PART – A

I. Pick the correct option among the four given options for ALL of the following questions:

15×1 =15

1. A point charge q_1 exerts a force F on another point charge q_2 when placed at a fixed distance. If another point charge q_3 is brought near q_2, the force on q_2 due to q_1:
   a) Increases b) decreases
   c) May increase or increase d) Does not change

   Ans: d) Does not change

2. Equipotential surfaces for an isolated point charge are ________ in shape.
   a) Spherical b) Planar c) Cylindrical d) Conical

   Ans: a) Spherical

3. Resistivity of a metal wire depends on its:
   a) Area of cross-section b) Length
   c) Material d) Volume

   Ans: c) Material

4. The following table lists magnetic fields due to different current configurations. Column I lists the current configurations and column II lists expressions for magnetic fields. Symbols have usual meanings.

Column I	Column II
i) At a distance r from an infinitely long straight wire.	p) $B=\mu_0 nI$
ii) At the centre of a circular current loop of radius r.	q) $B=\frac{\mu_0 I}{2r}$
iii) At the centre of a current carrying solenoid.	r) $B=\frac{\mu_0 I}{2\pi r}$

   a) (i) – (p), (ii) – (q), (iii) – (r) b) (i) – (r), (ii) – (q), (iii) – (p)
   c) (i) – (r), (ii) – (p), (iii) – (q) d) (i) – (q), (ii) – (r), (iii) – (p)

   Match the current configurations in Column - I with the correct magnetic - field expressions in Column - II.

   Ans: b) (i) – (r), (ii) – (q), (iii) – (p)

5. ‘The net magnetic flux through any closed surface is zero’. This law is called
   a) Gauss’ law in electrostatics b) Gauss’ law in magnetism
   c) Ampere’s circuital law d) Faraday’s law of electromagnetic induction

   Ans: b) Gauss’ law in magnetism

6. Consider the following statements:

Statement 1: AC generator worked on the principle of electromagnetic induction.

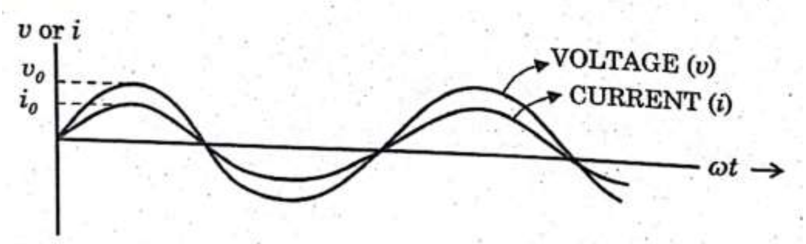
Statement 2: In an AC generator, as the armature is rotated in a uniform magnetic field, the magnetic flux linked with the coil changes which induces an emf in the coil.

Among the above two statements:

a) Both statements are true
b) Both statements are false.
c) Statement 1 is true and statement 2 is false
d) Statement 2 is false and statement 2 is true

Ans: a) Both statements are true

7. The variation of voltage and current through ac circuit with time is as shown in the figure.



Along with the ac source, the circuit:

a) Has a series combination of resistance and capacitance
b) Has only inductance
c) Has only capacitance
d) May have only resistance or may have a suitable series combination of inductance (L), capacitance (C) and resistance (R).

Ans: d) May have only resistance or may have a suitable series combination of inductance (L), capacitance (C) and resistance (R).

8. Transformer cores are usually laminated. This is to reduce energy loss due to

a) Flux leakage b) Winding resistance c) Eddy currents d) Hysteresis

Ans: c) Eddy currents

9. 'Ampere-Maxwell Law' is written as (symbols have usual meanings):

a) $\oint \vec{B}.\vec{dl} = \mu_0 i + \mu_0 \varepsilon_0 \frac{d\phi_E}{dt}$ b) $\oint \vec{B}.\vec{dl} = \mu_0 i + \varepsilon_0 \frac{d\phi_E}{dt}$

c) $\oint \vec{B}.\vec{dl} = \mu_0 i$ d) $\oint \vec{E}.\vec{dl} = -\frac{d\phi_B}{dt}$

Ans: a) $\oint \vec{B}.\vec{dl} = \mu_0 i + \mu_0 \varepsilon_0 \frac{d\phi_E}{dt}$

10. Final image of a real object formed by a compound microscope is ______ with respect to the object.

a) Real, inverted and magnified b) Virtual, erect and magnified
c) Virtual, erect and diminished d) Virtual, inverted and magnified

Ans: d) Virtual, inverted and magnified

11. Which one of the following statements is WRONG about interference of light?
   a) Light waves of same wavelength coming from two independent sources can be coherent and can produce interference.
   b) When the path difference between two interfering waves in $n\lambda$, bright fringe is produced (here n = 0, 1, 2, … and λ is the wavelength of light)
   c) When the phase difference between two interfering waves is (2n + 1)π, dark fringe is produced (here n = 0, 1, 2,…)
   d) In Young's double slit experiment, dark and bright fringes are equally spaced.

