

Strictly As Per
Boards
New Syllabus

STATE BOARD

My Favorite Guide on

PHYSICS

भौतिकशास्त्र

आता...
मिळवा
70 पेकी
70

फक्त
ज्ञानदा
मधून

STD - 12th (Science)



महाराष्ट्रात प्रथमच...

11th आणि 12th (Science) ची पुस्तके
English व Scientific मराठी मधून...



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With Solutions of
Board Question Papers

Feb / March - 2022
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TOPIC - 01

ROTATIONAL DYNAMICS

1.1 Introduction

Circular motion is an essential part of our daily life. Every day we come across several revolving or rotating (rigid) objects.

During revolution, the object (every particle in the object) undergoes circular motion about some point outside the object or about some other object, while during rotation the motion is about an axis of rotation passing through the object.

Q.1 What is revolution and rotation of an object?

Ans: Revolution: During revolution, the object (every particle in the object) undergoes circular motion about some point outside the object or about some other object.

Rotation: During rotation, the motion is about an axis of rotation passing through the object.

1.2 Characteristics of Circular Motion

Q.2 What is circular motion?

Ans: Circular motion: Motion of an object around a circular path is called as circular motion.

Q.3 State the characteristics of circular motion.

Ans: Characteristics of circular motion:

i) Accelerated motion: As the direction of velocity changes at every instant, it is an accelerated motion.

ii) Periodic motion: During the motion, the particle repeats its path along the same trajectory. Thus, the motion is periodic.

Q.4 What are kinematical equations of motion?

Ans: Kinematical equations of motion:

No.	Linear motion	Rotational motion
i	$v = u + at$	$\omega = \omega_0 + \alpha t$
ii	$s = ut + \frac{1}{2}at^2$	$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$
iii	$v^2 = u^2 + 2as$	$\omega = \omega_0^2 + 2\alpha\theta$

Where,

v = Final linear velocity,
 u = Initial linear velocity,
 a = Linear acceleration,
 s = Linear displacement,
 ω = Final angular velocity,
 ω_0 = Initial angular velocity,
 α = Angular acceleration,
 θ = Angular displacement,
 t = time,

Q.5 State the analogy of the following linear and rotational quantities:

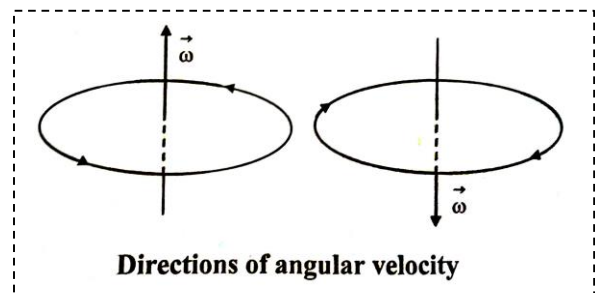
i) Displacement ii) Velocity iii) Acceleration

Ans:

Quantity	Linear	Rotational
Displacement	$\vec{s}$	$\vec{\theta}$
Velocity	$\vec{v} = \frac{d\vec{s}}{dt}$	$\vec{\omega} = \frac{d\vec{\theta}}{dt}$
Acceleration	$\vec{a} = \frac{d\vec{v}}{dt}$	$\vec{\alpha} = \frac{d\vec{\omega}}{dt}$

Q.6 What is right hand thumb rule?

Ans: Right hand thumb rule: To know the direction of $\vec{\omega}$, curl the fingers of the right hand along the sense of rotation, with the thumb outstretched. The outstretched thumb then gives the direction of $\vec{\omega}$.



Q.7 Give the relation of angular velocity with periodic time and frequency?

Ans: Relation between angular velocity(ω), periodic time (T) and frequency (n):

$$\omega = 2\pi n$$

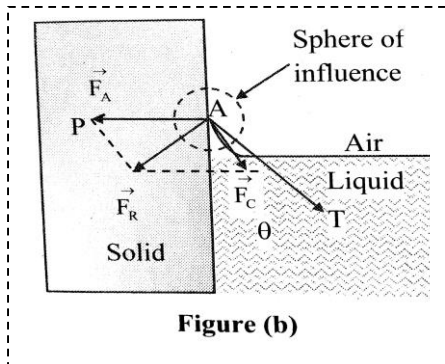
$$= \frac{2\pi}{T}$$

Q.31 Explain difference cases of liquid-solid interactions.**Ans: Different cases of liquid-solid interaction:****Case: 1) Acute angle of contact:**

i) Net adhesive force between liquid and solid on molecule A > net cohesive force between liquid molecules.

i.e., $\vec{F}_A > \vec{F}_C$

ii) Resultant force $\vec{F}_R$ is directed inside solid.



iii) For equilibrium or stability of a liquid surface, the net force $\vec{F}_R$ acting on the molecule A must be normal to the liquid surface at all points. For the resultant force $\vec{F}_R$ to be normal to the tangent, the liquid near the wall should pile up against the solid boundary so that the tangent AT to the liquid surface is perpendicular to $\vec{F}_R$. Thus, this makes the meniscus concave. Such liquid wets that solid surface.

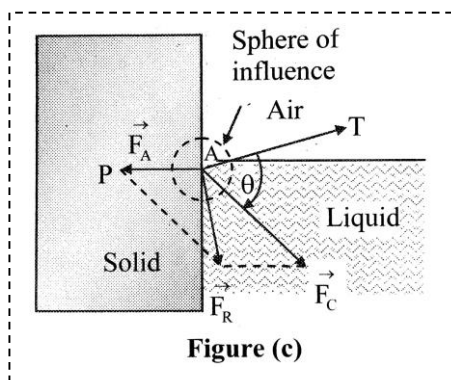
iv) Angle of contact is acute.

v) Example: Kerosene in a glass bottle.

Case: 2) Obtuse angle of contact:

i) Net adhesive force between liquid and solid on molecule A < resultant cohesive force between liquid molecules i.e., $\vec{F}_A < \vec{F}_C$

ii) Resultant force $\vec{F}_R$ is directed inside liquid.

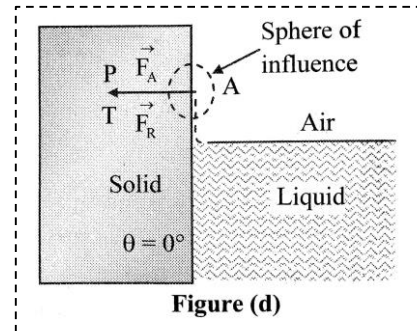


iii) For equilibrium or stability of a liquid surface, the net force $\vec{F}_R$ acting on all molecules similar to molecule A must be normal to the liquid surface at all points. The liquid near the wall should, therefore, creep inside against the solid boundary. This makes the meniscus convex, so that its tangent AT is normal to $\vec{F}_R$.

Such liquid does not wet that solid surface.

iv) Angle of contact is obtuse.

v) **Example:** Mercury in a glass bottle.

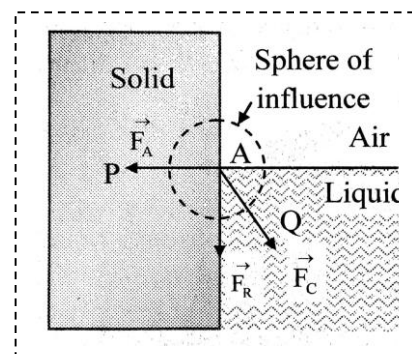
Case 3) Zero angle of contact:

i) Liquid molecules near the contact region are very less number such that $\vec{F}_C$ is negligible $\vec{F}_C = 0$.

ii) Net adhesive force itself is the resultant force i.e., $\vec{F}_R = \vec{F}_A$. Therefore, tangent AT is along the wall within the liquid.

iii) Angle of contact is almost zero ($\theta \rightarrow 0^\circ$)

iv) **Example:** Pure water in clean glass.

Q.32 Derive the conditions for acute and obtuse angle of contact for a solid-liquid interactions.**Ans: Solid-liquid interaction:**

i) Consider a hypothetical liquid having angle of contact 90° with a solid container.

ii) The molecule experiences both adhesive and cohesive force. Since the wall is vertical, the molecule 'A' is acted upon by a net adhesive force exerted horizontally by the molecules of the solid $\vec{AP}$ as $\vec{F}_A$. Net

Scientific मराठी स्पष्टीकरण:

प्रस्तावना: ज्याला mass (वस्तुमान) आहे व जे (space) अवकाश व्यापते त्याला matter (वस्तु) असे म्हणतात. वस्तु घन, द्रव आणि वायु अशा तीन अवस्थेत असू शकते. घन पदार्थातील कण एकमेकांच्या अतिशय जवळ आणि व्यवस्थित रचलेले असतात आणि त्यांना हालचाल करण्याचे फारसे स्वातंत्र्य नसते. द्रव पदार्थातील कण एकमेकांच्या जवळ असतात, पण त्यांना इकडेतिकडे हलणे शक्य असते. वायुमध्ये जे कण असतात, त्यांची हालचाल सहज व द्रुत गतीने होऊ शकते. कणांच्या अशा रचनेमुळे वेगवेगळ्या अवस्थेत वस्तुचे वेगवेगळे गुणधर्म दिसून येतात.

जशी आपण घन पदार्थाची लांबी, रुंदी मोजतो, तसा वायुचा दाब, तापमान वगैरे मोजले जाते. वायु व त्यांच्या विविध गुणधर्मावर बॉईल, न्युटन, बोल्ट्झमन अशा अनेक शास्त्रज्ञांनी संशोधन केले आहे. त्याचाच अभ्यास आपण करणार आहोत.

Ideal gas किंवा perfect gas (आदर्श वायु)- जो gas सर्व temperature आणि pressure ला gas च्या संबंधीत सर्व laws (नियमांचे) पालन करतो, त्या gas ला ideal gas असे म्हणतात.

