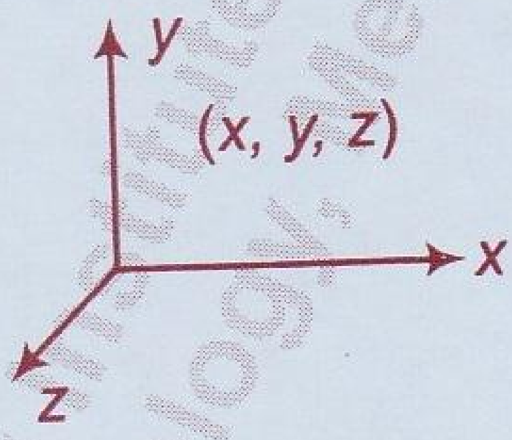
Unit-1

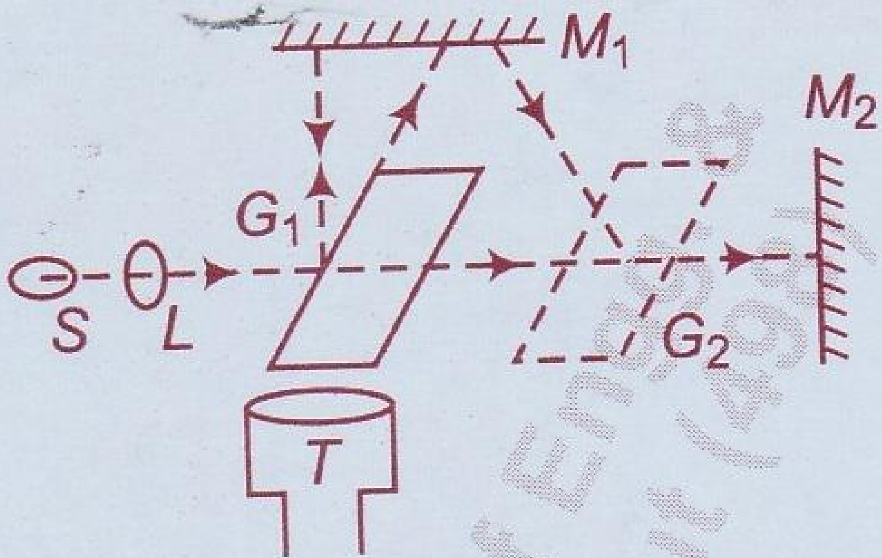
FRAME OF REFERENCE

A frame of references consists of an origin three co-ordinate axes in space and clock. The frame of references are classified into two types.



Inertial Frame of Reference

- It obey Newton's Law of inertia.



Michealson-Morley Experiment

Einstein's Special Theory of Relativity

- The law of physics in mathematical form are same in all inertial frame of references.
- The speed of light is same in all inertial frame.

ENGG. PHYSICS EP-5

Inverse Lorentz Transformation Equation

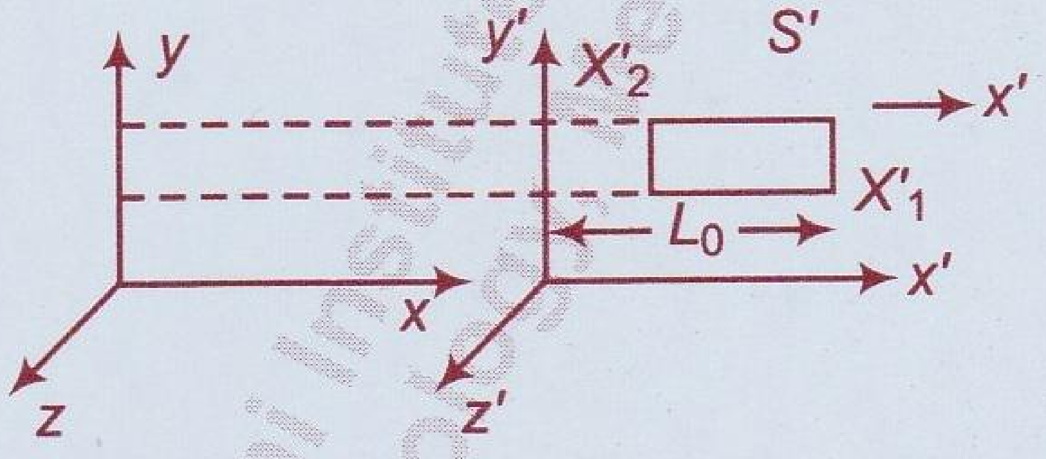
$$x = \frac{x' + vt'}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$t = \frac{t' + \frac{x'v}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$y = y'$$
$$z = z'$$

