \cdot \pi x^2 = \dfrac{i_0}{a^2} x^2$.

Ampere's law $\oint \vec{B} \cdot d\vec{l} - = \mu_0 i$ gives

$$B 2\pi x = \frac{\mu_0 i_0 x^2}{a^2} \text{ or, } B = \frac{\mu_0 i_0 x}{2\pi a^2}$$

The direction will be along the tangent to the circle.

(ii) (a) : The current enclosed within the circle in part b is i_0 so that

$$B 2\pi x = \mu_0 i_0 \ \ or,\ B = \frac{\mu_0 i_0}{2\pi x}$$

(iii) (b) : The area of cross-section of the outer shell is $\pi c^2 - \pi b^2$. The area of cross-section of the outer shell within the circle in part c of the figure is $\pi x^2 - \pi b^2$. Thus, the current through this part is $\dfrac{i_0(x^2 - b^2)}{c^2 - b^2}$. This is in the opposite direction to the current i_0 in then inner wire. Thus, the net current enclosed by the circle is

$$i_0 - \frac{i_0(x^2 - b^2)}{c^2 - b^2} = \frac{i_0(c^2 - x^2)}{c^2 - b^2}$$

From Ampere's law,

$$B 2\pi x = \frac{\mu_0 i_0 (c^2 - x^2)}{c^2 - b^2} \quad \text{or} \quad B = \frac{\mu_0 i_0 (c^2 - x^2)}{2\pi x (c^2 - b^2)}.$$

(iv) (d) : The net current enclosed by the circle in part d of the figure is zero and hence

$$B 2\pi x = 0 \text{ or } B = 0.$$

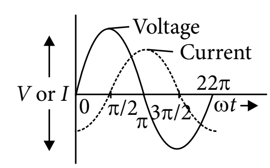
(v) (b) : Using Ampere's law, $\oint \vec{B} \cdot \vec{dl} = \mu_0 i_{\text{enclosed}}$

Outside : $i_{\text{enclosed}} \neq 0$ (Some value) $\Rightarrow B \neq 0$

Inside : $i_{\text{enclosed}} = 0 \Rightarrow B = 0$

17. $V = V_0 \sin\omega t$;

$$I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$$



OR

For maximum power to be delivered from the generator to the load, the total reactance must vanish. *i.e.*, $X_L + X_g = 0$ or $X_L = -X_g$.

18. (a) X-rays - used to study atomic structure.

(b) Microwaves - used in radar application.

19. We know the radius of nucleus depend upon mass number 'A'

As $R = R_0 A^{1/3}$, where $R_0 = 1.1 \times 10^{-15}$ m

$$\therefore \quad \frac{R(^{197}\text{Au})}{R(^{107}\text{Ag})} = \left(\frac{197}{107}\right)^{1/3} \simeq 1.23$$

Since the nuclear mass density is independent of the size of the nucleus, so $\dfrac{\rho_{\text{nu}}(\text{Au})}{\rho_{\text{nu}}(\text{Ag})} \simeq 1$.

OR

The stability of a nucleus depends on its neutron to proton ratio. More is the number of protons in the nucleus, greater is the electrical forces between them. Therefore more neutrons are needed to provide the strong attractive force necessary to keep the nucleus stable.

20. $\because \quad E_n = \dfrac{-13.6}{n^2}$ eV

Energy of the photon emitted during a transition of the electron from the first excited state to its ground state is,

$\Delta E = E_2 - E_1$

$$= \frac{-13.6}{2^2} - \left(\frac{-13.6}{1^2}\right) = \frac{-13.6}{4} + \frac{13.6}{1} = -3.40 + 13.6$$

$= 10.2$ eV

This transition lies in the region of Lyman series.

21. Fringe width, $\beta = \frac{D\lambda}{d}$

When D and d are kept fixed, $\frac{\beta}{\beta_1} = \frac{\lambda}{\lambda_1}$

or $\lambda_1 = \frac{\lambda\beta_1}{\beta} = \frac{630 \times 8.1}{7.2} = \frac{5103}{7.2} = 708.75$ nm

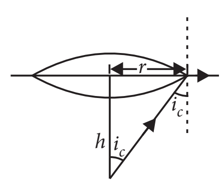
22. $\phi_{net} = 0$, As the net electric flux with closed surface like cube in uniform electric field is equal to zero, because the number of lines entering the cube is the same as the number of lines leaving the cube.

OR

Electrostatic fields are caused by excess charges. The large electric fields between the protons and electrons bind the atom to neutral entity. Thus, there are no excess charges inside the conductor and so electrostatic field inside a conductor is zero.