प्रत्यक्षात ideal gas नसतोच, मात्र real gases हे gas च्या संबंधीत laws चे पालन low pressure आणि high temperature ला करतात. त्यानंतर temperature, pressure आणि volume यांच्यामधील relation प्रश्नामध्ये दिले आहे, त्याचे अवलोकन करा.

Boyles law (बॉईलचा नियम)- एका स्थिर तापमानावर दिलेल्या mass च्या gas ने exerts (कार्यान्वीत) केलेला pressure हा त्याने व्यापलेल्या volume (आकारमानाच्या) inversely (व्यस्त) प्रमाणात असतो. म्हणजेच

$$P \propto \frac{1}{V}$$

∴ PV = Constant

Charles law (चार्ल्सचा नियम)- Gas चा pressure स्थिर असताना gas चे volume हे त्याच्या absolute temperature (निरपेक्ष तापमानाच्या) समानुपाती असते. म्हणजेच $V \propto T$

i) Free path (मुक्त पथ)- एखाद्या molecule ने दोन successive (लागोपाट येणा-या) collisions (संघातामध्ये) पूर्ण केलेल्या distance (अंतराला) free path असे म्हणतात.

ii) Mean free path (माध्य मुक्त पथ)- एखाद्या gas molecule ने दोन successive (लागोपाट येणा-या) collisions (संघातामध्ये) पूर्ण केलेल्या average distance (सरासरी अंतराला) mean free path असे म्हणतात.

Law of equipartition energy (ऊर्जा समविभाजन)- माध्यमातील Total energy हि एकसमानपणे सगळीकडे सर्व possible modes मध्ये वितरीत होते आणि प्रत्येक mode ची energy, $\frac{1}{2}kT$ इतकी असते. Monoatomic (एक अण्विक), diatomic (द्विअण्विक) आणि polyatomic (बहुअण्विक) gas molecules चे $\gamma = \frac{C_p}{C_v}$ च्या किंमती प्रश्नामध्ये दिल्या आहेत, त्याचे अवलोकन करा.

Degree of freedom (कणांची मुक्तता कोटी)- एखाद्या system ची state (आवस्था) specify (उल्लेखित करण्यासाठी) लागणा-या independent variable किंवा coordinates (स्वतंत्र किंवा अवलंबून नसणा-या) (चल किंवा सहनिर्देशकाची) कमीतकमी संख्या म्हणजेच Degree of freedom होय.

प्रश्नामध्ये degree of freedom आणि त्यावरून law of equipartition energy (ऊर्जा समविभाजनाचा नियम) चे स्पष्टीकरण दिले आहे, त्याचे अवलोकन करा.

i) Coefficient of absorption (a) (अवशोषण गुणांक)- दिलेल्या वेळेमध्ये एखाद्या वस्तुने absorb (शोषित) केलेली heat आणि त्या body वर incident (आपाती) होणारी एकुण radiant heat (प्रारित उष्णता) यांचे गुणोत्तर म्हणजेच Coefficient of absorption होय.

त्याचा formula प्रश्नामध्ये दिला आहे. Coefficient of absorption लाच absorptance किंवा absorptivity असे म्हणतात. त्याला units आणि dimensions नसतात.

ii) Coefficient of reflection (r) (परावर्तन गुणांक)- दिलेल्या वेळेमध्ये एखाद्या वस्तुने reflect (परावर्तीत) केलेली heat आणि त्या body वर incident (आपाती) होणारी एकुण radiant heat (प्रारित उष्णता) यांचे गुणोत्तर म्हणजेच Coefficient of reflection होय.

त्याचा formula प्रश्नामध्ये दिला आहे. Coefficient of reflection लाच reflectance किंवा reflectivity असे म्हणतात. त्याला units आणि dimensions नसतात.

iii) Coefficient of transmission (t) (पारेषण गुणांक)- दिलेल्या वेळेमध्ये एखाद्या वस्तुने transmitt (पारेषीत) केलेली heat आणि त्या body वर incident (आपाती) होणारी एकुण radiant heat (प्रारित उष्णता) यांचे गुणोत्तर म्हणजेच Coefficient of transmission होय.

त्याचा प्रश्नामध्ये दिला आहे. Coefficient of transmission लाच transmittance किंवा transmittivity असे म्हणतात. त्याला units आणि dimensions नसतात.

Coefficient of absorption (a), Coefficient of reflection (r) आणि Coefficient of transmission (t) यांच्यातील relation प्रश्नामध्ये दिले आहे, simple-simple formulae आहेत, ते निट समजून घ्या.

i) Diathermanous body / substances (अंतस्तापनशील पदार्थ)- ज्या पदार्थामधून heat radiation जाऊ शकतात त्या पदार्थांना Diathermanous body असे म्हणतात. Diathermanous body साठी Coefficient of transmission (t) $\neq 0$ असतो. उदा. glass, किंवा hydrogen, oxygen सारखे वायु.

ii) Athermanous (adiathermanous) body/ substances (अतापनशील पदार्थ)- ज्या पदार्थामधून heat radiation जाऊ शकत नाहीत, त्या पदार्थांना athermanous body असे म्हणतात.

Athermanous body साठी Coefficient of transmission (t) $= 0$ असतो.

उदा. लाकूड, पाणी, copper, iron सारखे धातू

Solved and Unsolved Examples

i) An ideal mono-atomic gas is adiabatically compressed so that its final temperature is twice its initial temperature. Calculate the ratio of final pressure to its initial pressure. (Feb/Mar-2023)-2m

Ans: Given:

As gas is monoatomic, $\gamma = \frac{5}{3}$

$$T_2 = 2T_1 \quad \therefore \frac{T_2}{T_1} = 2$$

$$\text{Ratio of final pressure to its initial pressure} = \frac{P_2}{P_1} = ?$$

We have formula,

$$P_1^{1-\gamma} T_1^\gamma = P_2^{1-\gamma} T_2^\gamma$$

$$\therefore \left(\frac{P_1}{P_2}\right)^{1-\gamma} = \left(\frac{T_2}{T_1}\right)^\gamma$$

$$\therefore \left(\frac{P_1}{P_2}\right)^{\frac{-2}{3}} = \left(\frac{T_2}{T_1}\right)^{\frac{5}{3}}$$

$$\therefore \left(\frac{P_2}{P_1}\right)^{\frac{2}{3}} = \left(\frac{T_2}{T_1}\right)^{\frac{5}{3}}$$

On taking cube of both sides, we get,

$$\therefore \left(\frac{P_2}{P_1}\right)^2 = \left(\frac{T_2}{T_1}\right)^5$$

$$\therefore \left(\frac{P_2}{P_1}\right)^2 = (2)^5 = 32$$

Taking square root of both sides, we get

$$\frac{P_2}{P_1} = \sqrt{32} = 4\sqrt{2} = 4 \times 1.41 = 5.6$$

Ex.01 A gas enclosed in a cylinder is expanded to double its initial volume ($V_i = 0.5$ units) at a constant pressure of one atmosphere. How much work is done in this process? Is this work done on the gas or by the gas? How do you know this?

Solution: Given: Pressure (p) = 1atm = 1.01×10^5 Pa,

Change in volume (ΔV) = ($V_f - V_i$)

$$= (2V_i - V_i)$$

$$= 0.5\text{units}$$

Find: Work done (W)

We have, **Formula:** $W = P \Delta V = P(V_f - V_i)$

Calculation: From formula,

$$W = 1.01 \times 10^5 \times 0.5$$

$$= 0.505 \times 10^5$$

$$= 5.05 \times 10^4 \text{ J}$$

Positive sign of the work done implies that the work is done by the gas.

Ans: Work done in the process is $5.05 \times 10^4 \text{ J}$. The positive work done implies that the work is done by the gas.

Ex.02 104 kJ of work is done on certain volume of a gas. If the gas releases 125 kJ of heat, calculate the change in internal energy (in kJ) of the gas.

OR

Ex.02) 104 J of work is done on certain volume of a gas. If the gas pop releases 125 kJ of heat, calculate the change in internal energy of the gas.

(Feb/Mar-2023)-2m

Solution: Given: $W = -104 \text{ kJ}$, $Q = -125 \text{ kJ}$

Find: Change in internal energy (ΔU)

We have, **Formula:** $\Delta U = |Q| - |W|$

Calculation: From formula,

$$\Delta U = |Q| - |W|$$

$$\therefore \Delta U = (125 - 104) = 21 \text{ kJ}$$

Ans: Change in internal energy is **21 kJ**.

Ex.03 A gas contained in a cylinder fitted with a frictionless piston expands against a constant external pressure of 1 atm from a volume of 5 litres to a volume of 10 litres. In doing so it absorbs 400 J of thermal energy from its surroundings. Determine the change in internal energy of system.

Solution: Given: $p = 1 \text{ atm} = 1.013 \times 10^5 \text{ Pa}$, $Q = 400 \text{ J}$,

$$V_i = 5 \text{ L} = 5 \times 10^{-3} \text{ m}^3,$$

$$V_f = 10 \text{ L} = 10 \times 10^{-3} \text{ m}^3$$

Find: Change in internal energy of system.

We have, **Formulae:** i) $W = p\Delta V = p(V_f - V_i)$

$$\text{ii) } \Delta U = |Q| - |W|$$

Calculation: From formula (i),

$$W = 1.013 \times 10^5 (10 \times 10^{-3} - 5 \times 10^{-3})$$

$$= 1.013 \times 10^5 \times 5 \times 10^{-3}$$

$$= 5.065 \times 10^2$$

$$= 506.5 \text{ J}$$

Ex.07 Find the distance between two successive nodes in a stationary wave on a string vibrating with frequency 64 Hz. The velocity of progressive wave that resulted in the stationary wave is 48 m s^{-1} .