   Ans: a) Light waves of same wavelength coming from two independent sources can be coherent and can produce interference.

12. A ball is dropped from a certain height and it falls freely under gravity. During the fall, the de Broglie wavelength associated with it:
   a) Keeps increasing   b) Keep decreasing
   c) Is zero   d) May increase or decrease

   Ans: b) Keep decreasing

13. In Rutheford's α-ray scattering experiment, α-particles of specific energy are projected towards a thin gold foil. If the impact parameter for the α particles is zero, the angle of scattering is
   A) $\theta = 0^0$ b) $\theta = 90^0$ c) $\theta = 180^0$ d) $\theta = 45^0$

   Ans: c) $\theta = 180^0$

14. Binding energy per nucleon of a nucleus is a measure of its
   a) Radius   b) Mass   c) Volume   d) Stability

   Ans: d) Stability

15. The energy gap for silicon is:
   a) 0.72 eV   b) 1.1 eV   c) 3 eV   d) 5 eV

   Ans: b) 1.1 eV

II. Fill in the blanks by choosing appropriate answer given in the bracket for all of the following questions: **5 × 1 = 5**

(diamagnetic, ferromagnetic, instantaneous, transverse, force, torque)

16. An electric dipole placed in a uniform electric field experiences a net ____
   Ans: Torque

17. Water is an example for ______ material.
   Ans: Diamagnetic

18. When a ____ rod is inserted into a coil, its self- inductance increases.
   Ans: Ferromagnetic

19. Polarization of light shows that light is a ____ wave.
   Ans: Transverse

20. Photoelectric effect is a/ an ____ effect.
   Ans: Instantaneous

PART – B

III. Answer any FIVE of the following questions: 5 × 2 = 10

21. Define electric potential energy of a system of charges.
What happens to the potential energy of a system of two unlike charges when the distance between them is increased (assume there is no external electric field)?
Ans:

Electrostatic potential energy of a system of point charges is defined as the work required to assembling the system of charges by bringing them from infinite distance.

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

The potential energy of a system of two unlike charges increases, when distance between them is increased.

22. List any two limitations of Ohm's law.
Ans:

- Ohm's law is applicable only if all the physical conditions remain constant.
- Ohm's law is not applicable at very low and at very high temperature.
- Ohm's law holds good for metallic conductor for which V-I graph is linear.
- Ohm's law is not applicable for semiconductors, electrolyte, discharge tube etc. Because here V-I graph is non-linear.

23. Write the expression for Lorentz force and explain the terms.
Ans:

$\vec{F} = q\vec{E} + q(\vec{v} \times \vec{B})$ where $\vec{E}$ and $\vec{B}$ are perpendicular to each other

Where, $\vec{F}$ = total force experienced by the particle due to magnetic field and electric field

q = charge

$\vec{E}$ = electric field in which charge is placed

$\vec{v}$ = velocity of the particle placed in electric field and magnetic field

$\vec{B}$ = magnetic field in which charge is placed

24. State Lenz's law. What is its significance?
Ans:
It states that, "The direction of induced emf is such that it opposes the cause which produced it".

Lenz's law follows the principle of conservation of energy.

Significance: Conservation of energy.

25. Give any two uses of microwaves.
Ans:
- Radar systems used in aircraft navigation.
- Speed guns
- Microwave ovens

26. How are focal length (f) and radius of curvature (R) of a spherical mirror related? What is the sign of focal length of a convex mirror?

Ans:

$$f = \frac{R}{2}$$

Sign of focal length of a convex mirror is positive.

27. Mention the condition for total internal reflection.

Ans:

- The ray of light must pass from Denser medium to Rarer medium.
- The angle of incidence in the denser medium must be greater than the critical angle for the given pair of media.

28. An intrinsic semiconductor crystal is doped with pentavalent atoms has an electron concentration of $5\times10^{22} m^{-3}$. If, at thermal equilibrium, the intrinsic concentration $n_i = 1.5\times10^{16} m^{-3}$, find the hole concentration.