23. Radius,

$$r = h \tan i_c = h\frac{\sin i_c}{\cos i_c}$$



$$r = h\frac{1/\mu}{\sqrt{1 - \frac{1}{\mu^2}}} = \frac{h}{\sqrt{\mu^2 - 1}}$$

24. For dc, capacitor is an open circuit because $X_C = \frac{1}{\omega C} = \infty$, the lamp will not glow at all, even if C is reduced. For ac, the lamp will glow because capacitor conducts ac. If C is reduced, the reactance X_C will increase and the brightness of the lamp will decrease further.

25. A full wave rectifier gives a continuous, unidirectional but pulsating output voltage or current. The rectified ouput is passed through a filter circuit which removes the ripple and an almost steady d.c. output (voltage or current) is obtained.

26. Compass needle points 12° west of geographical north, hence angle of declination θ is 12° west.

North tip of magnetic needle is 60° above horizontal, hence the location is in southern hemisphere and angle of dip is 60°.

Magnitude of net magnetic field can be calculated as

$$B = \frac{B_H}{\cos\delta} = \frac{0.16\, G}{\cos 60°} = 0.32 \text{ G}$$

27. Electric field $E = -\frac{dV}{dx}$ ...(i)

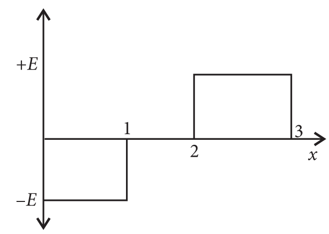
For $x = 0$ to 1, $V = kx$

$x = 1$ to 2, $V = k$

$x = 2$ to 3, $V = -kx$

where k is some constant

So, using (i) the variation of electric field is shown in figure.



OR

Let P be a point at distance r from the sheet.

$W = q \cdot (V_P - V_\infty)$ ...(i)

Now, $V_P - V_\infty$

$$= -\int_\infty^r \vec{E} \cdot d\vec{r} = -\int_\infty^r E dr = -\int_\infty^r \left(\frac{\sigma}{2\varepsilon_0}\right) \cdot dr$$

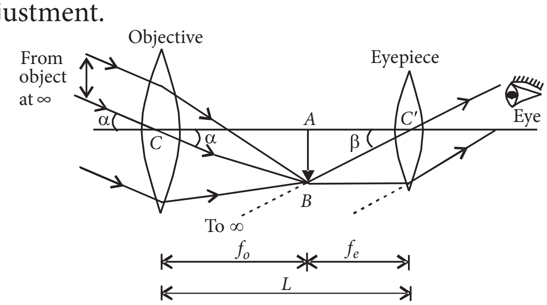
(Field from an infinitely large plane sheet of charge q is uniform and is given by $\frac{\sigma}{2\varepsilon_0}$).

$$-\frac{\sigma}{2\varepsilon_0}\int_\infty^r dr = -\frac{\sigma}{2\varepsilon_0} \cdot [r]_\infty^r$$

$$-\frac{\sigma}{2\varepsilon_0}(r - \infty) = \infty \text{ or, } V_P - V_\infty = \infty$$

From eq. (i) $W = \infty$

28. (a) (i) An astronomical telescope in normal adjustment.



It is used to see distant objects.

It consists of two lenses:

Objective of large aperture and large focal length f_o.

Eyepiece of small aperture and short focal length f_e.

(ii) Working : Telescope has an objective and eyepiece. The objective has a large focal length and much larger aperture than the eyepiece. Light from a distant object enters the objective and a real image is formed in the tube at its second focal point. The eye piece magnifies this image and the final inverted image is formed at infinity.

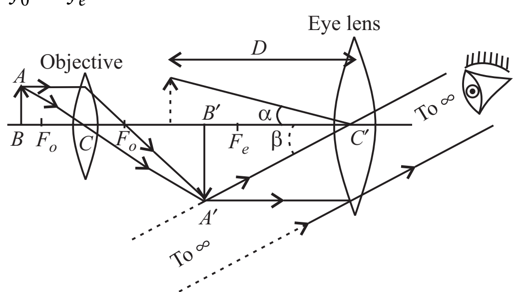
(b) $m = -\frac{f_0}{f_e} = -\frac{P_c}{P_0} = -\frac{10\text{D}}{1\text{D}} = -10$

Here the objective has large focal length and smaller power.