$$L_0 = \frac{x_2 - x_1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$L_0 = \frac{L}{\sqrt{1 - \frac{v^2}{c^2}}}$$



L = Length contraction

L_0 = Proper length

ADDITION OF VELOCITIES

The velocity of the particle

$$U_x = \frac{dx}{dt}; \quad U'_x = \frac{dx'}{dt'}$$

$$x = \frac{x' + vt'}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$y = y'$$

$$z = z'$$

$$t = \frac{t' + \frac{x'v}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

Differentiating above equation

Similarly,

$$U'_y = \frac{u_y \sqrt{1 - \frac{v^2}{c^2}}}{\left(1 + \frac{uv'}{c^2}\right)},$$

$$U'_z = \frac{u_z \sqrt{1 - \frac{v^2}{c^2}}}{\left(1 + \frac{uv'}{c^2}\right)}$$

If $u = c$ then $u_x = c$

The velocity of light is same in all inertial frame of references.

By the law of conservation of momentum

$$m_1u_1 + m_2u_2 = (m_1 + m_2)v \quad \ldots(3)$$

$$m_1\left(\frac{u'_x + v}{1+\dfrac{u'_x\,v}{c^2}}\right) + m_2\left(\frac{-u'_x + v}{1-\dfrac{u'_x\,v}{c^2}}\right) = (m_1 + m_2)v$$

$$\frac{m_1}{m_2} = \frac{1+\dfrac{u'_x + v}{c^2}}{1-\dfrac{u'_x\,v}{c^2}} \quad \ldots(4)$$

From Equation (1)

For $v = 0, m = m_0$

$$m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

MASS-ENERGY RELATION

By work-energy theorem

$$dw = dE_k = F.ds$$

By Newton's law

$$F = \frac{d}{dt}(mv) = m\frac{dv}{dt} + \frac{vdm}{dt}$$

$$E_k = \frac{m\,dv}{dt}ds + \frac{v\,dm}{dt}ds$$

$$dE_k = mv\,dv + v^2 dm$$

$$dE_k = c^2 dm$$

Integrating

$$E_k = c^2 \int_{m_0}^{m} dm$$

$$E_k = (m - m_0)c^2$$

$$= \Delta mc^2 \quad [\Delta m = m - m_0]$$

The total energy :

$$E = E_k + P_E$$

$$E = m_0c^2 + (m - m_0)c^2$$

$$E = m_0c^2 + mc^2 - m_0c^2$$

$$E = mc^2$$

This is Einstein's mass energy relation.

(E_k = Kinetic energy)

De-Broglie wave length of an electron accelerated though potential difference :

$$\lambda = \frac{12 \cdot 27}{\sqrt{V}} \text{ Å}$$

Phase Velocity :

It is the velocity with which a particular phase of a wave propagate in a medium.

$$V_p = \frac{w}{k}$$

Group Velocity :

The velocity with which a wave packet moves forward in

Application of Heisenberg Principle

1. Non existence of electron in the nucleus.
2. Binding energy of electron in the nucleus.
3. Radius of first Bohr orbit in the nucleus.

