ARYAN INSTITUTE

General Instructions:

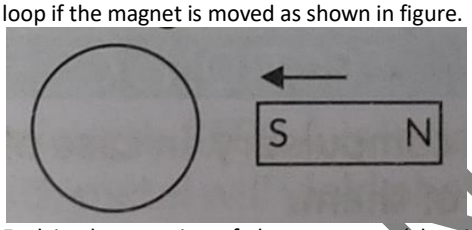
I. All questions are compulsory. There are 33 questions in all.
II. This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
III. Section A contains ten very short answer questions and four assertion reasoning MCQs of 1 mark each. Section B has two case based questions of 4 marks each, Section C contain nine short answer question 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.

Time: 3 hrs. **Max. Marks:** 70

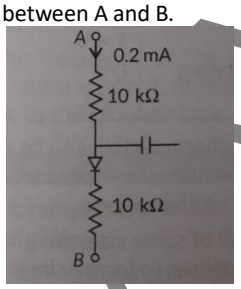
Section A

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

1. If the total charge enclosed by a surface is zero, does it imply that the electric field everywhere on the surface is zero, does it imply that net charge inside is zero?
   OR
   Two materials Si and Cu, are cooled from 300 K to 60 K. What will be the effect on their resistivity?
2. Give the relation between amplitudes of electric and magnetic fields in free space.
3. If one of the slits in Young's double slit experiment is fully closed, what is the change in angular size of central maximum in the new pattern?
4. Peak value of e.m.f. of an a.c. source is ε_0. What is its r.m.s. value?
   OR
   In which direction will the current be induced in the closed loop if the magnet is moved as shown in figure.



5. Explain the meaning of the statement 'electric charge of a body is quantized'.
6. In a circuit as shown in the figure, if the diode forward voltage drop is 0.3 v, then find the voltage difference between A and B.



7. Can the potential function have a maximum or minimum value in free space?
8. How is a sample of an n-type semiconductor electrically neutral though it has an excess of negative charge carriers?
9. How is the radius of a nucleus related to its mass number?
   OR
   Name the reaction responsible for energy production in the sun.
10. How much reactance is offered by pure inductor to direct current? Why?

For question numbers 11 to 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) If both assertion and reason are true and reason is the correct explanation of assertion.
b) If both assertion and reason are true but reason is not the correct explanation of assertion.
c) If assertion is true but reason is false.
d) If both assertion and reason are false.

11. **Assertion (A):** In photoelectric effect, on increasing the intensity of light, both the number of electrons emitted and kinetic energy of each of them get increased but photoelectric current remains unchanged.
    Reason (R): The photoelectric current depends only on wavelength of light.
12. **Assertion (A):** A point charge is lying at the centre of a cube of each side having equal area. $1^{th}/6$ is the electric flux emanating from each surface of the cube of total flux.
    Reason (R): According to Gauss theorem, total electric flux through a closed surface enclosing charge is equal to $1/\varepsilon_0$ times the magnitude of the charge enclosed.
13. **Assertion (A):** Basic difference between an electric line and magnetic line of force is that former is discontinuous and the latter is continuous or endless.
    Reason (R): No electric lines of forces exist inside a charged body but magnetic lines do exist inside a magnet.
14. **Assertion (A):** Hydrogen atom consists on only one electron but its emission spectrum has many lines.
    Reason (R): Only Lyman series is found in the absorption spectrum of hydrogen atom whereas in the emission spectrum, all the series are found.

Section B

Question 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. A lens is a portion of a transparent refracting medium bound by two spherical surfaces or one spherical surface and the other plane surface. Lens Maker's formula is a relation that connects focal length of a lens to radii of curvature of the two surfaces of the lens and refractive index of the material of the lens. It is useful to design lenses of desired focal length using suitable material and surfaces of suitable radii of curvature.
    (i) An equiconvex lens has power P. It is cut into two symmetrical halves by a plane containing the principal axis. The power of one part will be
    (a) 0 (b) $\frac{P}{2}$ (c) $\frac{P}{4}$ (d) P
    (ii) A convex lens is dipped in a liquid whose refractive index is equal to the refractive index of the lens. Then its focal length will
    (a) become zero
    (b) become infinite
    (c) become small, but non-zero
    (d) remain unchanged.

