

50 SURE SHOT QUESTIONS
(LONG ANSWER TYPE)

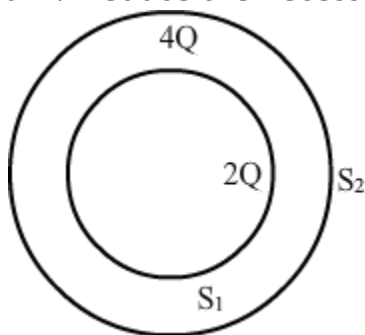
1.

Define electric field intensity and electric dipole moment. Derive expression for electric field intensity at any point along the equatorial line of an electric dipole and at a point on the axial line of a dipole.

2.

(a) Deduce the expression for the torque acting on a dipole of dipole moment $\vec{p}$ in the presence of a uniform electric field $\vec{E}$.

(b) Consider two hollow concentric spheres, S_1 and S_2 , enclosing charges $2Q$ and $4Q$ respectively as shown in the figure. (i) Find out the ratio of the electric flux through them. (ii) How will the electric flux through the sphere S_1 change if a medium of dielectric constant ' ϵ_r ' is introduced in the space inside S_1 in place of air? Deduce the necessary expression.



3.

(a) Define electric dipole moment. Is it a scalar or a vector? Derive the expression for the electric field of a dipole at a point on the equatorial plane of the dipole.

(b) Draw the equipotential surfaces due to an electric dipole. Locate the points where the potential due to the dipole is zero.

4.

Using Gauss's law deduce the expression for the electric field due to a uniformly charged spherical conducting shell of radius R at a point

(i) outside and (ii) inside the shell.

Plot a graph showing variation of electric field as a function of $r > R$ and $r < R$.
(r being the distance from the centre of the shell)

5.

(a) Using Gauss law, derive an expression for the electric field intensity at any point outside a

uniformly charged thin spherical shell of radius R and charge density $s \text{ C/m}^2$.

Draw the field lines

when the charge density of the sphere is (i) positive, (ii) negative.

(b) A uniformly charged conducting sphere of $2 \times 5 \text{ m}$ in diameter has a surface charge density of

100 mC/m^2 . Calculate the

charge on the sphere (ii) total electric flux passing through the sphere.

6.

State Gauss's theorem in electrostatics. Using this theorem, derive an expression for the electric field intensity to infinity long straight wire of linear charge density $\lambda \text{ Cm}^{-1}$

Derive an expression for the electric field intensity to infinity at a point near a thin infinite plane sheet of charge density $\alpha \text{ Cm}^{-2}$

7.

(a) State Kirchhoff's rules and explain on what basis they are justified.

(b) Two cells of emfs E_1 and E_2 and internal resistances r_1 and r_2 are connected in parallel. Derive the expression for the (i) emf and (ii) internal resistance of a single equivalent cell which can replace this combination.

8.

State the underlying principle of potentiometer.

Describe briefly, giving the necessary circuit diagram, how a potentiometer is used to measure the internal resistance of a given cell.

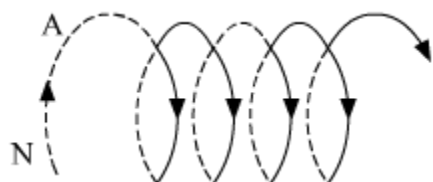
Explain how potentiometer can be used to compare the emfs of two primary cells.

9.

(a) State Ampere's circuital law. Use this law to obtain the expression for the magnetic field inside an air cored toroid of average radius ' r ', having ' n ' turns per

unit length and carrying a steady current I .

(b) An observer to the left of a solenoid of N turns each of cross section area ' A ' observes that a steady current I in it flows in the clockwise direction. Depict the magnetic field lines due to the solenoid specifying its polarity and show that it acts as a bar magnet of magnetic momentum $m = NIA$.



10.

(a) Deduce an expression for the frequency of revolution of a charged particle in a magnetic field and show that it is independent of velocity or energy of the particle.

(b) Draw a schematic sketch of a cyclotron. Explain, giving the essential details of its construction, how it is used to accelerate the charged particles.

11.

(a) Draw a labelled diagram of a moving coil galvanometer. Describe briefly its principle and working.

(b) Answer the following:

(i) Why is it necessary to introduce a cylindrical soft iron core inside the coil of a galvanometer?

(ii) Increasing the current sensitivity of a galvanometer may not necessarily increase its voltage sensitivity. Explain, giving reason.

12.

(a) Draw a schematic sketch of a cyclotron. Explain clearly the role of crossed electric and magnetic field in accelerating the charge. Hence derive the expression for the kinetic energy acquired by the particles.