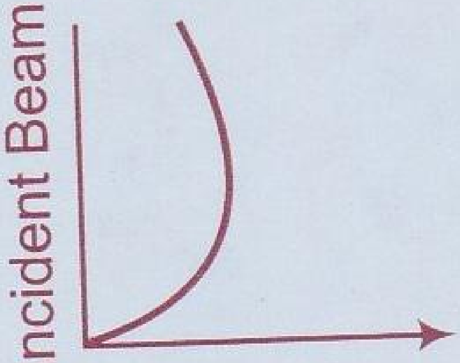
Davisson and Germer Experiment

Davisson and Germer performed an experiment which demonstrated diffraction of electron. The wavelength of electron calculated from the diffraction pattern approx with

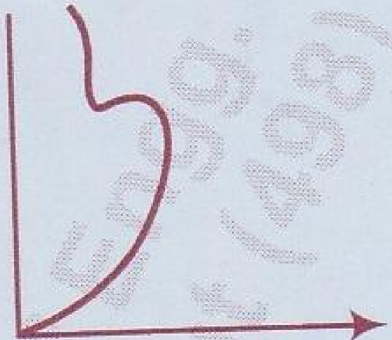
ENGG. PHYSICS

EP-23

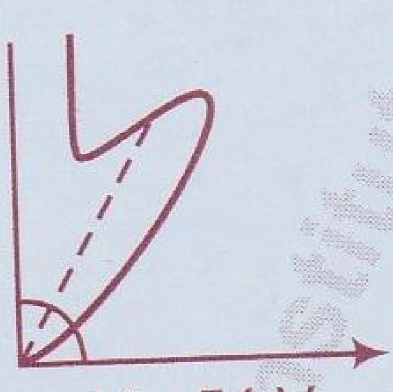
Observation from Experiment



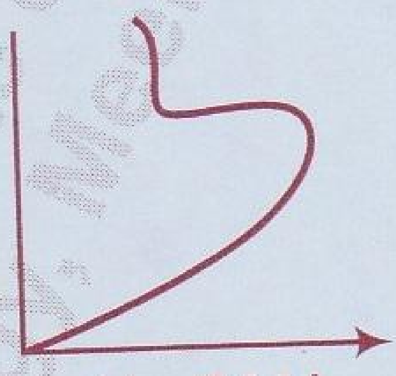
$V = H_0 V$



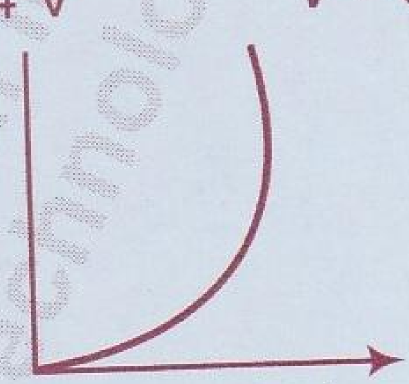
$V = 48$ V



$V = 54$ V



$V = 64$ V



$V = 68$ V

Schrodinger Wave Equation

The wave equation which represent the space and time of paticle is known Schrodinger wave equation. It is two types :

1. Time Independent Wave Equation
2. Time Dependent Wave Equation

Time Independent Schrodinger Wave Equation

The general differential equation is given by,

$$\frac{\partial \psi^2}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 \psi}{\partial t^2} \quad \ldots(1)$$

The total energy

$$E = \text{K.E.} + \text{P.E.}$$

$$= \frac{1}{2} mv^2 + V$$

$$E = \frac{p^2}{2m} + v,$$

$$p^2 = 2m\,(E - V)$$

From equation (3)

$$\frac{\partial^2 \psi}{\partial x^2} = \frac{4\pi^2 p^2}{h^2} \psi$$

$$\frac{\partial^2 \psi}{\partial x^2} = \frac{4\pi^2\, 2m\,(E - V)}{h^2} \psi$$

$$\frac{\partial^2 \psi}{\partial x^2} = \frac{8\pi^2 m\,(E - V)}{h^2} \psi$$

$$\frac{\partial \psi}{\partial t} = \frac{-iE}{h}\Psi \quad \left[\omega = \frac{E}{h}\right]$$

$$E\psi = ih\frac{\partial \psi}{\partial t}$$

Put this value in Schrodinger time independent equation

$$\frac{\partial^2 \psi}{\partial x^2} + \frac{2m}{h^2}(E - V)\psi = 0$$

PARTICLE IN RIGID BOX (Infinite Potential Well)

$\nu = \infty$ for $x \leq 0$ and for $x \geq L$

$v = 0$ for $0 < x < L$

$$E_n = \frac{n^2 h^2}{8mL^2}$$

E_n = Energy

Unit-3

INTEFERENCE

When light from two source move in a direction the light wave train from these sources superimpose upon each other resulting in the modification of distribution of intensity. This modification of light energy due to superposition of two or more wave train is called interference.