OR

When image is formed at infinity the magnifying power of compound microscope is given by

$M = \frac{-L}{f_0} \times \frac{D}{f_e}$



Magnification due to objective, $m_0 = \frac{L}{-f_0}$

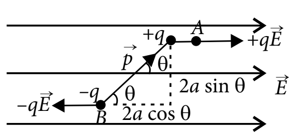
Angular magnification due to eyepiece, $m_e = \frac{D}{f_e}$

Total magnification when the final image is formed at infinity,

$m = m_0 \times m_e = -\frac{L}{f_0} \times \frac{D}{f_e}$

Obviously, magnifying power of the compound microscope is large when both f_0 and f_e are small.

29. (a) Torque on a dipole in uniform electric field:



When electric dipole is placed in a uniform electric field, its two charges experience equal and opposite forces, which cancel each other and hence net force on an electric dipole in a uniform electric field is zero. However these forces are not collinear, so they give rise to some torque on the dipole given by

Torque = Magnitude of either force

× Perpendicular distance between them

$\tau = Fr_\perp = qE.2a \sin\theta = q2a.\, E \sin\theta$ or $\tau = pE \sin\theta$

where θ is the angle between the directions of $\vec{p}$ and $\vec{E}$.

In vectorial form, $\vec{\tau} = \vec{p} \times \vec{E}$

(i) When θ = 0° or 180° then $\tau_{min} = 0$

(ii) When θ = 90° then $\tau_{max} = pE$

(b) Thus, torque on a dipole tends to align it in the direction of uniform electric field.

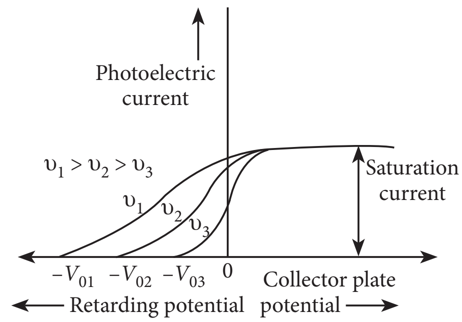
If the field is not uniform in that condition the net force on electric dipole is not zero.

When θ = 0; τ = 0 and $\vec{p}$ and $\vec{E}$ are parallel and the dipole is in a position of stable equilibrium.

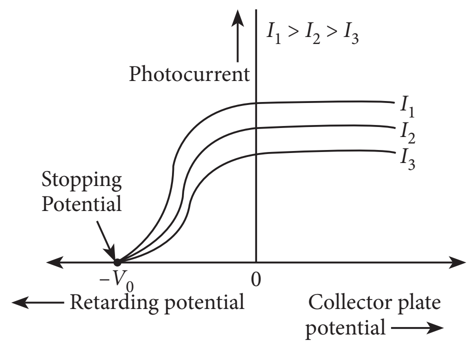
30. (a) The variable X on the horizontal axis is collector plate potential.

(b) The point A on the horizontal axis represents stopping potential.

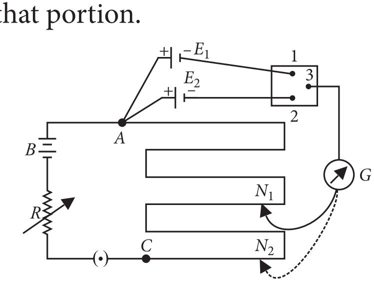
(c)



(d)



31. (a) Working principle of potentiometer : When a constant current is passed through a wire of uniform area of cross-section, the potential drop across any portion of the wire is directly proportional to the length of that portion.



Application of potentiometer for comparing emf's of two cells : The given figure shows an application of the potentiometer to compare the emf of two cells of emf E_1 and E_2. E_1, E_2 are the emfs of the two cells and 1, 2, 3 form a two way key.

When 1 and 3 are connected, E_1 is connected to the galvanometer (G).

Jokey is moved to N_1, which is at a distance l_1 from A, to find the balancing length.

Applying loop rule to $AN_1\, G31A$,

$\phi l_1 + 0 - E_1 = 0$ ...(i)

Where, ϕ is the potential drop per unit length.

Similarly, for E_2 balanced against $l_2(AN_2)$,

$\phi l_2 + 0 - E_2 = 0$ ...(ii)

From equation (i) and (ii)

$$\frac{E_1}{E_2} = \frac{l_1}{l_2} \qquad \text{...(iii)}$$

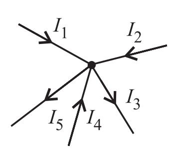
Thus we can compare the emfs of any two sources. Generally, one of the cells is chosen as a standard cell whose emf is known to a high degree of accuracy. The emf of the other cell is then calculated from equation (iii).

(b) The potentiometer wire is made of an alloy, such as constantan or manganin. It is because, an alloy has high resistivity and a low value of temperature coefficient of resistance.