(b) An α -particle and a proton are released from the centre of the cyclotron and made to accelerate.

(i) Can both be accelerated at the same cyclotron frequency?

Give reason to justify your answer.

(ii) When they are accelerated in turn, which of the two will have higher velocity at the exit slit of the does?

13.

(a) Using Biot – Savart's law, derive the expression for the magnetic field in the vector form at a point on the axis of a circular current loop.

(b) What does a toroid consist of? Find out the expression for the magnetic field inside a toroid for N turns of the coil having the average radius r and carrying a current I . Show that the magnetic field in the open space inside and exterior to the toroid is zero.

14.

(a) Write the expression for the force, $\vec{F}$, acting on a charged particle of charge 'q', moving with a velocity $\vec{v}$ in the presence of both electric field $\vec{E}$ and magnetic field $\vec{B}$. Obtain the condition under which the particle moves undeflected through the fields.

(b) A rectangular loop of size $l \times b$ carrying a steady current I is placed in a uniform magnetic field $\vec{B}$. Prove that the torque $\vec{\tau}$ acting on the loop is given by $\vec{\tau} = \vec{m} \times \vec{B}$, where $\vec{m}$ is the magnetic moment of the loop.

15.

(a) Explain, giving reasons, the basic difference in converting a galvanometer into (i) a voltmeter and (ii) an ammeter.

(b) Two long straight parallel conductors carrying steady currents I_1 and I_2 are separated by a distance 'd'. Explain briefly, with the help of a suitable diagram, how the magnetic field due to one conductor acts on the other. Hence deduce the expression for the force acting between the two conductors. Mention the nature of this force.

16.

(a) Draw a labelled diagram of a moving coil galvanometer. Describe briefly its principle and working.

(b) Answer the following:

(i) Why is it necessary to introduce a cylindrical soft iron core inside the coil of a galvanometer?

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17.

A long straight wire of a circular cross-section of radius ' a ' carries a steady current ' I '. The current is uniformly distributed across the cross-section. Apply Ampere's circuital law to calculate

the magnetic field at a point ' r ' in the region for (i) $r < a$ and (ii) $r > a$.

Two infinitely long straight parallel wires, '1' and '2', carrying steady currents I_1 and I_2 in the same direction are separated by a distance d . Obtain the expression for the magnetic field B due to the wire '1' acting on wire '2'. Hence find out, with the help of a suitable diagram, the magnitude and direction of this force per unit length on wire '2' due to wire '1'. How does the nature of this force changes if the currents are in opposite direction? Use this expression to define the S.I. unit of current.

18.

(a) Show that a planar loop carrying a current I , having N closely wound turns and area of cross-section A , possesses a magnetic moment $M = NIA$

(b) When this loop is placed in a magnetic field B , find out the expression for the torque acting on it.

(c) A galvanometer coil of $50\ \Omega$ resistance shows full scale deflection for a current of 5 mA . How

will you convert this galvanometer into a voltmeter of range 0 to 15 V ?

19.

(a) State Lenz's law. Give one example to illustrate this law. "The Lenz's law is a consequence

of the principle of conservation of energy." Justify this statement.

(b) Deduce an expression for the mutual inductance of two long co-axial solenoids but

having different radii and different number of turns.

20.

(a) Define mutual inductance and write its S.I. units.

(b) Derive an expression for the mutual inductance of two long co-axial solenoids of same length wound one over the other,

(c) In an experiment, two coils C_1 and C_2 are placed close to each other. Find out the expression for the emf induced in the coil C_1 due to a change in the current through the coil C_2 .

21.

(a) What are eddy currents? How are these currents reduced in the metallic cores of transformers?

(b) A step down transformer operates on a $2 \times 5\text{ KV}$ line. It supplies a load with 20 A . The ratio of

the primary winding to the secondary is 10: 1. If the transformer is 90% efficient, calculate:

- (i) the power output,
- (ii) the voltage, and
- (iii) the current in the secondary.

22.

State the working principle of an AC generator with the help of a labelled diagram.

Derive an expression for the instantaneous value of the emf induced in coil. Why is the emf maximum when the plane of the armature is parallel to the magnetic field?

23.

A series *LCR* circuit is connected to an ac source having voltage $v = v_m \sin \omega t$.

Derive the expression for the instantaneous current I and its phase relationship to the applied voltage.

Obtain the condition for resonance to occur. Define 'power factor'. State the conditions under which it is (i) maximum and (ii) minimum.

24.