(1) Due to Reflected Light

The path difference

Δ = path $(AC + CD)$ in film − path AL in air

$$\Delta = \mu\,(AC + CD) - AL$$

For destructive inteference :

$$2\mu t \cos r - \frac{\lambda}{2} = (2n-1)\frac{\lambda}{2}$$

$$2\mu t \cos r = (2n-1)\frac{\lambda}{2} + \frac{\lambda}{2}$$

[Dark (where $n = 0, 1, 2, \ldots$)]

(2) Due to Transmitted Light

The path difference

$$\Delta = \text{Path } (BC + CD) \text{ in film} - \text{Path } BN \text{ in air}$$

By substituting the value BC, CD and BN

$$\Delta = 2\mu t \cos r$$

Constructive interference

$$2\mu t \cos r = n\lambda$$

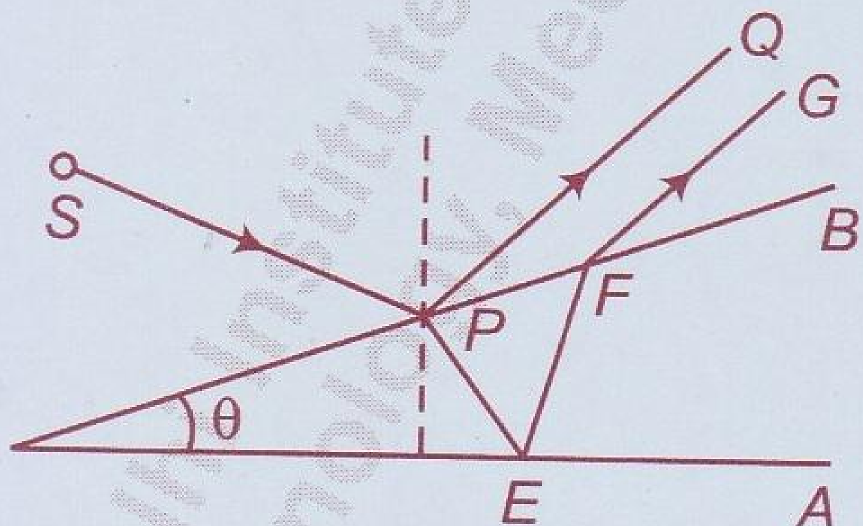
$$2\mu t \cos r = (2n - 1)\frac{\lambda}{2}$$