Ans:

Given $n_i = 1.5\times10^{16} m^{-3}$

$n_e = 5\times10^{22} m^{-3}$

$n_e.n_h = n_i^2$

$\Rightarrow n_h = \frac{n_i^2}{n_e}$

$= 4.5\times10^{9}\ m^{-3}$

PART – C

IV. Answer any FIVE of the following questions: **5 × 3 = 15**

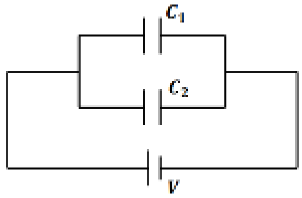
29. Mention three properties of electric field lines.

Ans: (Any Three)

- The tangent drawn to an electric field line at any point gives the direction of electric field at that point.
- Two electric field lines do not intersect each other. [If two electric field lines cross each other then at the point of intersect there will be two tangents. It means that there are two values of the electric field at a point which is not possible].
- Electric field lines are closer (crowded) when the electric field is stronger and electric field lines spread out when the field is weaker.
- The lines of force do not pass through a conductor as the electric field inside a conductor is always zero.

30. Derive the expression for the equivalent capacitance of two capacitors connected in parallel.

Ans:



Consider three capacitors of capacitance C_1 and C_2 connected in parallel between A & B as shown.

Let a battery of 'V' volt be connected across the combination. Let the charge on the left plates of C_1 and C_2 be $+q_1$ and $+q_2$ respectively. Then the charges on the right plates of C_1 and C_2 are $-q_1$ and $-q_2$ and respectively.

We have $q = q_1 + q_2$ ---------(1)

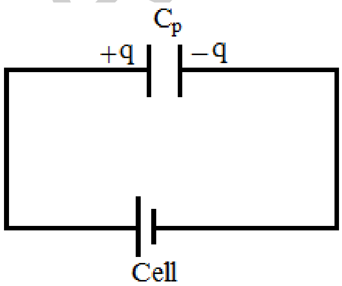
But, $q_1 = C_1V$

$q_2 = C_2V$

Then, $q = C_1V + C_2V$

$q = (C_1+C_2) V$ ---------(2)

Let the combination of capacitors between A & B be replaced by a single capacitor called the equivalent capacitor which effectively replace the combination, so that same charge q is stored under the same potential difference 'V'.



Let C_p be the capacitance of equivalent capacitor.

Then, $q = C_pV$ ------------(3)

From equation (2) & (3)

$C_pV = (C_1+C_2) V$

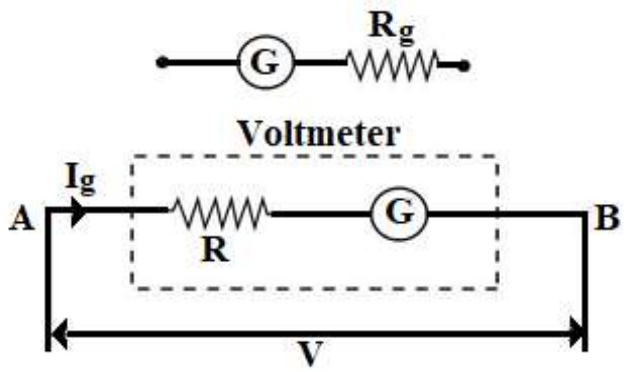
ie $C_p = C_1+C_2$

Thus, the equivalent capacitance of a number of capacitors in parallel is equal to the sum of their individual capacitance.

31. Explain with a circuit diagram, how a galvanometer can be converted into voltmeter.

Ans:

A voltmeter is an instrument used to measure potential difference. It is always connected in parallel in a circuit. A galvanometer is very sensitive device and it can be used to measure very low currents.



A galvanometer can be converted into a voltmeter by connecting a high resistance in series with the coil of the galvanometer. Let R_g be the resistance of the galvanometer, I_g be the current required for full scale deflection and R be the high resistance to be connected in series with the galvanometer. If V is the maximum potential difference to be measured then

$$V = I_g(R_g + R)$$

$$\frac{V}{I_g} = R + R_g$$

$$R = \frac{V}{I_g} - R_g$$

Since $R_{g\ \text{and}}$ R are constant so V is directly proportional to I_g

32. Define the terms:
a) Magnetization
b) Magnetic permeability and
c) Magnetic susceptibility.
Ans:

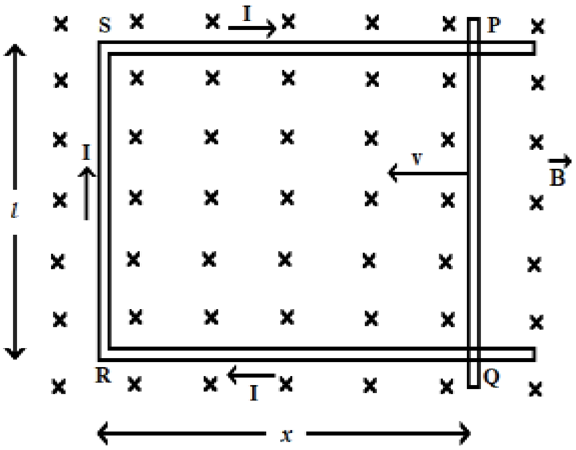
a) Magnetization
Magnetization of the material is defined as net magnetic dipole moment per unit volume of the material. It is also known as Intensity of magnetization.

