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. Force between two point electric charges kept at distance d apart in air is F. If the distance between two charges is halved and their individual charges are doubled then what is the new force between them?

   OR

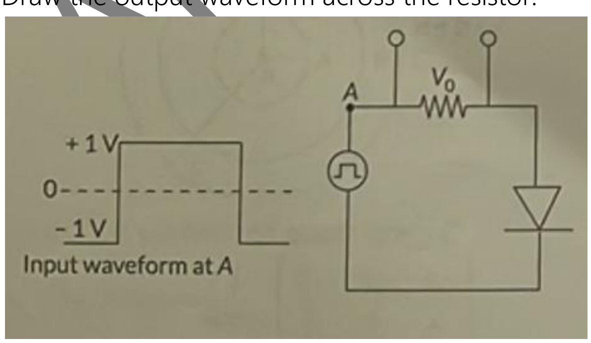
   A and B are two identical spherical charged bodies, which repel each other with force F, kept at a finite distance. A third uncharged sphere c of the same size is brought in contact with sphere A and removed. It is then kept at mid point of A and B. Find the magnitude of force on C.

2. Why are elemental dopants for Silicon or Germanium usually chosen from group XIII or group XV?

   OR

   Sn, C, and Si, Ge are all group XIV elements. Yet, Sn is a conductor, C is an insulator while Si and Ge are semiconductors. Why?

3. A permanent magnet in the shape of a thin cylinder of length 10 cm has M = 10_6 A m^{-1}. Calculate the magnetization current I_m.
4. There are two sources of light, each emitting with a power of 100 W. One emits X-rays of wavelength 1 nm and the other visible light of 500 nm. Find the ratio of number of photons of X-rays to the photons visible light of the given wavelength?
5. Why is the orientation of the portable radio with respect to broadcasting station important?
6. Draw the output waveform across the resistor.



7. The magnetic force depends on v which depends on the inertial frame of reference. Does then the magnetic force differ from inertial frame to frame? Is it reasonable that the net acceleration has a different value in different frames of reference?
8. What are two sources of magnetic fields?
9. Do all the electrons that absorb a photon come out as photoelectrons?

OR

There are materials which absorb photons of shorter wavelength and emit photons of longer wavelength. Can there be stable substances which absorb photons of larger wavelength and emit light of shorter wavelength.

10. A variable frequency a.c. source is connected to a capacitor. How will the displacement current change with decrease in frequency?

OR

The magnetic field of a beam emerging from a filter facing floodlight is given by
$B_0 - 12 \times 10^{-8} \sin (1.20 \times 10^7 z - 3.60 \times 10^{15} t)$T.
What is the average intensity of the beam?

For question number 11-14, two statements are given-one labeled Assertion (A) and the other labeled 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.

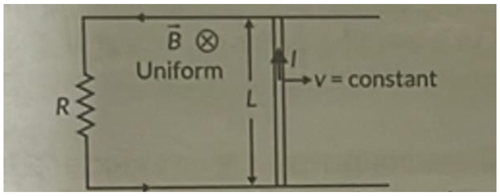
11. **Assertion (A):** Three equal charges are situated on a circle of radius r such that they form an equilateral triangle, then the electric field intensity at the centre is zero.
Reason (R): The force on unit positive charge at the centre, due to the three equal charges are represented by the three sides of a triangle taken in the same order. Therefore, electric field intensity at centre zero.
12. **Assertion (A):** In interference all the fringes are of same width.
Reason (R): In interference fringe width is independent of position of the fringe.
13. **Assertion (A):** X-rays in vacuum travel faster than light waves in vacuum.
Reason (R): The energy of X-rays photon is less than that of light photon.
14. **Assertion (A):** Only a change in magnetic flux will maintain an induced current in the coil.
Reason (R): The presence of large magnetic flux through a coil maintains a current in the coil if the circuit is continuous.