Draw a necessary arrangement for winding of primary and secondary coils in a step-up transformer. State its underlying principle and derive the relation between the primary and secondary voltages in terms of number of primary and secondary turns. Mention the two basic assumptions used in obtaining the above relation.

State any two causes of energy loss in actual transformers.

25.

Draw a labelled diagram of a step-up transformer and explain briefly its working.

Deduce the expressions for the secondary voltage and secondary current in terms of the number of turns of primary and secondary windings.

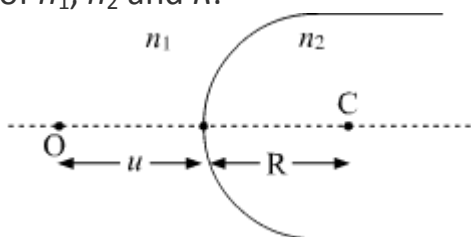
How is the power transmission and distribution over long distances done with the use of transformers?

26.

- (a) A point object 'O' is kept in a medium of refractive index n_1 in front of a convex spherical surface of radius of curvature R which separates the second medium

of refractive index n_2 from the first one, as shown in the figure.

Draw the ray diagram showing the image formation and deduce the relationship between the object distance and the image distance in terms of n_1 , n_2 and R .



- (b) When the image formed above acts as a virtual object for a concave spherical surface separating the medium n_2 from n_1 ($n_2 > n_1$), draw this ray and write the similar relation. Hence obtain lens maker's formula.

27.

Draw a labelled ray diagram of a refracting telescope. Define its magnifying power and write the expression for it.

Write two important limitations of a refracting telescope over a reflecting type telescope.

28.

Derive an expression for the magnifying power of a compound microscope when the image is formed at the near point.

- (a) A ray of light is incident in glass on a glass-water boundary. The angle of incidence is 50° .

Calculate the angle of refraction. Refractive index of glass = 1.50; refractive index of water = 1.33.

29.

Derive an expression for the refractive index of prism material in terms of angle of the prism and the angle of minimum deviation.

- (a) The refractive index of the material of a prism of 60° angle for yellow light is $(2)^{1/2}$.

Determine the angle of minimum deviation

30.

Trace the rays of light showing the formation of an image due to a point object placed on the axis of a spherical surface separating the two media of refractive indices n_1 and n_2 . Establish the relation between the distances of the object, the image and the radius of curvature from the central point of the spherical surface. Hence, derive the expression of the lens maker's formula.

31.

(a) For a ray of light travelling from a denser medium of refractive index n_1 to a rarer medium of refractive index n_2 , prove that $\frac{n_1}{n_2} = \sin i_c$, where i_c is the critical angle of incidence for the media.

(b) Explain with the help of a diagram, how the above principle is used for transmission of video signals using optical fibres.

32.

Draw a labelled ray diagram of an astronomical telescope, in the normal adjustment position and write the expression for its magnifying power. An astronomical telescope uses an objective lens of focal length 15 m and eye-lens of focal length 1 cm. What is the angular magnification of the telescope?

If this telescope is used to view moon, what is the diameter of the image of moon formed by the objective lens? (Diameter of moon = 3×10^6 m and radius of lunar orbit = 3×10^8 m).

33.

(a) With the help of a suitable ray diagram, derive the mirror formula for a concave mirror.

(b) The near point of a hypermetropic person is 50 cm from the eye. What is the power of the lens required to enable the person to read clearly a book held at 25 cm from the eye?

34.

(a) Draw a ray diagram for formation of image of a point object by a thin double convex lens having radii of curvatures R_1 and R_2 and hence derive lens maker's formula.

(b) Define power of a lens and give its S.I. units. If a convex lens of focal length 50 cm is placed in contact coaxially with a concave lens of focal length 20 cm, what is the power of the combination?

35.

- (a) Using Huygens's construction of secondary wavelets explain how a diffraction pattern is obtained on a screen due to a narrow slit on which a monochromatic beam of light is incident normally.
- (b) Show that the angular width of the first diffraction fringe is half that of the central fringe.
- (c) Explain why the maxima at $\theta = \left(n + \frac{1}{2}\right) \frac{\lambda}{a}$ become weaker and weaker with increasing n .

36.

- (a) In Young's double slit experiment, describe briefly how bright and dark fringes are obtained on the screen kept in front of a double slit. Hence obtain the expression for the fringe width.
- (b) The ratio of the intensities at minima to the maxima in the Young's double slit experiment is 9 : 25. Find the ratio of the widths of the two slits.

37.