(c) The sensitivity of a potentiometer can be increased by increasing the length of potentiometer wire which is responsible for decreasing the value of potential gradient.

OR

(a) Kirchhoff's first rule : The algebraic sum of all the current passing through a junction of an electric circuit is zero.

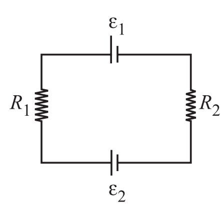


Here, I_1, I_2, I_3, I_4 and I_5 are current in different branches of a circuit which meet at a junction.

$I_1 + I_2 - I_3 + I_4 - I_5 = 0$

This rule is based on the principle of conservation of charge.

Kirchhoff's second rule : The algebraic sum of the applied emf's of an electrical circuit is equal to the algebraic sum of potential drops across the resistors of the loop.



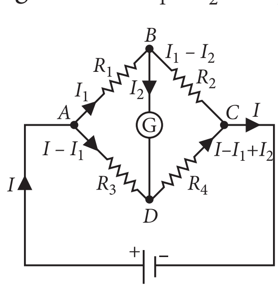
Mathematically,

$\Sigma\varepsilon = \Sigma IR$

This is based on energy conservation principle

Using this rule, $\varepsilon_1 - \varepsilon_2 = IR_1 + IR_2$

(b)



Consider loop $ABDA$

$I_1R_1 + I_2G - (I - I_1)R_3 = 0$

$$I_1(R_1 + R_3) + I_2G - IR_3 = 0 \qquad \text{...(i)}$$

Consider loop $BCDB$

$(I_1 - I_2)R_2 - (I - I_1 + I_2)R_4 - I_2G = 0$

$$I_1(R_2 + R_4) - I_2(R_2 + R_4 + G) - IR_4 = 0 \qquad \text{...(ii)}$$

When bridge is balanced, B and D are at same potential *i.e.*, $I_2 = 0$. From equations (i) and (ii), we get

$$\frac{R_1 + R_3}{R_2 + R_4} = \frac{R_3}{R_4}$$

$R_1R_4 + R_3R_4 = R_3R_4 + R_2R_3$; $R_1R_4 = R_2R_3$

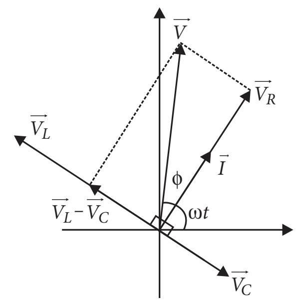
$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

32. (a) AC source, $V = V_0 \sin\omega t$

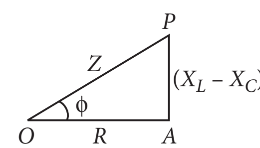
Voltage across resistor of resistance R, $V_R = IR$

Voltage across inductor of inductance L, $V_L = IX_L$

Voltage across capacitor of capacitance C, $V_C = IX_C$



Using Pythagorean theorem,



$V^2 = V_R^2 + (V_L - V_C)^2$

$V^2 = I^2R^2 + I^2(X_L - X_C)^2$

$V^2 = I^2[R^2 + (X_L - X_C)^2]$

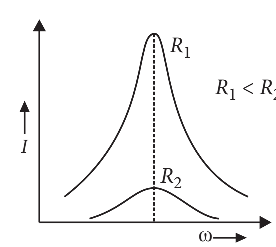
$$\therefore \quad I_0 = \frac{V_0}{\sqrt{R^2 + (X_L - X_C)^2}} = \frac{V_0}{Z}$$

where, $Z = \sqrt{R^2 + (X_L - X_C)^2}$ is called its impedance. Using impedance triangle the phase angle can be given as $\tan\phi = \dfrac{X_L - X_C}{R}$

$I = I_0 \sin(\omega t - \phi)$ For $V_L > V_C$ or $X_L > X_C$

$I = I_0 \sin(\omega t + \phi)$ For $V_L < V_C$ or $X_L < X_C$

(b) Variation of the current I as a function of angular frequency ω.



At resonance, when maximum current flows through the circuit.

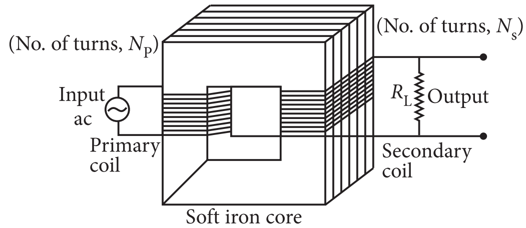
$$\omega_r = \frac{1}{\sqrt{L_1C_1}} = \frac{1}{\sqrt{L_2C_2}}$$

$$\Rightarrow \quad L_1C_1 = L_2C_2 \Rightarrow \frac{L_1}{L_2} = \frac{C_2}{C_1}$$

For fine tuning in the receiver set, combination L_1C_1 and R_1 is better because maximum current flows through the circuit.