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. The emf induced across the ends of a conductor due to its motion in a magnetic field is called motional emf. It is produced due to the magnetic Lorentz force acting on the free electrons of the conductor. For a circuit shown in

figure, if a conductor of length L moves with velocity v in a magnetic field B perpendicular to both its length and the direction of the magnetic field, then all the induced parameters are possible in the circuit.



(i) Direction of current induced in a wire moving in a magnetic field is found using

(a) Fleming's left hand rule

(b) Fleming's right hand rule

(c) Ampere's rule

(d) Right hand clasp rule

(ii) A conducting rod of length L is moving in a transverse magnetic field of strength B with velocity v. The resistance of the rod is R. The current in the rod is

(a) $\frac{BLv}{R}$ (b) BLv (c) zero (d) $B^2v^2L^2$ / R

(iii) A 0.1 m long conductor carrying a current of 50 A is held perpendicular to a magnetic field of 1.25 mT. The mechanical power required to move the conductor with a speed of 1 ms^{-1} is

(a) 62.5 mW (b) 625 mW (c) 6.25 mW (d) 12.5 mW

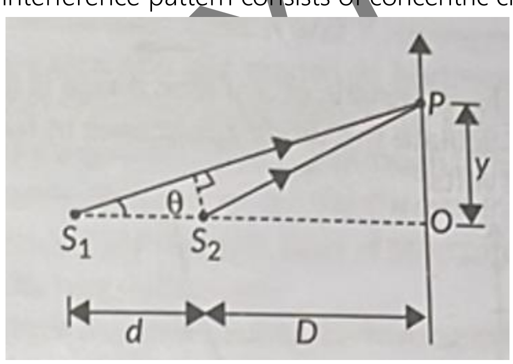
(iv) A bicycle generator created 1.5V at 15km/hr. The EMF generated at 10km/hr is

(a) 1.5 volts (b) 2 volts (c) 0.5 volts (d) 1 volts

(v) The dimensional formula for emf ε in MKS system will be

(a) $[ML^2T^{-3}A^{-1}]$ (b) $[ML^2T^{-1}A]$ (c) $[ML^2A]$ (d) $[MLT^2A^{-2}]$

16. In young's double slit experiment, the width of the central bright fringe is equal to the distance between the first dark fringes on the two sides of the central bright fringe.
In given figure below a screen is placed normal to the line joining the two point coherent source S_1 and S_2. The interference pattern consists of concentric circles.



(i) The optical path difference at P is

(a) $d\left[1+\frac{y^2}{2D}\right]$ (b) $d\left[1+\frac{2D}{y^2}\right]$

(c) $d\left[1-\frac{y^2}{2D^2}\right]$ (d) $d\left[2D-\frac{1}{y^2}\right]$

(ii) Find the radius of the n^{th} bright fringe.

(a) $D\sqrt{1\left(1-\frac{n\lambda}{d}\right)}$ (b) $D\sqrt{2\left(1-\frac{n\lambda}{d}\right)}$

(c) $2D\sqrt{2\left(1-\frac{n\lambda}{d}\right)}$ (d) $D\sqrt{2\left(1-\frac{n\lambda}{2d}\right)}$

(iii) If d = 0.5 mm, λ = 5000 A and D = 100cmm, find the value of n for the closest second bright fringe

(a) 888 (b) 830 (c) 914 (d) 998

(iv) The coherence of two light sources means that the light waves emitted have

(a) Same frequency

(b) Same intensity

(c) Constant phase difference

(d) Same velocity.