Solution: Given: $v = 48 \text{ ms}^{-1}$, $n = 64 \text{ Hz}$

Find: Distance between two successive nodes $\left(\frac{\lambda}{2}\right)$

We have, **Formula:** $v = n\lambda$

Calculation: From formula,

$$\lambda = \frac{v}{n} = \frac{48}{64} = 0.75 \text{ m}$$

Distance between two successive nodes

$$= \frac{\lambda}{2} = \frac{0.75}{2} = \mathbf{0.375 \text{ m}}$$

Ans: Distance between two successive nodes is **0.375 m**.

Ex.08 A sound wave in a certain fluid medium is reflected at an obstacle to form a standing wave. The distance between two successive nodes is 3.75 cm. If the velocity of sound is 1500 m/s, find the frequency.

Solution: Given: Distance between two successive nodes $\left(\frac{\lambda}{2}\right) = 3.75 \text{ cm} = 3.75 \times 10^{-2} \text{ m}$

Find: Frequency of sound wave (n)

We have, **Formula:** $n = \frac{v}{\lambda}$

Calculation: As $\frac{\lambda}{2} = 3.75 \times 10^{-2} \text{ m}$

$$\therefore \lambda = 7.5 \times 10^{-2} \text{ m}$$

From formula,

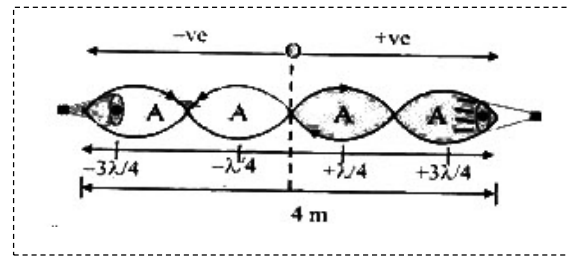
$$n = \frac{1500}{7.5 \times 10^{-2}} = 200 \times 10^2$$

$$= 20 \times 10^3 = \mathbf{20 \text{ kHz}}$$

Ans: The frequency of the sound wave is **20 kHz**.

Ex.09 Two sources of sound are separated by a distance 4 m. They both emit sound with the same amplitude and frequency (330 Hz), but they are 180° out of phase. At what points between the two sources, will the sound intensity be maximum?

Solution: For intensity to be maximum, it should be the point of antinodes. At the extremes, nodes are formed. Distance between successive nodes and antinodes is $\frac{\lambda}{4}$.



Now $\lambda = \frac{v}{n}$

$$= \frac{330}{330} \quad \text{..... } (\because \text{speed of sound} = 330 \text{ m/s})$$

$$= 1 \text{ m}$$

Hence, there will be 4 loops in between two sources. Taking centre as reference, (as shown in the figure)

Antinode is at $\pm \frac{\lambda}{4}, \pm \frac{3\lambda}{4}, \pm \frac{5\lambda}{4}$ and $\pm \frac{7\lambda}{4}$

Thus, $\pm 0.25 \text{ m}, \pm 0.75 \text{ m}, \pm 1.25 \text{ m}$ and $\pm 1.75 \text{ m}$ from the centre are the point of maximum sound intensity.

Ex.10 A transverse wave is produced on a stretched string 0.9 m long and fixed at its ends. Find the speed of the transverse wave, when the string vibrates while emitting second overtone of frequency 324 Hz.

Solution: Given: $l = 0.9 \text{ m}$, $n = 324 \text{ Hz}$

Find: Speed (v)

We have, **Formula:** $v = n\lambda$

Calculation: In 2nd overtone, 3 loops are formed.

$$\therefore l = \frac{3}{2} \lambda$$

$$\therefore \lambda = \frac{2l}{3}$$

From formula,

$$v = n \left(\frac{2l}{3} \right) = 324 \left(\frac{2}{3} \times 0.9 \right)$$

$$\therefore v = \mathbf{194.4 \text{ m/s}}$$

Ans: The speed of the transverse wave is **194.4 m/s**.

Scientific मराठी स्पष्टीकरणः

Introduction - दैनंदिन जीवनात आपण विविध पद्धतींच्या गतिंचा अनुभव घेत असतो. या आधी आपण particles ची सरळरेखी गति व प्रक्षेपणास्त्राची प्रक्षेप्य गति अभ्यासली. या दोन्ही गति प्रारंभ झाल्यापासुन वारंवार घडणाऱ्या नाहीत. याच समवेत आपण वर्तुळाकार व ग्रहांच्या भ्रमणकक्षीय गतिंचा अभ्यास देखील केला. या दोन गतिवरून हे दिसून आले की, विशिष्ट कालावधी नंतर गतिंची पुनरावृत्ती होते. अशा गतिंना आवर्ती गती असे म्हणतात. याचबरोबर घड्याळाचा दोलक, पक्ष्यांच्या पंखाची हालचाल, झाडांच्या फांद्यांची दोलने व स्वयंचलित वाहनांमधील पिस्टन यांची मागेपुढे होणारी किंवा खालीवरती होणारी हालचाल oscillatory motion (दोलनकारी गति) म्हणुन ओळखली जाते.

Periodic motion (आवर्ती गती)- जी motion, equal intervals (सारख्याच अंतरालाने) आणि same path (एकाच मार्गावर) होत असल्यास त्या motion ला Periodic motion असे म्हणतात.

Oscillatory motion (दोलनकारी गती)- किंवा Vibratory motion (स्पंदनात्मक गती/हालचाल)- एखाद्या body ची एखाद्या fixed point भोवतीची to and fro (मागे आणि पुढे) अशी एका definite time interval मध्ये होणारी motion म्हणजेच Oscillatory motion होय. ह्या motion मध्ये body हि mean position (मध्य स्थितीपासुन) दोन्ही बाजूला एका ठराविक limits मध्येच फिरत असते.

Linear simple harmonic motion (रेषीय सरल आवर्ती गती)- एखाद्या particle ची linear SHM म्हणजेच ज्यामध्ये त्या particle वर act होणाऱ्या restoring force चे magnitude हे त्या particle चे mean position पासुन मोजलेल्या displacement (x) शी समानुपाती असते. तसेच तो force नेहमी mean position च्या दिशेत कार्यान्वीत असतो, म्हणजेच linear displacement (x) च्या opposite मध्ये असतो. म्हणजेच $F \propto -x$, $F = -Kx$ यामध्ये k हा restoring force constant असतो, त्यालाच spring constant असेही म्हणतात. K ची units आणि dimensions प्रश्नामध्ये दिलेली आहेत. त्याचे अवलोकन करा.

उदाहरणे-

- Simple pendulum ची motion
- pendulum clock मधील pendulum ची motion
- Tuning force च्या prongs (शुल)
- Spring ला बांधुन लटकवलेली body
- Sewing machine (शिलाई मशिनच्या) needle (सुई) ची गती.

Spring आणि body oscillator (वजन दोलक)-

- वरील प्रश्नामध्ये दाखविलेल्या figure नुसार एक m इतके mass असलेली body एका elastic spring ला attach केलेली आहे, ज्याचा spring constant k आहे. तसेच हि body ला frictionless smooth horizontal surface वर ठेवलेली आहे.
- ह्या स्थितीमध्ये spring हि equilibrium (समतोल) असुन spring त्या body वर कोणत्याच प्रकारचा force, exerts (प्रयुक्त) करीत नाही.
- पुढील position मध्ये body ला x इतक्या distance ने mean position पासुन उजव्या दिशेला ओढल्यानंतरची स्थिती (position-B) पहा. त्यानंतर spring मधील elastic properties मुळे body वरती internal restoring force (अंतर्गत पुनःस्थापी बल) प्रयुक्त होते. ह्या condition मध्ये restoring force ची direction हि mean position कडे असते, आणि जेव्हा ताणुन धरलेली body सोडुन देतो तेव्हा ति mean position कडे जाते.
- त्यानंतर inertia (जडत्वामुळे) body हि mean position पासुन डावीकडे जाते व spring compressed (आकुंचित/संपादित) होते. (position-A) पहा. spring compressed हि body वर restoring force अशाप्रकारे प्रयुक्त करते कि, body mean position पर्यंत गेली पाहिजे.
- ह्या case मध्ये body to and fro (पुढे आणि मागे) अशी straight line path (सरल रेषीय मार्गावर) फिरते, त्यामुळे ह्या motion ला oscillatory motion असे म्हणतात.
- ह्या oscillatory motion मध्ये restoring force (F) हे displacement (x) शी proportional (समानुपाती) आहे, मात्र त्याची direction हि displacement च्या opposite (विरुद्ध) आहे. त्यामुळे त्या motion ला linear simple harmonic motion (SHM) असेही म्हणतात.
- जर x हे displacement जे कि, mean position (o) पासुन मोजलेले आहे, आणि F हे restoring force असेल तर $F \propto -x$ म्हणजेच $F = -Kx$ ह्या formula नुसार restoring force शोधतात.