OR

(a) Step-up transformer (or transformer) is based on the principle of mutual induction.



An alternating potential (V_p) when applied to the primary coil induced an emf in it.

$$\varepsilon_p = -N_p \frac{d\phi}{dt}$$

If resistance of primary coil is low $V_p = \varepsilon_p$.

i.e., $V_p = -N_p \frac{d\phi}{dt}$

As same flux is linked with the secondary coil with the help of soft iron core due to mutual induction, emf is induced in it.

$$\varepsilon_s = -N_s \frac{d\phi}{dt}$$

If output circuit is open $V_s = \varepsilon_s$

$$V_s = -N_s \frac{d\phi}{dt}$$

Thus $\frac{V_s}{V_p} = \frac{N_s}{N_p}$

For an ideal transformer, $P_{\text{out}} = P_{\text{in}} \Rightarrow I_s V_s = I_p V_p$

$$\therefore \quad \frac{V_s}{V_p} = \frac{I_p}{I_s} = \frac{N_s}{N_p}$$

For step-up transformer $\frac{N_s}{N_p} > 1$

In case of dc voltage, flux does not change. Thus no emf is induced in the circuit.

(i) The core of the transformer is laminated to reduce eddy current losses.

(ii) Thick copper wire is used in voindings of transformers because of its low resistivity i.e., low resistance.

There are number of energy losses in a transformer.

(i) Copper losses due to Joule's heating produced across the resistances of primary and secondary coils. It can be reduced by using copper wires.

(ii) Hysteresis losses due to repeated magnetization and demagnetization of the core of transformer. It is minimized by using soft iron core, as area of hysteresis loop for soft iron is small and hence energy loss also becomes small.

(iii) Iron losses due to eddy currents produced in soft iron core. It is minimized by using laminated iron core.

(iv) Flux losses due to flux leakage or incomplete flux linkage and can be minimised by proper coupling of primary and secondary coils.

(b) Here $N_P = 100$, $\frac{N_S}{N_P} = 100$

$\varepsilon_i = \varepsilon_P = 220\ V$, $P_I = 1100\ W$

(i) $N_P = 100$

$\therefore\ N_S = 10000$

(ii) $I_P = \frac{P_I}{\varepsilon_P} = \frac{1100}{220} = 5\text{ A}$

(iii) $\varepsilon_S = \frac{N_S}{N_P} \times \varepsilon_P = 100 \times 220 = 22000\text{ V}$

(iv) $I_S = \frac{P_O}{\varepsilon_S} = \frac{1100}{22000} = \frac{1}{20}\text{ A}$ $\qquad (\because P_O = P_I)$

(v) $P_S = P_O = P_I = 1100$ W.

33. Depletion layer : The small region in the vicinity of the junction which is depleted of free charge carriers and has only immobile ions is called the depletion layer.

Barrier potential : Due to accumulation of negative charges in the p-region and positive charges in the n-region sets up a potential difference across the junction sets up. This acts as a barrier and is called potential barrier V_B which opposes the further diffusion of electrons and holes across the junction.

(i) When there is an increase in doping concentration, the applied potential difference causes an electric field which acts opposite to the potential barrier. This results in reducing the potential barrier and hence the width of depletion layer decreases.

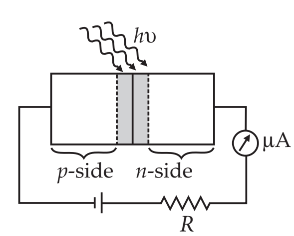
(ii) In forward biasing the width of depletion layer reduced and the external applied field is able to overcome the strong electric field of depletion layer. In reverse biasing the width of depletion layer increases and the electric field of depletion layer become more stronger.

OR

(a) Photo diodes are used to detect optical signals.

(b) Photodiode is used to detect the light signal and to measure light intensity.

(c) Working of photodiode : A junction diode made from light sensitive semiconductor is called a photodiode. A photodiode is a p-n junction diode arranged in reverse biasing.



The number of charge carriers increases when light of suitable frequency is made to fall on the p-n junction, because new electron holes pairs are created by absorbing the photons of suitable frequency. Intensity of light controls the number of charge carriers. Due to this property photodiodes are used to detect optical signals.

☺☺☺