b) Magnetic permeability and
It is the ratio of intensity of magnetization developed in the material to the applied magnetizing force (H).

c) Magnetic susceptibility
The magnetic permeability of a material is defined as the ratio of magnetic induction to magnetic intensity.

33. Derive the expression for motional emf induced in a rod moving in a uniform magnetic field.
Ans:

Let us consider a straight conductor moving in a uniform and time independent magnetic field. Let PQRS is a rectangular conductor in which the conductor PQ is free to move. Let the rod PQ is moved towards the left with a constant velocity *v*. Assume that there is no loss of energy due to friction. The conductor PQ is perpendicular to the plane of the system. Let RQ = *x* and RS = *l*



The area swept by the conductor A = lx

The magnetic flux enclosed by the loop PQRS is $\emptyset_B$= Blx. $\therefore$ $(\theta = 0^0)$

From Faraday's second law:

The rate of change of flux will induce an emf and is given by

$$\in = -\frac{d}{dt}\emptyset_B$$

$$\in = \frac{-d(Blx)}{dt}$$

$$\in = -Bl\frac{dx}{dt}$$

$\in = Blv$ Where, $v = -\frac{dx}{dt}$ is the speed of the conductor PQ.

34. When a light radiation of energy 3 eV falls on a metal surface, photoelectrons with a maximum kinetic energy 1 eV are emitted from the surface. Find the threshold frequency for the metal surface. (Given : Planck's constant, $h = 6.63\times10^{-34}\,Js$; Charge on the electron $e = 1.6\times10^{-19}\,C$).

Ans:

Energy of incident photon , hv = 3 eV

Maximum k.e. of ejected electrons = 1 eV

$$K_{max} = hv - hv_0$$

$$hv_0 = hv - K_{max}$$

$$\left(6.63\times10^{-34}\right)\left(v_0\right) = \left(3-1\right)ev$$

$$v_0 = \frac{2\times1.6\times10^{-19}}{6.63\times10^{-34}} = 4.82\times10^{14}\,Hz$$

35. State the postulates of Bohr's hydrogen atom model.

Ans:

Bohr's model is based on the following postulates.

- **Postulate 1:** Electrons revolve round the nucleus only in certain stable orbits (called stationary orbits) without the emission of radiant energy.

- **Postulate 2:** Electrons revolve around the nucleus only in those orbits for which the angular momentum of the electron is integral multiple of $\frac{h}{2\pi}$ where h is Planck's constant.

  i.e., Angular momentum, $mvr = n\frac{h}{2\pi}$ where $n = 1, 2, 3 \ldots. \infty$ (Bohr's quantization rule) where n is called principal quantum number.

- **Postulate 3:** An electron might make a transition from one of its (specified non-radiating) orbits to another of lower energy. When it does so, a photon is emitted having energy equal to the energy difference between the inner and the outer orbits.

  i.e., $h\nu = E_o - E_i$ (Bohr's frequency condition)

36. Write any three properties of nuclear force.
Ans: Any Three

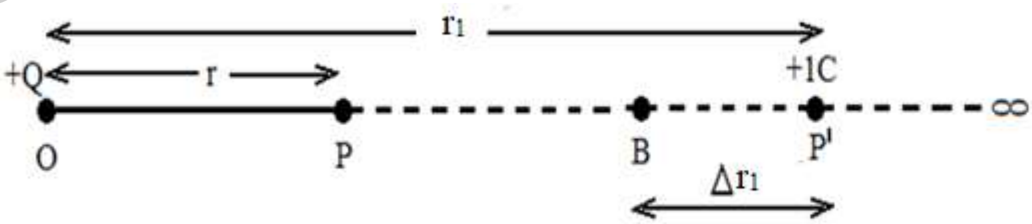
- Nuclear force is the strongest known force in nature.
- **Nuclear forces are short range forces:** nuclear forces are appreciable only when the distance between nucleons is of the order of 10^{-15}m or less.
- **Nuclear forces are charge independent:** The magnitude of the nuclear force is same between two protons or two neutrons or a proton and a neutron.
- **Nuclear forces are spin dependent:** The force of attraction between two nucleons having parallel spin is stronger than the force between two nucleons having anti parallel spin.
- They have the property of saturation: Nucleons in a nucleus can interact only with its neighbouring nucleolus.
- Nuclear forces are attractive in nature within the range.
- Nuclear forces are repulsive when the distance between the nucleons is very close (≈0.5 fermi)