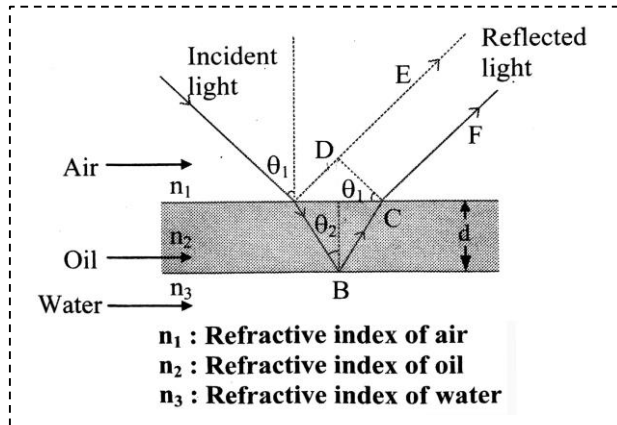
i) Displacement (विस्थापन)- एखाद्या particle ने S.H.M perform करीत असताना त्याच्या mean position पासुन त्याच्या कोणत्याही instant (क्षणापर्यंतचे) cover केलेले distance म्हणजेच displacement होय. Displacement ची units आणि dimensions वरील प्रश्नामध्ये दिली आहेत.

ii) Amplitude (परमप्रसर/आयाम)- एखाद्या particle ने SHM ने असताना त्याच्या mean position पासुन cover केलेले distance ला amplitude असे म्हणतात.

iii) Range (पल्ला किंवा टप्पा)- particle ने SHM मध्ये असताना cover केलेल्या दोन extreme (अखेरच्या) positions (स्थानांमधील) distance म्हणजेच range होय. हे distance, amplitude च्या दुप्पट

Q.51 Why are multiple colours observed over a thin film of oil floating on water? Explain with the help of a diagram.

Ans: Multiple colours observed over a thin film of oil floating on water:



- i) The multiple colours observed over a thin oil films on the surface of water are due to the interference of light waves reflected from the upper and lower surfaces of the film.
- ii) Path difference between two rays depends on the point on the film that is being viewed as shown in figure.
- iii) The incident wave gets partially reflected from upper surface as shown by ray AE. The rest of the light gets refracted and travels along AB.
- iv) At B it again gets partially reflected and travels along BC.
- v) At C it refracts into air and travels along CF.
- vi) The parallel rays AE and CF have a phase difference due to their different path lengths in different media.
- vii) The phase difference depends on the angle of incidence θ_1 , i.e., the angle of incidence at the top surface, which is the angle of viewing, and also on the wavelength of the light as the refractive index of the material of the thin film depends on it.
- viii) The two rays AE and CF interfere, producing maxima and minima for different colours at different angles of viewing. Hence, one sees different colours when the film is viewed at different angles.

7.9 Diffraction of Light

Q.52 What is diffraction of light? Give examples.

Ans: Diffraction of light: *The bending of light near the edge of an obstacle or slit and spreading into the region of geometrical shadow is called diffraction of light.*

Examples:

- i) At noon, circular patches of Sunlight are seen on the ground, when observed from underneath trees.
- ii) When sun is viewed through fine piece of cloth, coloured spectra is observed due to diffraction of light.
- iii) The luminous border surrounding the boundary of mountain just before the sunrise or sunset is due to diffraction of light.

Q.53 Distinguish between interference and diffraction.

Ans: Interference and Diffraction:

No.	Interference	Diffraction
i	Interference due to the superposition of waves from different wavefronts.	Diffraction is due to many waves coming from different parts of the same wavefront.
ii	All bright fringes are of equal intensity.	Intensity decreases with the order of bright band.
iii	Minimum intensity may be zero.	Minimum intensity is not zero.
iv	Width of the central maximum is same as that of other bright fringes i.e fringe width is same for all fringes including central maxima.	Width of central maximum is broader than other maxima and it is double the fringe width.
v	The waves emitted by two coherent sources travel in straight line.	The light waves are bent at the corners and displaced from their straight line path.
vi	The resolving power of an optical instrument does not depend on the phenomena of interference.	The resolving power of an optical instrument depends on the phenomena of diffraction.

Q.54 What are Fraunhofer and Fresnel diffractions?

Ans: i) Fraunhofer diffraction: If the distances between the primary source of light, the obstacle/slit causing diffraction and the screen for viewing the diffraction pattern are very large, the diffraction is called Fraunhofer diffraction.

In this case, the wavefront incident on the obstacle can be considered to be a plane wavefront.

ii) Fresnel diffraction: In this case, the distances are much smaller and the incident wavefront is either cylindrical or spherical depending on the source.

Multiple Choice Questions

i) The property of light which does not change, when it travels from one medium to another is -----

(Feb/March-2022)

- a) velocity b) wavelength c) frequency d) amplitude

Ans: c) frequency

ii) In Young's double slit experiment the two coherent sources have different amplitudes. If the ratio of maximum intensity to minimum intensity is 16:1, then the ratio of amplitudes of the two sources will be -----

(Feb/March-2022)

- a) 4:1 b) 5:3 c) 1:4 d) 1:16

Ans: b) 5:3

iii) The property of light which remains unchanged when it travels from one medium to another is -----

(Feb/March-2023)

- a) velocity b) wavelength c) amplitude d) frequency

Ans: d) frequency

iv) In biprism experiment, the distance of 20th bright band from the central bright band is 1.2 cm. Without changing the experimental set-up, the distance of 30th bright band from the central bright band will be _____. **(Feb/March-2024)**

- a) 0.6 cm b) 0.8 cm c) 1.2 cm d) 1.8 cm

Ans: d) 1.8 cm

1. Which of the following phenomenon proves that light is a transverse wave?

- a) Reflection b) Interference
c) Diffraction d) Polarization

2. Which property of light does not change when it travels from one medium to another?

- a) Velocity b) Wavelength c) Amplitude d) Frequency

3. When unpolarized light is passed through a polarizer, its intensity

- a) increases

b) decreases

c) remains unchanged

d) depends on the orientation of the polarizer

4. In Young's double slit experiment, the two coherent sources have different intensities. If the ratio of maximum intensity to the minimum intensity in the interference pattern produced is 25:1. What was the ratio of intensities of the two sources?

- a) 5:1 b) 25:1 c) 3:2 d) 9:4

5. In Young's double slit experiment, a thin uniform sheet of glass is kept in front of the two slits, parallel to the screen having the slits. The resulting interference pattern will satisfy:

- a) The interference pattern will remain unchanged
b) The fringe width will decrease
c) The fringe width will increase
d) The fringes will shift.

6. According to wave theory of light, velocity of light in rarer medium is

- a) equal to velocity of light in denser medium.
b) greater than velocity of light in denser medium.
c) less than velocity of light in denser medium.
d) approximately equal to velocity of light in denser medium.

7. The wavefront originating from the point source of light at finite distance is _____ wavefront.

- a) spherical b) plane c) cylindrical d) circular

8. Cylindrical wavefront can be obtained from

- a) point source of light.
b) light source like slit.
c) light source like circle
d) point source of light at infinity.

9. Plane wavefront can be obtained from

- a) any point source of light
b) point source placed at focus of convex lens.
c) linear source of light.
d) co-axial source.

10. A spherical wavefront propagating in a medium will change into _____.

- a) circular wavefront b) cylindrical wavefront
c) plane wavefront d) elliptical wavefront

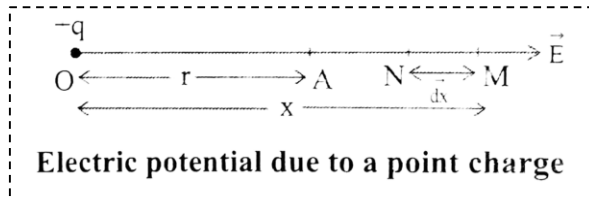
11. When a ray of light enters into water from air, _____.

- a) its wavelength decreases b) its wavelength increases

8.4 Electric Potential due to a Point Charge, a Dipole and a System of Charges

Q.19 Derive an expression for electric potential due to a point charge.

Ans: Expression for electric potential due to a point charge:



i) Consider a point charge $+q$ located at point O. Let a positive unit charge be brought from ∞ to point A as shown in figure.

ii) Point 'M' is an intermediate point on this path such that $OM = x$.

iii) Magnitude of electrostatic force on a unit positive charge at M is

$$E = \frac{1}{4\pi\epsilon_0} \times \frac{q}{x^2} \quad \dots\dots\dots (1)$$

It is directed away from O, along OM.

iv) For infinitesimal displacement dx from M to N, the amount of work done is given by

$$\therefore dW = -Fdx \quad \dots\dots\dots (2)$$

The negative sign appears as the displacement is directed opposite to that of the force.

v) Total work done in displacing the unit positive charge from ∞ to point A is given by,

$$\begin{aligned} W &= \int_{\infty}^r -Fdx = \int_{\infty}^r \frac{1}{4\pi\epsilon_0} \frac{q}{x^2} dx \\ &= \frac{-q}{4\pi\epsilon_0} \left(\frac{-1}{x} \right)_{\infty}^r \quad \dots\left(\because \int x^{-2} dx = \frac{-1}{x} \right) \\ &= \frac{q}{4\pi\epsilon_0} \left(\frac{1}{r} - \frac{1}{\infty} \right) \quad \dots\dots\dots \left(\frac{1}{\infty} = 0 \right) \end{aligned}$$

$$W = \frac{q}{4\pi\epsilon_0 r} \quad \dots\dots\dots (3)$$

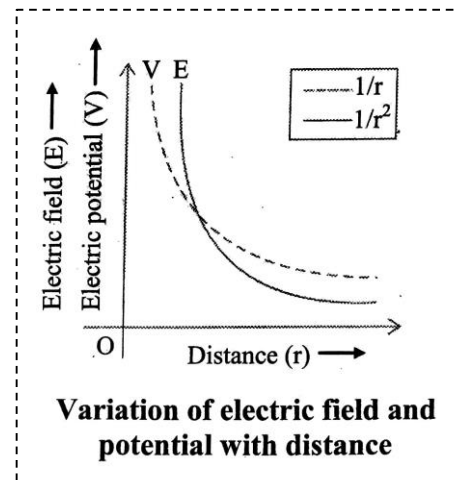
v) Electrostatic potential at A due to charge q is $V =$

$$W = \frac{q}{4\pi\epsilon_0 r} \quad \dots\dots\dots (4)$$

This is the required expression.