$$(n = 0, 1, 2, \ldots)$$

WEDGE SHAPED FILM

The path difference

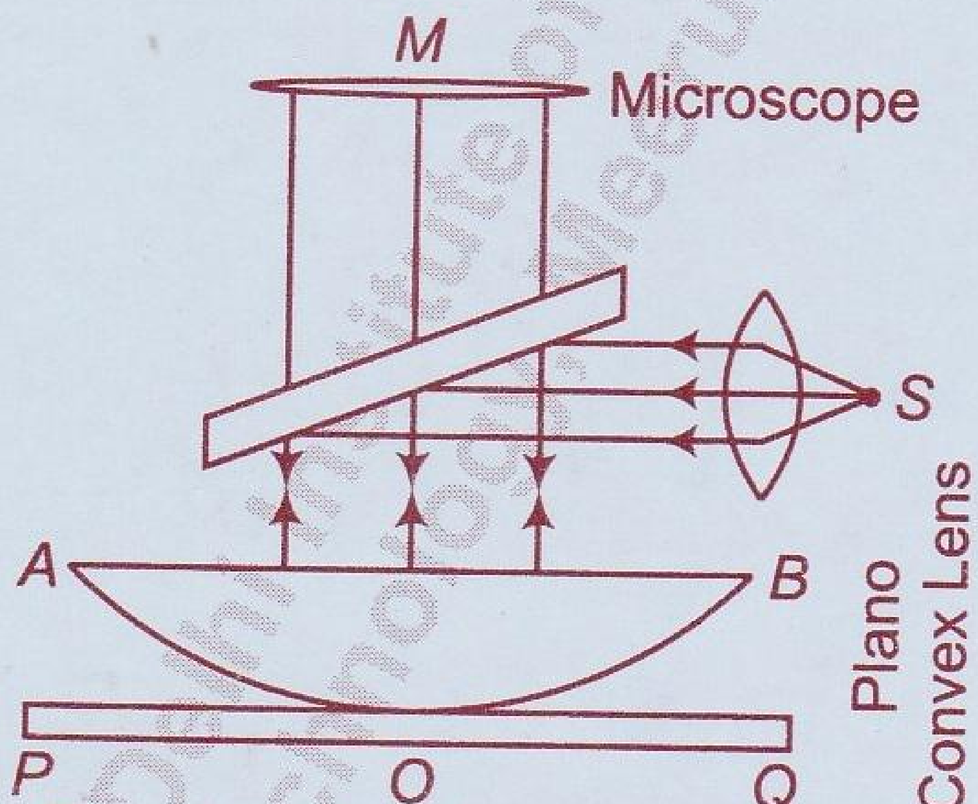
$$\Delta = 2\mu t + \frac{\lambda}{2}$$



For constructive interference

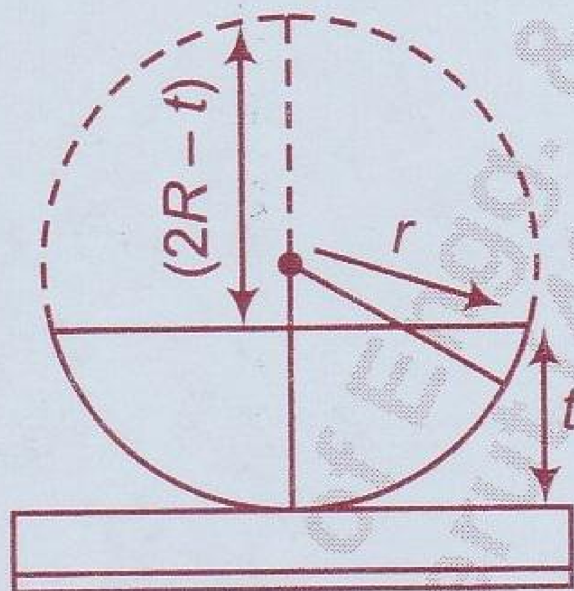
$$2\mu t + \frac{\lambda}{2} = 2n\frac{\lambda}{2}$$

film *POQ*. As a result an alternate dark and bright circular ring concentric around the point of contact on seen. These ring are called Newton's ring.



Experimental Arrangement

(For Air $\mu = 1$)



For Dark Ring :

$$2\mu \frac{r^2}{2R} = 2\lambda$$

$$r^2 = \frac{n\lambda R}{\mu}$$

$$D_n^2 = \frac{4n\lambda R}{\mu}$$

$$D_n = \sqrt{4n\lambda R} \text{ (For air } \mu = 1)$$

$$R = na\frac{\sin\alpha}{\alpha} = \frac{A\sin\alpha}{\alpha}$$

Resultant intensity at *P* :

$$I = R^2 = A^2\left(\frac{\sin\alpha}{\alpha}\right)^2$$

Position of maxima and minima

$$R = \frac{A\sin\alpha}{\alpha}$$

$$= \frac{A}{\alpha}\left[\alpha - \frac{\alpha^3}{3!} + \frac{\alpha^5}{5!} - \frac{\alpha^7}{7!} + \ldots\right]$$

$$= A\left[1 - \frac{\alpha^2}{3!} + \frac{\alpha^4}{5!} - \frac{\alpha^6}{7!} + \ldots\right]$$