PART – D

V. Answer any THREE of the following questions: **3 × 5 = 15**

37. Derive the expression for the electric potential at a point due to a point charge.
Ans:

Consider a point charge +Q at the origin O. Let P be a point at a distance 'r' from O.



The electric potential at P, is the amount of work done in carrying a unit positive charge from infinity to P. Consider some intermediate point P^1 at a distance r_1 from O. Let a unit positive charge +1C at P^1. Then the electrostatic force between charge +Q and charge at P_1 is;

$\vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r_1^2}\hat{r}_1$ where, $\hat{r}_1$is a unit vector along OP_1 outwards

Work done to move a unit positive charge +1C from p^I to B a small distance Δr_1 is

$$\Delta W = -\vec{F}.\vec{\Delta r_1}$$

$$\Delta W = -\frac{1}{4\pi\varepsilon_0}\frac{Q}{r_1^2}\Delta r_1$$

∴ The total work done in moving a unit positive charge from infinity to the point P is;

$$W = -\int_{\infty}^{r}\frac{Q}{4\pi\varepsilon_0 r_1^2}dr_1$$

$$W = -\frac{Q}{4\pi\varepsilon_0}\int_{\infty}^{r}\frac{1}{r_1^2}dr_1$$

$$W = \frac{Q}{4\pi\varepsilon_0 r_1}\Big]_{\infty}^{r}$$

$$w = \frac{Q}{4\pi\epsilon 0}\left[\frac{1}{r_1}\right]_{\infty}^{r}$$

$$W = \frac{Q}{4\pi\varepsilon_0 r}$$

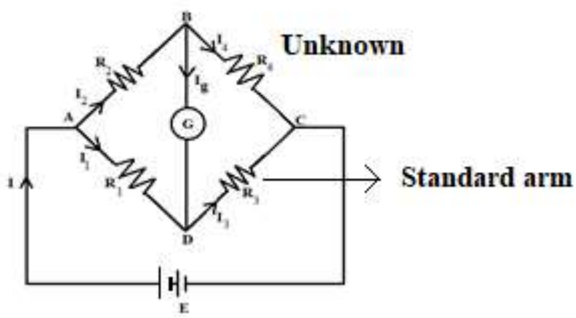
By definition this work done is equal to the electrostatic potential V at the point P due to the charge Q.

$$V(r) = \frac{Q}{4\pi\varepsilon_0 r}$$

38. Arrive at the condition for balance of a Wheatstone's network using Kirchhoff's rules.
Ans:

Wheatstone's Bridge is a circuit which is used to determine the value of unknown resistance by adjusting three known resistances.

The bridge has four resistors R_1, R_2, R_3 and R_4. Across one pair of diagonally opposite points a source is connected and the other two vertices a galvanometer is connected. Let Ig be the current through the galvanometer.



Applying Kirchhoff's junction rule at the junction B and D

$I_2 = I_4 + I_g$ ------------- (1)

$I_1 + I_g = I_3$ -------------(2)

Applying Kirchhoff's loop rule to ADBA

$-I_1R_1 + I_gG + I_2R_2 = 0$ --------------- (3)

Applying Kirchhoff's loop rule to CBDC

$I_4R_4 - I_gG - I_3R_3 = 0$ ------------------ (4)

The current I_g through the galvanometer can be altered by varying the resistance in the bridge. Let any one or more of the four resistances be changed until current through the galvanometer I_g becomes zero. Under this condition the bridge is said to be balanced.