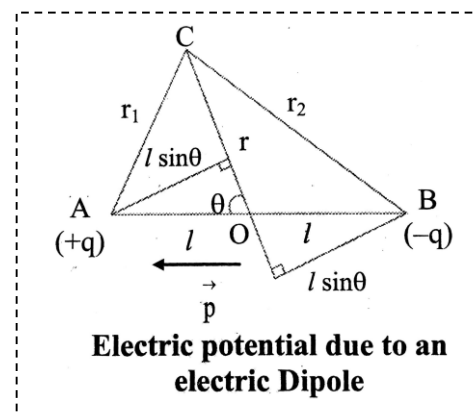
Q.20 Show graphical variation of electric field (or electric force) and electric potential due to a single charge at a distance r .

Ans:



Q.21 Derive an expression for electric potential due to an electric dipole. Discuss the same at axial and equatorial point.

Ans: Expression for electric potential due to an electric dipole:



i) Consider an electric dipole. Let origin be at the centre of the dipole as shown in figure.

ii) Let C be any point near the electric dipole at a distance r from the centre O inclined at an angle θ with axis of the dipole.

Let r_1 and r_2 be the distances of point C from charges $+q$ and $-q$, respectively.

iii) Potential at C due to charge $+q$ at A is,

$$V_1 = \frac{+q}{4\pi\epsilon_0 r_1}$$

Potential at C due to charge $-q$ at B is,

$$V_2 = \frac{-q}{4\pi\epsilon_0 r_2}$$

iv) The potential at C due to the dipole is,

$$V_C = V_1 + V_2 = \frac{q}{4\pi\epsilon_0} \left[\frac{1}{r_1} - \frac{1}{r_2} \right] \quad \dots\dots\dots (1)$$

Reflection of transverse wave (अवतरंगाचे परावर्तन)- जेव्हा माध्यमात प्रवास करताना incident transverse waves चे reflecting surfaces (परावर्तीत पृष्ठभागावरील) एखाद्या point वरून turning back (पुन्हा परत येतात), त्या घटनेला Reflection of transverse wave (अवतरंगाचे परावर्तन) म्हणतात.

Reflection of transverse wave (अवतरंगाचे परावर्तन)- Transverse waves चे reflection दोन प्रकारे स्पष्ट केले आहे.

Reflection of transverse wave from denser medium (घन माध्यमातून अवतरंगाचे परावर्तन)-

अशी कल्पना करा कि, एका string (दोरीचे) टोक एका rigid wall (दृढ भिंतीला) बांधलेले आहे आणि दुसरे टोक मोकळे आहे. त्या दोरीचे मोकळे टोक वर आणि खाली हालवून त्या string मध्ये एक crest (शिखा) असलेला pulse (स्पंद) निर्माण केला तर निर्माण झालेला crest दोरीच्या fixed end कडे पोहचतो आणि upward direction मध्ये force निर्माण करते. String मधील equal आणि opposite reaction मुळे string मधील particles ची velocity हि reverse (प्रतिक्रमित) केली जाते. Figure मध्ये दाखविल्याप्रमाणे एक trough (द्रोणी) विरुद्ध दिशेने प्रवास करते. अशा प्रकारे denser medium मधून transverse wave चे reflection होताना phase change हा 180° किंवा π radians इतका असतो.

Reflection of transverse wave from rarer medium (विरल माध्यमातून अवतरंगाचे परावर्तन)-

जेव्हा transverse waves हे denser medium मधून प्रवास करीत असतील आणि rarer medium च्या boundary (सीमेवर) incident (आपाती) होत असतील, तर निर्माण होणारा resistance (रोध) हा नगण्य असतो. त्यामुळे reflection मध्ये crest हे crest च्या रुपात आणि trough हे trough रुपात परावर्तीत होतात. यामध्ये जर particles च्या velocity च्या direction मध्ये बदल नसेल तर particles च्या reflection phase मध्ये बदल होत नाही.

Reflection of Longitudinal waves (अनुतरंगाचे परावर्तन)-

Longitudinal waves चे reflection दोन प्रकारे स्पष्ट केले आहे.

Reflection of Longitudinal waves from denser medium (घन माध्यमातून अनुतरंगाचे परावर्तन)- आकृतीमध्ये

दाखविल्याप्रमाणे एक longitudinal wave हि एका rigid wall (दृढ भिंतीकडे) प्रवास करीत आहे. अशी कल्पना करा कि, denser medium च्या wall एक compression (संपीडन) incident आहे, wall हि rigid असल्याने ति equilibrium (समतोल स्थितीमध्ये) राहिल. नंतर compressions मुळे जस-जसा pressure वाढेल, तस-तसे compression हे भिंतीकडून opposite direction ने परत पाठविले जाईल. अशा रीतीने compression हे compression च्या रुपात आणि rarefaction हे rarefaction च्या रुपात परावर्तीत केले

जाईल. जर particle ची velocity, reversed (परावर्तीत) असेल तर, त्याचा phase change हा 180° किंवा π radians इतका असतो.

Reflection of Longitudinal waves from rarer medium

(विरल माध्यमातून अनुतरंगाचे परावर्तन)- जेव्हा longitudinal waves हे denser medium मधून प्रवास करीत असतील आणि rarer medium च्या boundary (सीमेवर) incident (आपाती) होत असतील, तर निर्माण होणारा resistance (रोध) हा नगण्य असतो. अशा रीतीने compression हे rarefaction च्या रुपात आणि rarefaction हे compression च्या रुपात परावर्तीत केले जाईल. यामध्ये जर particles च्या velocity च्या direction मध्ये बदल नसेल तर particles च्या reflection phase मध्ये बदल होत नाही.

Principle of superposition of waves (तरंगांचे अधिरोपण)-

जेव्हा एकाच medium मध्ये प्रवास करणा-या दोन किंवा त्याहून अधिक waves ह्या एकाच वेळी एकाच बिंदुवर पोहचतात, तेव्हा प्रत्येक waves स्वतंत्रपणे स्वःताचे displacement (विस्थापन) निर्माण करते, परिणामी resultant displacement (परिणामी विस्थापन) हे सर्व waves मुळे उत्पन्न होणा-या displacements च्या vector sum (सदिश बेरजेइतके) असते.

Stationary waves- प्रस्तावना-

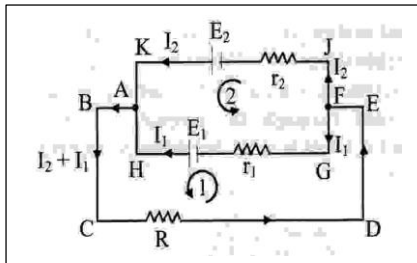
मागील प्रकरणात आपण प्रगामी तरंगाचा अभ्यास केला. निसर्गात आपल्याला भुकंप तरंग, सागरी तरंग, प्रकाश म्हणजे विद्युतचुंबकीय तरंग असे अनेक प्रकारचे प्रगामी तरंग अनुभवास येतात. प्रगामी तरंगात ऊर्जा पुढे जाते, पण स्थिर तरंगात ती बंदिस्त असते. ज्यांचे amplitude आणि frequency एकसारख्या आहेत, अशा दोन अवतरंगाचे स्थिर माध्यमात अधिरोपण केल्याने stationary waves मिळू शकतात. त्यासाठी ह्या waves विरुद्ध दिशेत पण एकाच रेषेत परस्परांवर अधिरोपित व्हावे लागतात.

Stationary waves (स्थिर तरंग)- जेव्हा दोन identical simple

harmonic progressive waves (एकसारखे दोन सरल आवर्त प्रगामी तरंग) कि, ज्यांचे amplitude, period, wavelength आणि speed एकसारखेच असते, तसेच ह्या waves एकाच medium मधून एका सरळ रेषेत मात्र opposite direction (विरुद्ध दिशेने) प्रवास करत त्यांचे interference (व्यतिकरण) होत असेल तर त्या दोन waves पासून निर्माण होणारी resultant wave हि forward (पुढच्या) किंवा backward (मागच्या) दिशेने प्रवास करीत नाही, ति तशीच stationary (स्थिर) राहते, त्या wave ला stationary wave असे म्हणतात.

Incident आणि reflected wave यांच्या velocity (वेगाचे) magnitude एकसारखेच असते, मात्र त्यांची direction हि opposite असते, त्या दोन waves पासून निर्माण होणारी resultant wave हि forward (पुढच्या) किंवा backward (मागच्या) दिशेने प्रवास करीत नाही, ति stationary (स्थिर) आहे, असे भासते, आणि त्यांच्याकडून

Ex.04) A battery of emf 4 volt and internal resistance 1Ω is connected in parallel with another battery of emf 1 V and internal resistance 1Ω (with their like poles connected together). The combination is used to send current through an external resistance of 2Ω . Calculate the current through the external resistance.



Solution: Given: $E_1 = 4\text{ V}$, $r_1 = 1\Omega$, $E_2 = 1\text{ V}$, $r_2 = 1\Omega$, $R = 2\Omega$

Applying Kirchhoff's 2nd law in Loop 1 (ABCDEF GHA),

$$-(I_2 + I_1)R - I_1 r_1 + E_1 = 0$$

$$\therefore I_2 R + I_1 (R + r_1) = E_1$$

$$\therefore 2I_2 + 3I_1 = 4 \quad \dots (i)$$

Applying Kirchhoff's 2nd law in Loop 2 (FGHAKJF),

$$-I_1 r_1 + E_1 - E_2 + I_2 r_2 = 0$$

$$\therefore -I_1 + 4 - 1 + I_2 = 0$$

$$\therefore I_1 - I_2 = 3$$

$$\therefore I_1 = 3 + I_2 \quad \dots (ii)$$

Substituting equation (ii) in equation (i),

$$2I_2 + 3(3 + I_2) = 4$$

$$\therefore 5I_2 = -5$$

$$\therefore I_2 = -1\text{ A}$$

$$\therefore I_1 = 3 - 1 = 2\text{ A}$$

$$\begin{aligned} \text{Current through external resistance 'R'} &= I_1 + I_2 \\ &= 2 - 1 \\ &= 1\text{ A} \end{aligned}$$

Ans: Current through external resistance is **1A**.