(iii) The focal length of converging lens is measured for violet, green and red colours. It is respectively f_v, f_g, f_r. We will get
(a) $f_v < f_r$ (b) $f_g > f_r$
(c) $f_v = f_g$ (d) $f_g < f_r$

(iv) If F_v and F_r are the focal lengths of a concave lens for violet and red light respectively, then we must have
(a) $F_v > F_r$ (b) $F_v > F_r$
(c) $F_v < F_r$ (d) $F_v < F_r$

(v) If a convex lens of focal length 80 cm and a concave lens of focal length 50 cm are combined together, what will be their resulting power?
(a) +7.5D (b) -0.75 D
(c) +6.5 D (d) -6.5 D

16. Inductance is analogous to inertia in mechanics, because inductance of an electrical circuit opposes any change of current in the circuit. When current through a coil changes with respect to the time then magnetic flux linked with the coil also changes with respect to time. Due to this an emf and a current is induced in the coil. According to Lenz's law, induced current opposes the change in magnetic flux. This phenomenon is called self induction and a factor by virtue of which the coil shows opposition for change in magnetic flux, called self inductance of the coil. The self-induced emf is given by $\varepsilon = -L\frac{dI}{dt}$, where L is the self-inductance of the coil. When current through a coil is constant, the magnetic fields as well as magnetic flux through it is constant, so no electromagnetic induction takes place. When an emf is produced in a coil because of change in current in a coupled coil, the effect is called mutual inductance.

(i) The mutual inductance M_{12} of a coil 1 with respect to coil 2
(a) increases when they are brought nearer
(b) depends on the current passing through the coils
(c) increases when one of them is rotated about an axis
(d) both (a) and (b) are correct.

(ii) The coefficient of mutual inductance of two coils depends on
(a) medium between of coils
(b) distance between the two coils
(c) orientation of the two coils
(d) all of these.

(iii) Two coils A and B are separated by a certain distance. If a current of 4 A flows through A, a magnetic flux of 10^{-3} Wb passes through B (no current through B). If no current passes through A and a current of 2 A passes through B, then the flux through A is
(a) 5×10^{-3} Wb (b) 4×10^{-4} Wb
(c) 5×10^{-4} Wb (d) 2×10^{-3} Wb

(iv) If number of turns in primary and secondary coils is increased to two times each, the mutual inductance
(a) becomes 4 times (b) becomes 2 times
(c) becomes $\frac{1}{4}$ times (d) remains unchanged.

(v) The physical quantity which is measured in the unit of Wb A^{-1} is
(a) self inductance (b) mutual inductance
(c) magnetic flux (d) both (a) and (b)

Section – C

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

17. The following table provides the set of values, of V and I, obtained for a given diode :

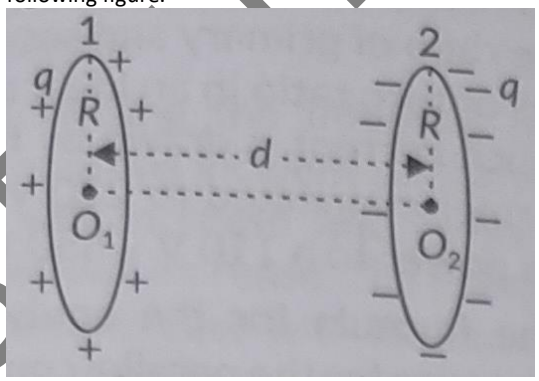
	V	I
Forward biasing	2.0 V	60 mA
	2.4 V	80 mA
Reverse biasing	0 V	0 μA
	−2 V	−0.25 μA

Assuming the characteristics to be nearly linear, over this range, calculate the forward and reverse bias resistance of the given diode.

18. n tiny drops, all of same size, are given equal charges. If the drops coalesce to form a single bigger drop, then what will be the new potential of the drop? What is the surface charge density of the bigger drop?

OR

Two wire rings, each having a radius R, are placed at a distanced apart with their axes coinciding as shown in the following figure.



The charges on the two rings are + and -q. Find the value of potential difference between the centres of the two rings.

19. Laser light of wavelength 640 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 light which produces interference fringes separated by 8.1 mm using same arrangement. Also find the minimum value of the order (n) of bright fringe of shorter wavelength which coincides with that of the longer wavelength.

OR

State the differences between interference and diffraction patterns.

20. Write the relation for the force F acting on a charge q moving with a velocity through v magnetic field B in vector notation. Using this relation, deduce the conditions under which this force will be (i) maximum (ii) minimum.
21. Draw a plot of potential energy of a pair of nucleons as a function of their separation. Write two important conclusions which you can draw regarding the nature of nuclear forces.
22. Explain why does a convex lens behave as a converging lens when immersed in water (μ= 1.33) and as a diverging lens when immersed in carbon disulphide (μ=1.63). The refractive index of lens material is 1.52.
23. An arbitrary surface encloses a dipole. What is the electric flux through this surface?
24. Light of wavelength 3500 A is incident on two metals A and B. Which metal will yield photoelectrons if their work functions are 4.3 eV and 1.9 eV respectively?

OR

Calculate the
(a) de Broglie wavelength of the electrons accelerated through a potential difference of 81 V.

(b) momentum.

25. Calculate the frequency of the photon radiated by a hydrogen atom when it de-excites from the first excited state to the ground state.

Section – D

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

26. (a) Using Bohr's second postulate of quantization of orbital angular momentum show that the circumference of the electron in the n^{th} orbital state in hydrogen atom is n time the de Broglie wavelength associated with it.
(b) The electron in hydrogen atom is intitially in the third excited state. What is the maximum number of spectral lines which can be emitted when it finally moves to the ground state?