(V) The phenomenon of interference is shown by

(a) Longitudinal mechanical waves only

(b) Transverse mechanical waves only

(c) Electromagnetic waves only

(d) All of these

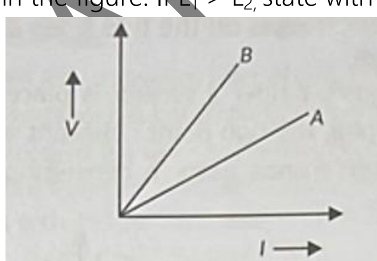
Section B

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

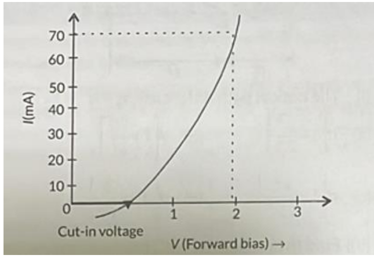
17. Briefly explain how the drift velocity of electrons in a metallic conductor varies, When (i) the temperature of the conductor is increased, and (ii) applied potential difference is decreased, keeping temperature constant.

OR

The voltage-current graphs for two resistors of the same material and same radii with lengths L_1 and L_2 are shown in the figure. If $L_1 > L_2$, state with reason, which of these graphs represents voltage-current change for L_1.



18. The V-1 characteristic of a silicon diode is given in the figure. Calculate the diode resistance in forward bias at V = +2 volts.



19. 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.
20. Using Bohr model, calculate the electric current created by the electron when the H-atom is in the ground state.
21. Use the mirror formula to show that for an object lying between the pole and focus of a concave mirror, the image formed is always virtual in nature.

OR

Use mirror formula to show that the virtual image produced by a convex mirror is always diminished in a size and is located between the focus and the pole.
22. Explain why the reactance offered by an inductor increases with increasing frequency of an alternating voltage.
23. A microscope is focused on a dot at the bottom of a beaker. Some oil is poured into the beaker to a height of y cm and it is found necessary to raise the microscope through a vertical distance of x cm to bring the dot again into focus. Express refractive index of oil in terms of x and y.

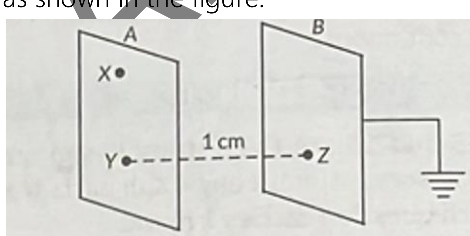
OR

The refractive index of water is 4/3. Obtain the value of the semi vertical angle of the cone within which the entire outside view would be confined for a fish under water. Draw an appropriate ray diagram.
24. A ray of light passes through an equilateral glass prism, such that the angle of incidence is equal to the angle of emergence. If the angle of emergence is ¾ times the angle prism, calculate the refractive index of the glass prism and angle of deviation.
25. A proton and an α-particle are accelerated, using the same potential difference. How are the de Broglie same potential difference. How are the de Broglie wavelengths λ_p and λ_α related to each other?

Section B

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

26. Two identical plane metallic surfaces A and B are kept parallel to each other in air, separated by a distance of 1 cm as shown in the figure.



A is given a positive potential of 10 V and the outer surface of B is earthed.

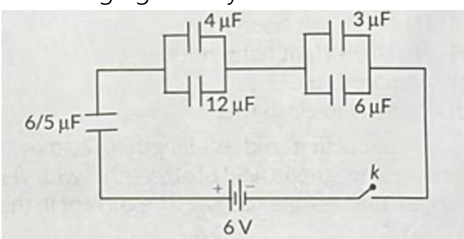
(i) What is the magnitude and direction of the uniform electric field between Y and Z?

(ii) What is the work done in moving a charge of 20 μC from X to Y?

27. Keeping the voltage of the charging source constant, what would be the percentage change in the energy stored in a parallel plate capacitor if the separation between its plates were to be decreased by 10%?

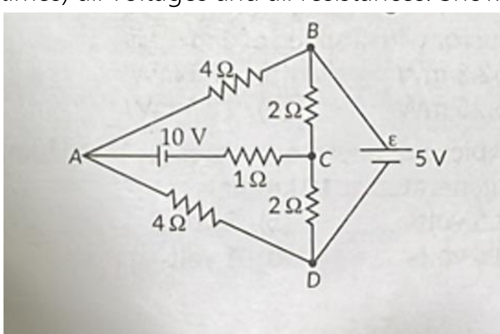
OR

Find: (i) the equivalent capacitance and (ii) the total energy stored in the system of capacitors given in the network. The charging battery has an emf of 6 V.