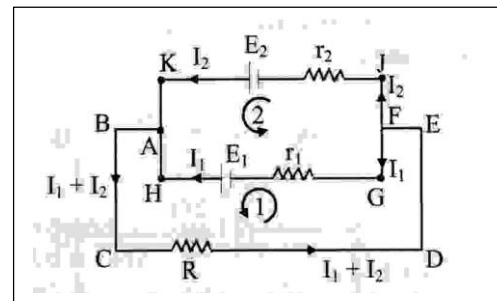
Ex.05) Two cells of emf 1.5 volt and 2 volt having respective internal resistances of 1Ω and 2Ω are connected in parallel so as to send current in same direction through an external resistance of 5Ω . Find the current through the external resistance.

OR

Ex.5) Two cells of emf 4V and 2V having respective internal resistance of 1Ω and 2Ω are connected in

parallel, so as to send current in the same direction through an external resistance of 5Ω . Find the current through the external resistance. **(Feb/Mar-2022)-3M**

Ans: Solve as per above Ex.



Solution: Given: $E_1 = 1.5\text{ V}$, $r_1 = 1\Omega$, $E_2 = 2\text{ V}$, $r_2 = 2\Omega$, $R = 5\Omega$

Applying Kirchhoff's 2nd law in Loop 1 (ABCDEF GHA),

$$-(I_1 + I_2)R - I_1 r_1 + E_1 = 0$$

$$\therefore (I_1 + I_2)R + I_1 r_1 = E_1$$

$$\therefore I_1 (R + r_1) + I_2 R = E_1$$

$$\therefore I_1 (5 + 1) + 5I_2 = 1.5$$

$$\therefore 6I_1 + 5I_2 = 1.5$$

$$\therefore 12I_1 + 10I_2 = 3 \quad \dots (i)$$

Applying Kirchhoff's 2nd law in Loop 2 (FGHAKJF),

$$-I_1 r_1 + E_1 - E_2 + I_2 r_2 = 0$$

$$-I_1 \times 1 + 1.5 - 2 + I_2 \times 2 = 0$$

$$\therefore 2I_2 - I_1 = 0.5$$

$$\therefore 4I_2 - 2I_1 = 1$$

$$\therefore I_2 = \frac{1+2I_1}{4} \quad \dots (ii)$$

Substituting equation (ii) in equation (i),

$$12I_1 + 10 \times \left(\frac{1+2I_1}{4} \right) = 3$$

$$\therefore 48I_1 + 10 + 20I_1 = 12$$

$$\therefore 68I_1 = 2$$

$$\therefore I_1 = \frac{1}{34}\text{ A}$$

$$\therefore I_2 = \frac{1+2 \times \frac{1}{34}}{4} \quad \dots [\text{From (ii)}]$$

$$= \frac{9}{34}\text{ A}$$

Current through external resistor

$$= I_1 + I_2$$

$$= \frac{1}{34} + \frac{9}{34} = \frac{10}{34} = \frac{5}{17}\text{ A}$$

9) A magnetising field of 2×10^3 ampere/m produces a magnetic flux density of 8π tesla in an iron rod. The relative permeability of the rod will be

- a) 10^2 b) 10^0 c) 10^4 d) 10^1

10) If a diamagnetic material is placed in a magnetic field, the flux density inside the material compared to that outside will be

- a) slightly less b) slightly more
c) very much more d) same

11) Paramagnetism is _____.

- a) an orientation effect
b) distortion effect
c) both orientation and distortion effects
d) neither orientation effect nor distortion effect

12) S.I. unit of magnetic dipole moment is _____.

- a) A/m^3 b) Am^{-2} c) Am^2 d) $A - m$

13) Which of the following materials is repelled by an external magnetic field?

- a) Iron b) Cobalt c) Steel d) Copper

14) A non-magnetic material when brought near a powerful magnet, it gets repelled. The material is _____.

- a) paramagnetic b) ferromagnetic
c) non-magnetic d) diamagnetic

15) Which of the following groups are diamagnetic?

- a) Hydrogen, oxygen, argon b) Oxygen, copper, silver
c) Hydrogen, argon, copper d) Lead, copper, bismuth

16) If a diamagnetic substance is brought near north or south pole of a bar magnet, it is

- a) attracted by the pole. b) repelled by the poles.
c) repelled by north pole and attracted by the south pole.
d) attracted by the north pole and repelled by the south pole.

17) In a ferromagnetic material, range of magnetic susceptibility is

- a) 10^2 to 10^3 b) 10^{20} to 10^{40}
c) -10^{-3} to -10^{-5} d) 0 to 10^{-3}

18) The magnetic moment is not represented by

- a) accelerated charge.
b) stationary charge.
c) retarded charge

d) charge moving with constant velocity.

19) If a magnetic material moves from stronger to weaker parts of a magnetic fields, then it is known as _____.

- a) diamagnetic b) paramagnetic
c) ferromagnetic d) anti-ferromagnetic

20) In paramagnetic substances, the atom has ____.

- a) no magnetic moment b) torque
c) magnetic moment d) domain

21) If the relative permeability of iron is 2000, its absolute permeability in SI unit is

- a) $8\pi \times 10^{-4}$ T m/A b) $80\pi \times 10^{-4}$ T m/A
c) $\frac{800}{\pi}$ T m/A d) $\frac{5 \times 10^9}{\pi}$ T m/A

22) Which of the following is incorrect relation?

- a) $\chi = \frac{M_z}{H}$ b) $B = \mu_0(1 + \chi)H$
c) $\mu_0 = \mu(1 + \chi)$ d) $\mu_r = 1 + \chi$

23) Which of the following is not a unit of the intensity of magnetization?

- a) $A m^{-1}$ b) $J T^{-1} m^{-3}$
c) $N T^{-1} m^{-2}$ d) $A T^{-1} m^{-2}$

Answers to multiple choice question

1	a	11	a	21	a
2	a	12	c	22	c
3	d	13	d	23	d
4	b	14	d	24	
5	c	15	d	25	
6	d	16	b	26	
7	b	17	a	27	
8	a	18	b	28	
9	c	19	a	29	
10	a	20	c	30	

Cyclotron (सायक्लोट्रॉन)- हा एक low voltage source असलेला circular accelerator असून त्याचा उपयोग high energy particles (उच्च उर्जा कण) निर्माण करून त्यांना गोल-गोल फिरवून त्यांचा वेग वाढविला जातो. ह्या कणांच्या गोलाकार गतीमुळे ह्या उपकरणाला cyclotron असे नाव देण्यात आले.

Cyclotron ला Magnetic resonance accelerator असेही म्हणतात. Positively charged particles म्हणजेच protons, deuterons, α -particles यांना accelerate करण्यासाठी म्हणजेच त्यांची गती वाढविण्यासाठी cyclotron चा उपयोग होतो.

Principle (तत्त्व)- cyclotron मध्ये positively charged (धन प्रभारित) कण पुनः पुन्हा high frequency electric field (अति उच्च वारंवारतेच्या) विद्युत क्षेत्रात प्रवास करतात, वेग वाढतो व त्यामुळे कणांतील गतीज ऊर्जा वाढते. यासाठी शक्तीशाली चुंबकीय क्षेत्रातून spiral (सर्पिलाकृती) मार्गाने धन कणास प्रवास करावा लागतो.

प्रश्नामध्ये cyclotron चे construction व working सोप्या भाषेत दिले आहे, त्याचे अवलोकन करा.

Cyclotron चे uses-

- Heavy positively charged particles म्हणजेच α - particles, helium ion सुद्धा accelerate होऊ शकतात.
- High Speed positively charged particles चा उपयोग atomic nuclei चे artificial disintegration करण्यासाठी होतो.
- cyclotron मुळे accelerated ions चा continuous stream (एकसारखा प्रवाह) मिळतो.

Cyclotron मधील Limitations-

- Cyclotron मुळे neutron सारख्या uncharged (उदासिन) कणांचा वेग वाढविता येत नाही.
- Cyclotron हे electrons ची गति वाढविण्यासाठी अक्षम आहेत, कारण electrons चे mass खूप कमी असते, व ते अत्यंत तीव्र वेगाने जातात, त्यामुळे चुंबकीय क्षेत्राच्या प्रावस्थेबाहेर जातात.
- Charged particles म्हणजेच positive particles हे cyclotron मधील दिलेल्या speed पेक्षा जादा वेगाने गतिमान होत नाहीत, म्हणजेच धनभारित कणांच्या वेगावर मर्यादा आहे.
- Cyclotron मुळे ५०० Mev पर्यंतच ऊर्जा असणारे energetic particles निर्माण करता येतात.

Moving Coil galvanometer (चालकुंडल विद्युत धारादर्शक)-

- Moving Coil galvanometer च्या रचनेमध्ये एक हलकी rectangular व insulated copper wire हि non-magnetic aluminum frame वर गुंडाळलेली असते.
- हि coil म्हणजेच चौकट धाग्याने वर टांगती बांधून ठेवली जाते, हि चौकट मुक्तपणे फिरत असते, त्याच्याभोवती एकसमान radial magnetic field निर्माण होते.

iii) त्याच्यामध्ये strong cylindrical concave pole चे pieces N आणि S वापरून magnetic field निर्माण केली जाते.

iv) आकृतीत दाखविल्याप्रमाणे soft iron cylinder C हा radial gap मध्ये बसविलेला असतो. त्यामुळे gap मध्ये magnetic field ची strength वाढते.

v) Phosphor bronze wire च्या मदतीने coil बांधली जाते.

vi) एक लहान आरसा हा Phosphor bronze fibre वर fix केलेला असतो, त्याचा उपयोग lamp आणि scale arrangement साठी वापरतात.

vii) Coil चे दुसरे end हे Phosphor bronze helical spring ला जोडलेले असते, त्यातून current बाहेर येतो, Helical spring मधील elastic property मुळे coil current cut off झाल्यावर पुन्हा मुळ स्थितीवर येते.