- (a) Describe briefly how a diffraction pattern is obtained on a screen due to a single narrow slit illuminated by a monochromatic source of light. Hence obtain the conditions for the angular width of secondary maxima and secondary minima.
- (b) Two wavelengths of sodium light of 590 nm and 596 nm are used in turn to study the diffraction taking place at a single slit of aperture 2×10^{-6} m. The distance between the slit and the screen is 1.5 m. Calculate the separation between the positions of first maxima of the diffraction pattern obtained in the two cases.

38.

- (a) In Young's double slit experiment, derive the condition for
 - (i) constructive interference and
 - (ii) destructive interference at a point on the screen.
- (b) A beam of light consisting of two wavelengths, 800 nm and 600 nm is used to obtain the interference fringes in a Young's double slit experiment on a screen placed 1.4 m away. If the two slits are separated by 0.28 mm, calculate the

least distance from the central bright maximum where the bright fringes of the two wavelengths coincide.

39.

(a) Use Huygens' principle to show the propagation of a plane wavefront from a denser medium to a rarer medium. Hence find the ratio of the speeds of wavefronts in the two media.

(b) (i) Why does an unpolarised light incident on a Polaroid get linearly polarised ?

(ii) Derive the expression of Brewster's law when unpolarised light passing from a rarer to a denser medium gets polarised on reflection at the interface.

40.

(a) How does an unpolarized light incident on a polaroid get polarized? Describe briefly, with the help of a necessary diagram, the polarization of light by reflection from a transparent medium.

(b) Two polaroids "A" and "B" are kept in crossed position. How should a third polaroid "C" be placed between them so that the intensity of polarized light transmitted by polaroid B reduces to $1/8^{\text{th}}$ of the intensity of unpolarized light incident on A?

41.

(a) What is plane polarised light? Two polaroids are placed at 90° to each other and the transmitted intensity is zero. What happens when one more polaroid is placed between these two, bisecting the angle between them ? How will the intensity of transmitted light vary on further rotating the third polaroid?

(b) If a light beam shows no intensity variation when transmitted through a polaroid which is rotated, does it mean that the light is unpolarised ? Explain briefly.

42.

Using Bohr's postulates, derive the expression for the frequency of radiation emitted when electron in hydrogen atom undergoes transition from higher energy state (quantum number n_i) to the lower state, (n_f).

When electron in hydrogen atom jumps from energy state $n_i = 4$ to $n_f = 3, 2, 1$, identify the spectral series to which the emission lines belong.

43.

(a) Draw the plot of binding energy per nucleon (BE/A) as a function of mass number A . Write two important conclusions that can be drawn regarding the nature of nuclear force.

(b) Use this graph to explain the release of energy in both the processes of nuclear fusion and fission.

(c) Write the basic nuclear process of neutron undergoing α -decay.

Why is the detection of neutrinos found very difficult?

44.

Write Einstein's photoelectric equation and point out any two characteristic properties of photons on which this equation is based.

Briefly explain the three observed features which can be explained by this equation.

The ground state energy of hydrogen atom is -13.6 eV. If an electron makes a transition from the energy level -0.85 eV to -3.4 eV, calculate the wavelength of the spectrum line to which this transition belongs?

45.

(a) Explain the formation of 'depletion layer' and 'barrier potential' in a p - n junction.

(b) With the help of a labelled circuit diagram explain the use of a p - n junction diode as a full wave rectifier. Draw the input and output waveforms.

46.

(a) Describe briefly, with the help of a diagram, the role of the two important processes involved in the formation of a p - n junction.

(b) Name the device which is used as a voltage regulator. Draw the necessary circuit diagram and explain its working.

47.

(a) Give a circuit diagram of a common emitter amplifier using an n - p - n transistor. Draw the input and output waveforms of the signal. Write the expression for its voltage gain.

(b) Identify the equivalent gate for the following circuit and write its truth table.



48.

(i) With the help of circuit diagrams distinguish between forward biasing and reverse biasing of a $p-n$ junction diode.

(ii) Draw $V-I$ characteristics of a $p-n$ junction diode in (a) forward bias, (b) reverse bias

49.

(a) Draw $I-V$ characteristics of a Zener diode.

(b) Explain with the help of a circuit diagram, the use of a Zener diode as a voltage-regulator.

(c) A photodiode is operated under reverse bias although in the forward bias the current is known to be more than the current in the reverse bias. Explain giving reason.

50.

Explain how a transistor in active state exhibits a low resistance at its emitter base junction

and high resistance at its base collector junction.

Draw a circuit diagram and explain the operation of a transistor as a switch.