Then equation (1), (2), (3) and (4) can be rewritten as,

$I_2 = I_4$ -------------- (5)

$I_1 = I_3$ -------------- (6)

$I_1R_1 = I_2R_2$ ---------- (7)

$I_3R_3 = I_4R_4$ ----------(8)

Substitute eqn. (5) and eqn. (6) in eqn. (8) we get,

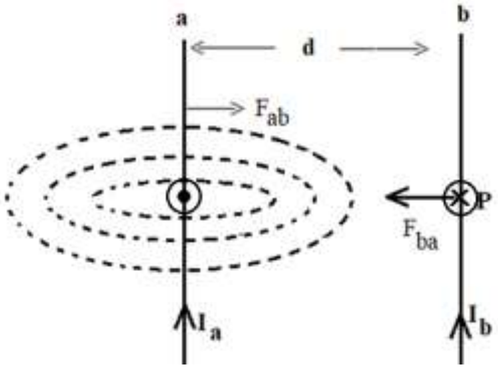
$I_1R_3 = I_2R_4$ --------------- (9)

Divide equation. (7) by eqn. (9) we get

$\frac{R_2}{R_4} = \frac{R_1}{R_3}$ This is the condition for balance of a Wheatstone's network.

39. Obtain the expression for the force per unit length between two infinitely long straight parallel current carrying conductors placed in vacuum. Hence define the unit 'ampere'.
Ans:

Consider two long straight parallel conductors 'a' and 'b' of length L separated by a distance 'd' and carrying a current I_a and I_b in the same direction. Each conductor is in the region of magnetic field produced by the other, Therefore, each conductor experiences a force.



The magnitude of the magnetic field at any point P on the conductor 'b', due to current I_a in the conductor 'a' is;

$B_a = \frac{\mu_0}{2\pi}\frac{I_a}{d}$ ………… (1)

Using right hand thumb rule, the direction of magnetic field is perpendicular to the plane of the paper directed inwards. Now the conductor 'b' will experience a magnetic force and is given by; $(\theta = 90^0$; sin90=1)

$F_{ba} = I_b B_a L$

$F_{ba} = \frac{\mu_0}{2\pi}\frac{I_a I_b}{d} L$ …………… (2)

Using Fleming's left-hand rule, the direction of F_{ba} towards the conductor 'a'.

Similarly, magnetic field at any point on conductor 'a' due to current in conductor 'b' is

$$B_b = \frac{\mu_0}{2\pi}\frac{I_b}{d} \quad \text{(acting outwards)} \;\ldots\ldots\ldots\ldots\; (3)$$

Then the force experience by the conductor 'a' is ($\theta = 90^0$; sin90=1)

$$F_{ab} = I_a B_b L$$

$$F_{ba} = \frac{\mu_0}{2\pi}\frac{I_a I_b}{d} L \quad \text{(towards the conductor b)} \;\ldots\ldots\ldots\ldots\; (4)$$

from equation (2) and (4)

$$F_{ab} = F_{ba} = \frac{\mu_0 I_a I_b}{2\pi d} L \qquad \ldots\ldots\ldots\ldots\; (5)$$

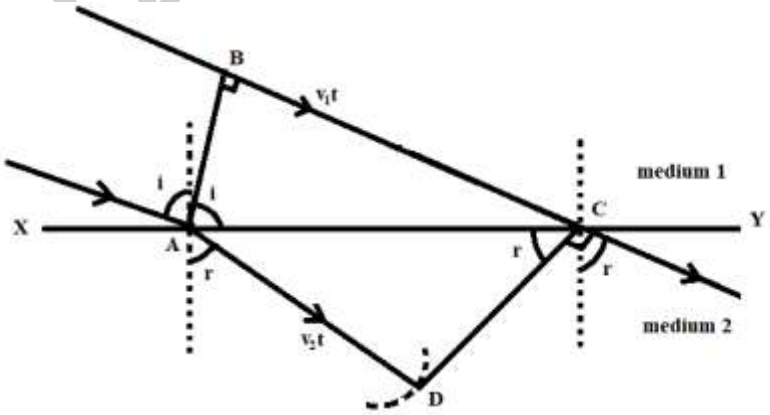
One ampere: It is defined as that current flowing in each of the two infinitely long parallel conductors of negligible cross section, separated 1m apart in vacuum, would produce a force of 2×10^{-7} N per meter length of each conductor.

40. a) State Huygen's principle **(1)**

Huygen's principle states that "every point on a wave front acts as a source of new wavelets, and the new wavefront is the surface tangent to all these wavelets".

b) Prove Snell's law of refraction using Huygen's principle by considering refraction of a plane wave by a surface. **(4)**

Let XY represent the surface separating medium 1 and medium 2. Let v_1 and v_2 be the speed of light in medium 1 and medium 2 respectively. Consider plane wavefront AB incident in medium 1 at an angle *i*. Let *t* be the time taken by the secondary waves to travel the distance BC. Then BC = v_1t. The secondary waves from A will travel a distance $v_2 t$ in medium 2 in the same time. Therefore, with A as centre and $v_2 t$ as radius draw an arc at D in medium 2. The tangent from C touches the arc at D. Then AD = $v_2 t$ and CD represent the refracted wavefront. Let *r* be the angle of refraction.