Moving coil Galvanometer चे principle (तत्त्व)- जेव्हा current वाहून नेणारी coil हि radial magnetic field मध्ये मुक्तपणे ठेवली असता, त्यावर maximum torque (आघूर्ण) तयार होते, व त्यामुळे coil deflect होते, ह्या coil मध्ये होणारे deflection हे coil मधून वाहणा-या current च्या समप्रमाणात असते. वरील प्रश्नातील figure पहा. त्यावरून Moving coil galvanometer चे principle दिले आहे. सर्व derivation व्यवस्थित समजून घ्या.

Biot- Savarts law (बायत- सावर्टसचा नियम) किंवा Laplace's law (ला प्लास चा नियम)-

विद्युत वाहकाच्या small element (एका सुक्ष्म/ लहान भागातून) electric current वाहत असेल तर त्याच्या कोणत्याही point जवळ निर्माण होणारे magnetic induction (चुंबकीय प्रेरण) हे

- Conductor मधून वाहणा-या current च्या समप्रमाणात
- Conductor च्या length (लांबीच्या) समप्रमाणत
- वाहकाची दिशा व conductor आणि त्याच्या centre जोडणारी रेषा यांच्यामधील sine angle यांच्या समप्रमाणात.
- तो बिंदु व element चा centre यांच्यामधील अंतराच्या वर्गाच्या व्यस्त प्रमाणात बदलते. प्रश्नामध्ये याबद्दलचा formula व्यवस्थित दिला आहे. दिलेल्या figure वरून असे लक्षात येते कि, dl एवढा लांबीचा conductor चा भाग असून त्यामधून I इतका current वाहत आहे, यापासून r इतक्या अंतरावर P हा point आहे, त्यानंतर θ -angle हा element व तो point ते element चा centre जोडणा-या रेषेच्या मधला आहे. त्यामुळे Biot-Savartes law नुसार, $db \propto \frac{I(dl) \sin \theta}{r^2}$

7.7 Polarization

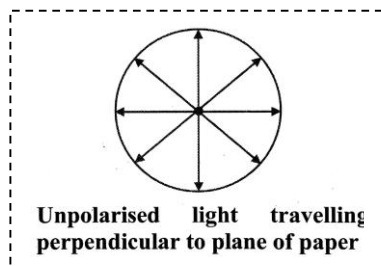
Q.28 Explain what is meant by polarization.

Ans: Polarization: The phenomenon of restriction of the vibration of light waves in a particular plane perpendicular to direction of wave motion is called polarization of light.

Q.29 Define: i) Unpolarised light ii) Plane polarised light. Give its symbolic representation.

Ans: Unpolarised light: A light in which the vibrations of the electric vectors are in all possible directions, which are perpendicular to the directions of propagation, is called as unpolarised light.

Symbolic representation of unpolarised light is as shown in figure.



ii) Plane polarised light: The light waves in which vibrations of the electric field vectors are confined only to one plane are called plane polarised light.

Representations of a plane polarised beam travelling perpendicular to plane of paper.



Fig. Polarized light with electric field along the horizontal direction.

Q.30 State methods to produce plane polarised light.

Ans: Plane polarised light can be produced by:

- i) reflection ii) scattering iii) refraction iv) polaroid

Q.31 Define the terms:

i) Polarizers

ii) Polaroid

iii) Polarizing axis of the polarizer

Ans: i) Polarizers: Certain types of materials which allow only those light waves which have their electric field along a particular direction to pass through and

block all other waves (which have their electric field in other directions) are called polarizers.

ii) Polaroid: A polaroid is a kind of synthetic plastic sheet which is used as polarizer.

iii) Polarizing axis of the polarizer: The particular direction along which the electric field of the emergent wave is oriented is called the polarizing axis of the polarizer.

Q.32 Define plane of vibration and plane of polarization.

Ans: a) Plane of vibration: The plane in which the vibrations of polarised light take place is called as plane of vibration.

b) Plane of polarisation: The plane perpendicular to the plane of vibration in which there are no vibrations of polarised light is called as plane of polarisation.

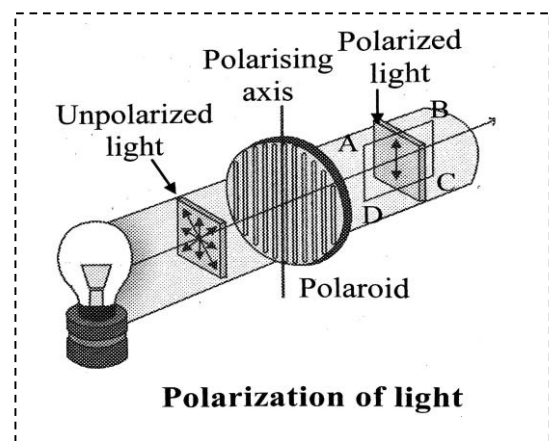
Q.33 Explain the intensity of an unpolarised wave passing through a polarizer.

OR

Q.33 Show that the intensity of an unpolarised wave reduces by half after passing through a polarizer.

Ans: Intensity of an unpolarised wave passing through a polarizer:

i) Consider an unpolarised wave having angular frequency ω and wave vector k , travelling along the X-direction.

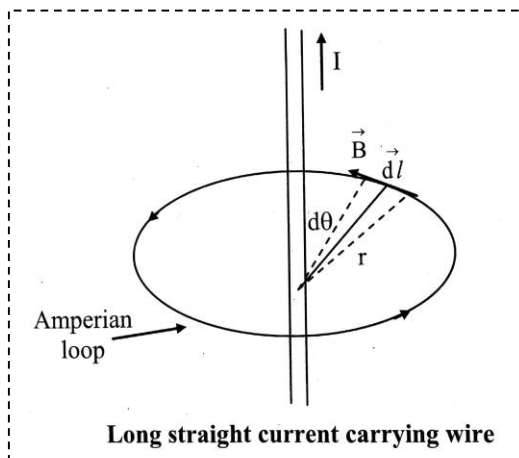


ii) The magnitude of its electric field is $E = E_0 \sin(kx - \omega t)$, E_0 being the amplitude of the wave and direction of the electric field can be anywhere

Q.32 Obtain expression for magnetic field at a distance r from straight current conducting wire using Ampere's law.

Ans: Expression for magnetic field at a distance r from straight current conducting wire using Ampere's law:

i) Consider a long straight wire carrying a current I as shown in figure below.



$\vec{B}$ and $d\vec{l}$ are tangential to the Amperian loop which in this case is a circle.

$$\vec{B} \cdot d\vec{l} = B dl$$

$$= B r d\theta$$

ii) The field $\vec{B}$ at a distance r from the wire is given by

$$B = \frac{\mu_0 I}{2\pi r}$$

$$\therefore \oint_c \vec{B} \cdot d\vec{l} = \int_0^{2\pi} \frac{\mu_0 I}{2\pi r} r d\theta$$

$$= \mu_0 I$$

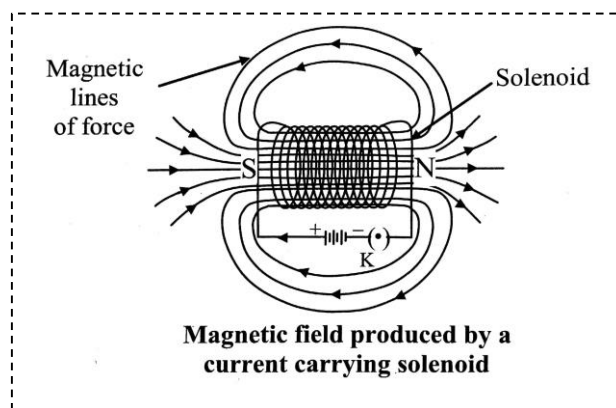
10.16 Magnetic Field of a Solenoid and a Toroid

Q.33 Write note on solenoid.

Ans: Solenoid: When a copper wire with a resistive coating is wound in a chain of loops (like a spring), it is called as solenoid.

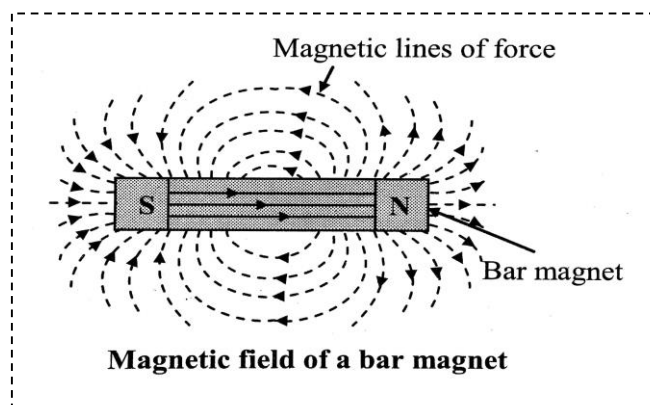
i) A solenoid is long, insulated copper closely wound on a hollow cylindrical glass or plastic tube in the form of a helix. Length of the solenoid is very large as compared to its diameter.

ii) Whenever electric current passes through a solenoid, magnetic lines of force are produced in a pattern as shown in the figure.