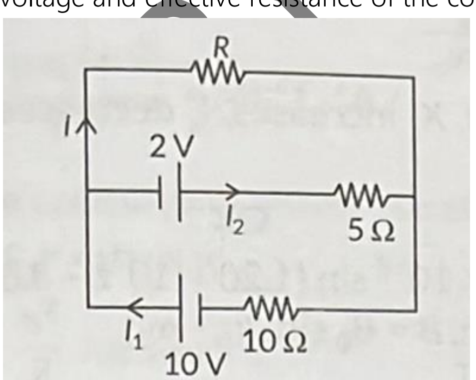
28. Distinguish between 'intrinsic' and 'extrinsic' semiconductors.

29. Suppose there is a circuit consisting of only resistances and batteries. Suppose one is to double (or increase it to n-times) all voltages and all resistances. Show that currents are unaltered. Do this for given circuit.



OR

Two cells of voltage 10 V and 2 V and internal resistances 10 Ω and 5 Ω respectively, are connected in parallel with the positive end of 10 V battery connected to negative pole of 2 V battery as shown in the figure. Find the effective voltage and effective resistance of the combination.



30. A room has AC run for 5 hours a day at a voltage of 220 V. The wiring of the room consists of Cu of 1 mm radius and a length of 10 m. Power consumption per day is 10 commercial units. What fraction of it goes in the joule heating in wires? What would happen if the wiring is made of aluminium of the same dimensions?

Section E

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

31. (a) Is Huygen's principle valid for longitudinal sound waves?

(b) Consider a point at the focal point of a convergent lens. Another convergent lens of short focal length is placed on the other side. What is the nature of the wavefronts emerging from the final image?

(c) What is the shape of the wavefront on earth for sunlight?

(d) Why is the diffraction of sound waves more evident in daily experience than that of light wave?

OR

(a) Three immiscible liquids of densities $d_1 > d_2 > d_3$ and refractive indices $\mu_1 > \mu_2 > \mu_3$ are put in a beaker. The height of each liquid column is $\frac{h}{3}$. A dot is made at the bottom of the beaker. For near normal vision, find the apparent depth of the dot.

(b) For a glass (m=$\sqrt{3}$) the angle of minimum deviation is equal to the angle of the prism. Find the angle of the prism.

32. (a) With the help of a diagram, explain the principle and working of a moving coil galvanometer.

(b) What is the importance of a radial magnetic field and how is it produced?

(c) Why is it that while using a moving coil galvanometer as a voltmeter a high resistance in series is required whereas in an ammeter a shunt is used?

OR

(a) Two circular coils X and Y having radii R and R/2 respectively are placed in horizontal plane with their centres coinciding with each other. Coil X has a current / flowing through it in the clockwise sense. What must be the current in coil Y to make the total magnetic field at the common centre of the two coils, zero?

(b) With the same currents flowing in the two coils, if the coil Y is now lifted vertically upwards through a distance R, what would be the net magnetic field at the centre of coil Y?

33. (a) Why do stable nuclei never have more protons than neutrons?

(b) Are the nucleons fundamental particles, or do they consist of still smaller parts? One way to find out is to probe a nucleon just as Rutherford probed an atom. What should be the kinetic energy of an electron for it to be able to probe a nucleon to be approximately 10^{-15} m.

(c) A nuclide 1 is said to be the mirror isobar of nuclide 2 if $Z_1 = N_2$ and $Z_2 = N_1$. (i) What nuclide is a mirror isobar of 23/11 Na? (ii) What nuclide out of the two mirror isobars have greater binding energy and why?

OR

(a) Define the terms mass defect and binding energy.

(b) Calculate the binding energy/nucleon for $_{26}Fe^{56}$. [mass of $_{26}Fe^{56}$ = 55.934932 amu]