In ΔABC, sin $i = \frac{BC}{AC}$ ………… (1)

In ΔACD, sin $r = \frac{AD}{AC}$ ………… (2)

∴ Eqn (1) / (2) $\frac{\sin i}{\sin r} = \frac{BC}{AD} = \frac{v_1 t}{v_2 t} = \frac{v_1}{v_2}$ ………… (3)

If n_1 and n_2 are the absolute refractive indices of medium 1 and medium 2 respectively and if *c* represents the speed of light in vacuum, then,

$n_1 = \frac{c}{v_1}$ and $n_2 = \frac{c}{v_2}$

$\therefore \frac{n_2}{n_1} = \frac{v_1}{v_2}$ ………… (4)

From (3) and (4) $\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$

$n_1 \sin i = n_2 \sin r$

This is the Snell's law of refraction.

41. a) What is a rectifier? **(1)**

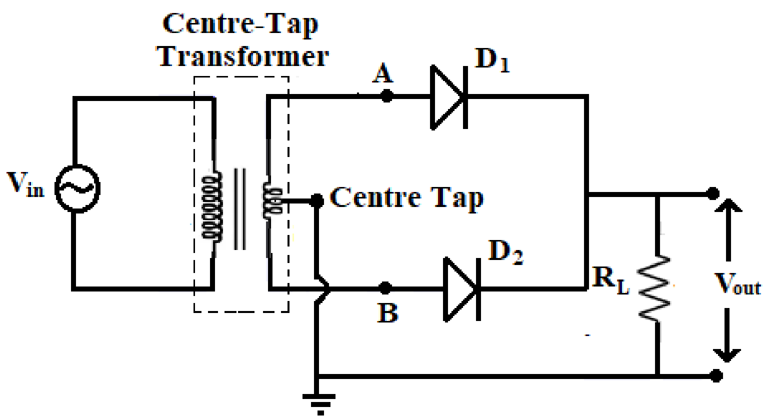
Ans:

The device which converts A.C to pulsating D.C is called rectifier.

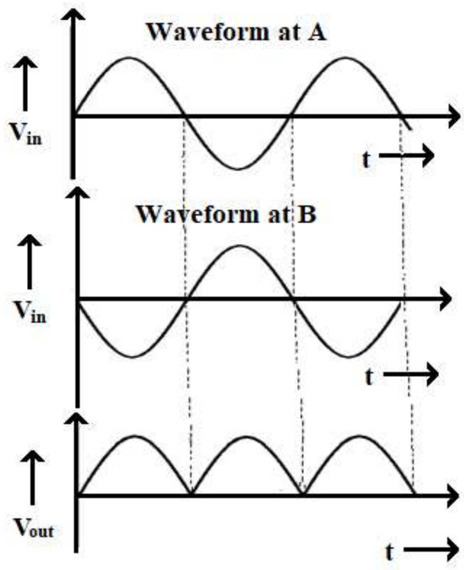
b) With the help of a circuit diagram, input and output waveforms, explain the working of a full wave rectifier. **(4)**

Ans:

A rectifier in which current flows over a complete cycle of the input A.C is called a full wave rectifier.



The circuit diagram is as shown in the figure. The diodes D_1 and D_2 with a load resistor R_L are connected across the secondary of the transformer. The R_L is connected to the center tap of the secondary transformer. The A.C voltage to be rectified is applied to the primary of the transformer.



During the positive half cycle of the input voltage i.e.., when potential at A is positive and at B is negative, the diode D_1 is forward biased and D_2 is reverse biased. So D_1 conducts & D_2 does not conduct. During the negative half cycles of the input voltage i.e.., when potential at A is negative and at B is positive the diode D_2 is forward biased and D_1 is reverse biased. So D_2 conducts and D_1 does not conduct. Thus, in each cycle the current flows through the load resistor R_L in the same direction. Hence output obtained is unidirectional (D.C.) and pulsatory.

VI. Answer any TWO of the following questions: **2 × 5 = 10**

42. A uniformly charged spherical shell of radius 10 cm has a surface charge density of 16 μ cm^{-2}. Find the electric field due to the shell at a distance of

a) 20 cm from the centre of the shell.

Ans:

a) Charge of shell, $Q = \sigma\left(4\pi R^2\right)$

$$E = \frac{1}{4\pi\varepsilon_0}\cdot\frac{Q}{r^2} = \frac{1}{4\pi\varepsilon_0}\cdot\frac{\sigma\left(4\pi R^2\right)}{r^2}$$

$$= \frac{9\times10^9\times16\times10^{-6}\left(4\right)\left(3.14\right)\left(10\right)^2}{\left(20\right)^2} = 4.5\times10^5\,N/C$$

b) 5 cm from the centre of the shell.