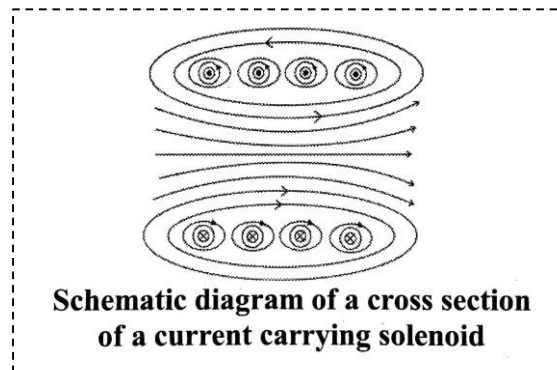
iii) The magnetic field produced by a solenoid is similar to the magnetic field of a bar magnet.

One end of the coil acts as south pole and the other end acts as north pole whereas, the field lines are parallel inside the solenoid.



Q.34 Explain magnetic field around solenoid carrying current.

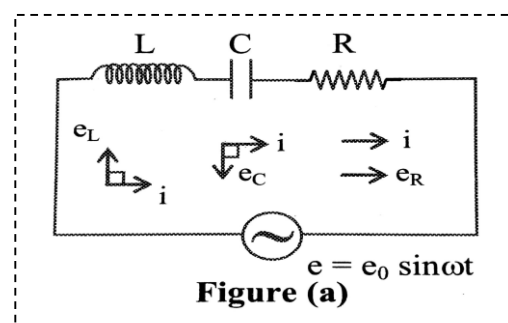
Ans: Magnetic field around solenoid carrying current:



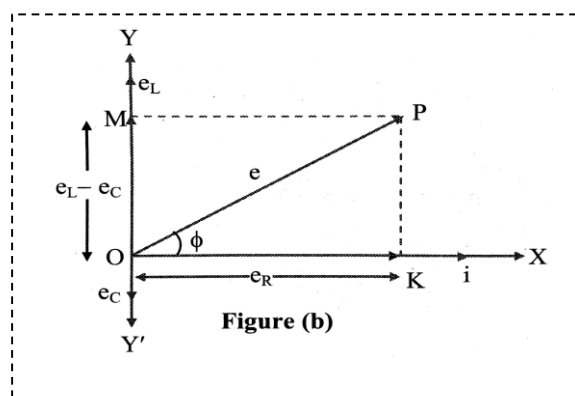
i) Consider a long, closely wound helical coil of a conducting wire such that the diameter of the coil is much smaller than its length. This forms a solenoid.

Q.21 Compare resistance and reactance.**Ans: Resistance and Reactance:**

No.	Resistance	Reactance
i	Equally effective for AC and DC.	Current is affected (reduced) but energy is not consumed (heat is not generated). The energy consumption by a coil is due to its resistive component.
ii	Its value is independent of frequency of the AC	Inductive reactance ($X_L = 2\pi fL$) is directly proportional and capacitive reactance ($X_C = \frac{1}{2\pi fC}$) is inversely proportional to the frequency of the AC.
iii	Current opposed by a resistor is in phase with the voltage.	Current opposed by a pure inductor lags in phase while that opposed by a pure capacitor leads is phase by π^c over the voltage.



iii) As ' e_R ' is in phase with current i , the vector e_R is drawn in the same direction as that of i along positive direction of X axis.



iv) e_C lags the current i by $\frac{\pi}{2}$ radian (90°), hence the vector ' e_C ' is drawn in the negative direction of the Y axis e_C along OY'.

v) e_L leads the current by $\frac{\pi}{2}$ radian (90°), hence vector e_L is drawn in the positive direction of Y axis.

vi) The voltages through L, C and R are given by
 $e_L = iX_L$, $e_C = iX_C$ and $e_R = iR$ (1)

vii) The voltages across L and C have a phase difference of 180° . Hence, the net reactive voltage is $(e_L - e_C)$

viii) Consider $e_L > e_C$. The net reactive emf $(e_L - e_C)$ is in the direction of e_L as shown in figure (b). Resultant of e_R , e_L and e_C given the r.m.s value (e) of applied e.m.f which is represented by diagonal OP in figure (b).

ix) From the figure (b),

$$OP = \sqrt{OK^2 + OM^2}$$

$$\therefore e^2 = e_R^2 + (e_L - e_C)^2$$

Q.22 Derive an expression for the impedance of an LCR circuit connected to an AC power supply.**OR****Q.22 Derive an expression for the impedance of an LCR circuit connected to an AC power supply. Draw phasor diagram. (Feb/Mar-2024)-3m****Ans: Expression for impedance of AC circuit containing LCR in series:**

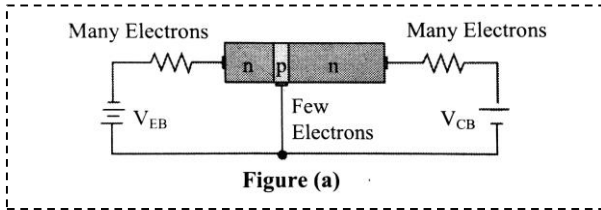
i) Consider an alternating e.m.f applied to a series combination of pure inductor of inductance L, capacitor of capacitance C and resistor of resistance R as shown in figure (a).

ii) Let e_L , e_C and e_R be the r.m.s voltage across inductor, capacitor and resistor. As R, L and C are in series, the current at any instant through the three elements has the same amplitude and phase and given as, $i = i_0 \sin \omega t$.

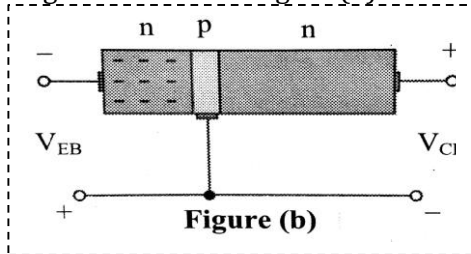
Q.49 Explain the working of n-p-n transistor with the help of diagrams. OR**Q.49 Explain the working of n-p-n transistor in common base configuration. (Feb/March-2023)-3m**

Ans: Working of n-p-n transistor:

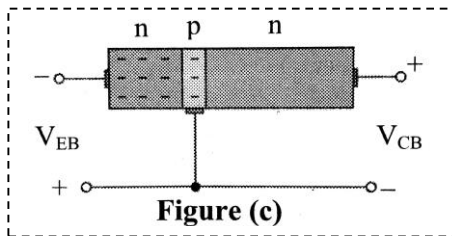
- i) Majority charge carriers in the emitter of n-p-n transistor are electrons.
 ii) A typical biasing of a transistor is shown in figure (a). In this, emitter-base junction is forward biased while collector-base junction is reverse biased.



- iii) At the instant when the EB junction is forward biased, electrons in the emitter region have not entered the base region as shown in figure (b).



- iv) When the biasing voltage V_{BE} is greater than the barrier potential (0.6-0.7 V for Si transistors). Many electrons enter the base region and form the emitter current I_E as shown in figure (c).

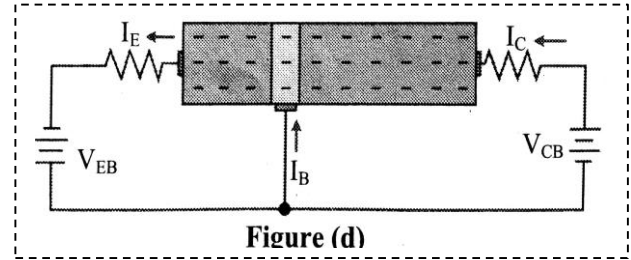


- v) These electrons can either flow through the base circuit and constitute the base current (I_B), or they can also flow through the collector circuit and contribute towards the collector current (I_C).

- vi) The base being thin and lightly doped, base current is only 5% of I_E .

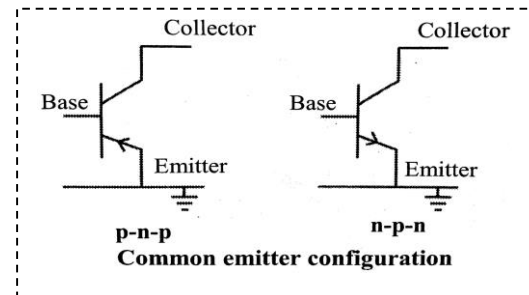
- vii) Electrons injected from the emitter into the base diffuse into the collector-base depletion region due to the thin base region. When the electrons enter the collector-base depletion region, they are pushed into the collector region by the electric fields at the collector-base depletion region. The collector current I_C flows through the external circuit as shown in figure (d). The collector current I_C is about 95% of I_E .

From the figure we can conclude that, $I_E = I_B + I_C$. Since the base current I_B is very small we can write $I_C \approx I_E$.

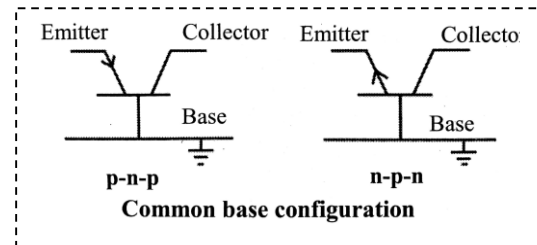
**Q.50 What are the possible configurations of transistor in a circuit? Explain each in brief.**

Ans: The possible configurations of transistor in a circuit are,

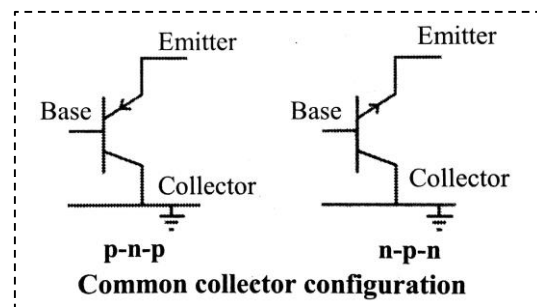
- i) Common emitter (CE):** The emitter of the transistor is common to both the input and the output.



- ii) Common Base (CB):** The base of the transistor is common to both the input and the output.



- iii) Common collector (CC):** The collector of the transistor is common to both the input and the output.



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