27. Distinguish between an intrinsic semiconductor and p-type semiconductor Give reason, why, a p-type semiconductor crystal is electrically neutral, although $n_h >> n_e$?

OR

Suppose a pure Si crystal has 5 x 10^{28} atoms m^{-3}. It is doped by 1 ppm concentration of pentavalent As. Given that n_i = 1.5 x $10^{16} m^{-3}$, calculate the number of electrons and holes.

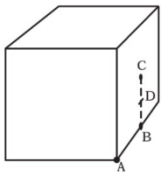
28. An alternating emf is applied across a capacitor. Show mathematically that current in it leads the applied emf by a phase angle of $\pi/2$. What is its capacitive reactance? Draw a graph showing the variation of capacitive reactance with the frequency of the a.c. source.

OR

How does the mutual inductance of a pair of coils change when
(a) the distance between the coil is increased?
(b) the number of turns in each coil is decreased?
(c) a thin iron sheet is placed between the two coils, other factors remaining the same?
Justify your answer in each case.

29. (a) When the oscillating electric and magnetic fields are along the x-and y-direction respectively.
(i) point out the direction of propagation of electromagnetic wave.
(ii) express the velocity of propagation in terms of the amplitudes of the oscillating electric and magnetic fields.
(b) How do you show that the e.m. wave carries energy and momentum?

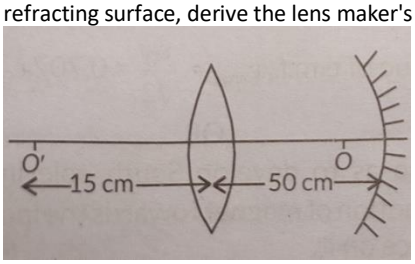
30. What will be the total flux through the faces of the cube with side of length a if a charge q is placed at
(i) A: a corner of the cube
(ii) B: mid-point of an edge of the cube
(iii) C: cente of a face of the cube
(iv) D: mid-point of B and C.



Section – E

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

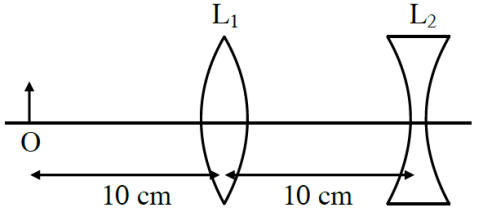
31. (i) Using the relation for refraction at a single spherical refracting surface, derive the lens maker's formula.



(ii) In the accompanying diagram, the direct image formed by the lens (f= 10 cm) of an object placed at O and that formed after reflection from the spherical the mirror are formed at the same point O'. What is the radius of curvature of the mirror?

OR

(a) An extended object is placed at point O, 10 cm in front of a convex lens L_1 and a concave lens L_2 is placed 10 cm behind it, as shown in the figure. The radii of curvature of all the curved surfaces in both the lenses are 20 cm. The refractive index of both the lenses is 1.5. The total magnification of this lens system is



(b) A spherical convex surface of power 5 dioptre separates object and image space of refractive indices 1.0 and $\frac{4}{3}$ respectively. The radius of curvature of the surface is

32. An ac source generating a voltage V = V_o sin ωt is connected to a capacitor of capacitance C. Find the expression for the current i, flowing through it. Plot a graph of V and i versus ωt to show that the current $\frac{\pi}{2}$ ahead of the voltage. A resistor of 200 Ω and a capacitor of 15.0 μF are connected in series to a 220 V, 50 Hz ac source. Calculate the current in the circuit and the rms voltage across the resistor and the capacitor. Is the algebraic sum of these voltage more than the source voltage? If yes, resolve the paradox.

OR

(i) Draw a labelled diagram of a step-down transformer. State the principle of its working.
(ii) Express the turn ratio in terms of voltages.
(iii) Find the ratio of and secondary currents in terms of turn ratio in an ideal transformer.
(iv) How much current is drawn by the primary of a transformer connected to 220 V supply when it delivers power to a 110 V - 550 W refrigerator?

33. Describe the formula for the equivalent EMF and internal resistance for the parallel combination of two cells with EMFs ε_1 and ε_2 and internal resistances r_1 and r, respectively. What is the corresponding formula for the series combination? Two cells of EMF 1V, 2V and internal resistances 2 Ω and 1 Ω respectively are connected in (i) series, (ii) parallel. What should be the external resistance in the circuit so that the current through the resistance be the same in the two cases? In which case more heat is generated in the cells?

OR

(i) State the two Kirchhoff's laws. Explain briefly how these rules are justified.

(ii) The current is drawn from a cell of emf E and internal resistance r connected to the network of resistors each of resistance r as shown in the figure. Obtain the expression for (a) the current drawn from the cell and (b) the power consumed in the network.