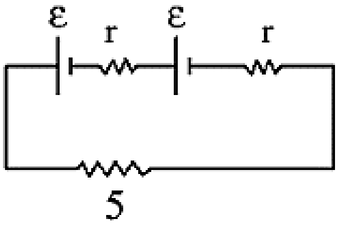
Field at an inside point of uniformly charged shall = 0

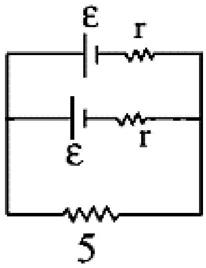
43. Two identical cells each of emf 15 V either connected in series or connected in parallel across an external resistance of 5Ω produce the same current through the resistor.

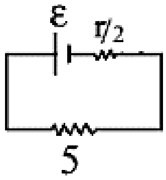
a) Calculate the value of internal resistance of the cell.

b) Find the current through the external resistor in either case.

Ans:







In series $\varepsilon_{eq} = \varepsilon_1 + \varepsilon_2$

$R_{eq} = r_1 + r_2$

$\varepsilon_{eq} = 30\,\text{V}$

Required = 2r

$$i_s = \frac{\varepsilon_{eq}}{R + r_{eq}} = \frac{30}{5+2r} \quad ...(1)$$

In parallel $\varepsilon_{eq} = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2} = \frac{15(r)+15(r)}{r+r}$ =15

Req. = $\frac{r_1 r_2}{r_1 + r_2} = \frac{r(r)}{r+r} = \frac{r}{2}$

$i_P = \frac{\varepsilon_{eq}}{R + r_{eq}} = \frac{15}{5+\frac{r}{2}}$ ..... (2)

$i_s = i_p$

From (1) & (2)

$\Rightarrow \frac{30}{5+2r} = \frac{15}{5+\frac{r}{2}}$

$\Rightarrow r = 5ohm$

$i_s = \frac{30}{5+2(5)} = 2Amp$

$\therefore i_s = i_p = 2Amp$

44. A series LCR circuit with L = 0.5H and R =100 Ω is connected to a 200 V, 50 Hz a.c. supply.
a) Calculate the value of capacitance of the capacitor that drives the circuit into resonance.
b) Find the value of voltage across the inductor at resonance.
Ans:

Given L = 0.5 H, R = 100Ω, V = 200 volts, f = 50 Hz

$w = 2\pi f = 100\pi$ rad/s

a) For resonance

$$\omega = \frac{1}{\sqrt{LC}}$$

$$100\pi = \frac{1}{\sqrt{(0.5)c}}$$

$$\sqrt{(0.5)c} = \frac{1}{100\pi}$$

$$c = \frac{1}{(0.5)(100\pi)^2}$$

$$= 2.02\times10^{-5}F = 20.2\mu F$$

b) Current at resonance

$i = \frac{V}{R} = \frac{200}{100} = 2A$

Voltage across inductor,

$V_L = iX_L$

$= i\omega L$

$= 2(100\pi)(0.5)$

$= 100\pi$ volts

=314 volts

$= iwL = 2(100\pi)(0.5) = 100\pi$ volts=314 volts

45. An object of height 1 mm is kept perpendicular to the axis of a thin convex lens of power +10 D. The distance between the object and the lens is 15 cm. Find the position and height of the image formed.

Ans:

Given P = +10D, h_0 = 1mm , u = -15 cm

$f = \frac{1}{p}$ = 0.1 m

= 10 cm

$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\Rightarrow \frac{1}{v} - \frac{1}{-15} = \frac{1}{+10}$

$\Rightarrow v = 30cm$

$\frac{h_i}{h_0} = \frac{v}{u}$

$\Rightarrow \frac{h_i}{1} = \frac{30}{-15}$

$\Rightarrow h_i = -2$

$\therefore$ Height of image = 2mm

Position of image = 30 cm

PART -E

VII. (For Visually Challenged Students only)

7. When a.c. is passed through an a.c. circuit, it is observed that the voltage and the current are in phase. Along with the a.c. source, the circuit:

a) has a series combination of resistance and capacitance.

b) has only inductance.

c) has only capacitance.

d) may have only resistance or may have a suitable series combination of inductance (L), capacitance (C) and resistance (R).

Ans: d) may have only resistance or may have a suitable series combination of inductance (L), capacitance (C) and resistance (R).