$$R'^2 = 4R^2 \cos^2 \frac{\phi}{2}$$

$$\beta = \frac{\phi}{2} = \frac{\pi}{\lambda}(a + b)\sin\theta$$

The resultant intensity at P

$$I = R'^2 = 4A^2 \frac{\sin^2\alpha}{\alpha^2}\cos^2\beta$$

N-SLIT DIFFRACTION

$$R' = R\frac{\sin N\beta}{\sin\beta}$$

$$= \frac{a\sin\alpha}{\alpha} \cdot \frac{\sin N\beta}{\sin\beta}$$

$$I = R'^2 = \frac{A^2\sin^2\alpha}{\alpha^2} \cdot \frac{\sin^2 N\beta}{\sin^2\beta}$$

angle of diffraction with the change in the wavelength of light used :

$$\frac{d\theta}{d\lambda} = \frac{n}{(a+b)\cos\theta}$$

$$= \frac{1}{\sqrt{\left(\frac{a+b}{n}\right)^2 - \lambda^2}}$$

RESOLVING POWER OF A DIFFRACTION GRATING

It is defined as the ratio of the **wave length** of any spectral lines to the smallest **wave length** difference neighbouring lines for which the spectral lines can be just

(O-ray). The second image is called extraordinary image (E-rays).

NICOL PRISM

When an unpolarised beam of light enters the calcite crystal is splits up into two plane polarised ray as O-ray and E-ray, with vibration in two mutually perpendicular planes.

The nicol prism is designed in such a way so as to eliminate the ordinary by total internal reflection. Hence, only the extra ordinary ray is transmitted throguh the prism.

This is equation of an oblique ellipse.

Special Cases :

1. **Plane Polarised Light :**

Case 1. $\sin\delta = 0,$

$\cos\delta = 1$

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} - \frac{2xy}{ab} = 0$$

$$\left(\frac{x}{a} - \frac{y}{b}\right)^2 = 0$$

$$y = \pm\left(\frac{b}{a}\right)x$$

Case 2. $y = -\frac{b}{a}x$

Unit-4

LASER

Light Amplification by Stimulated Emission of Radiation

- Laser is a device which produces light wave all exactly in phase.
- Interference pattern may be obtained by two separated lasers.
- It mainly works on stimulated emission of radiation.

Properties of Laser :

1. Coherence
2. Monochromatic

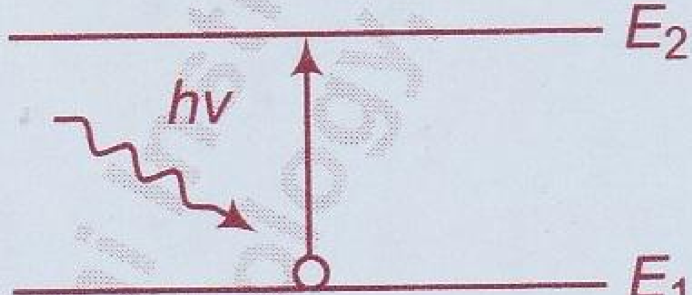
3. Intense

4. Directional

Coherence Source : Two sources are said to be coherent if the phase difference between them remain constant.

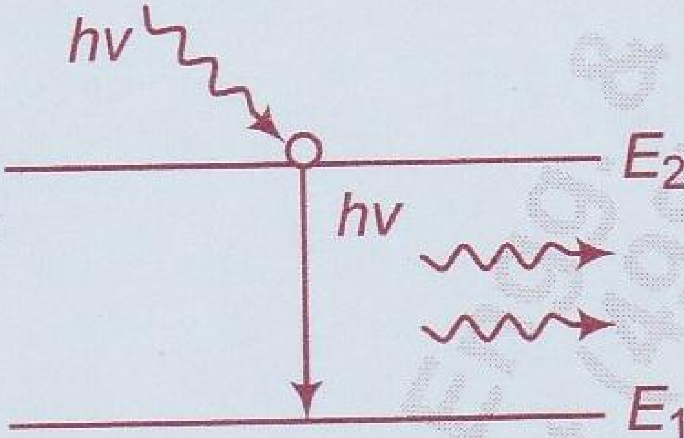
RADIATION OF MATTER

1. Absorption of Radiation



In fig. photon is incident on an atom in its ground state, the atom absorbs the photon

3. Stimulated Emission



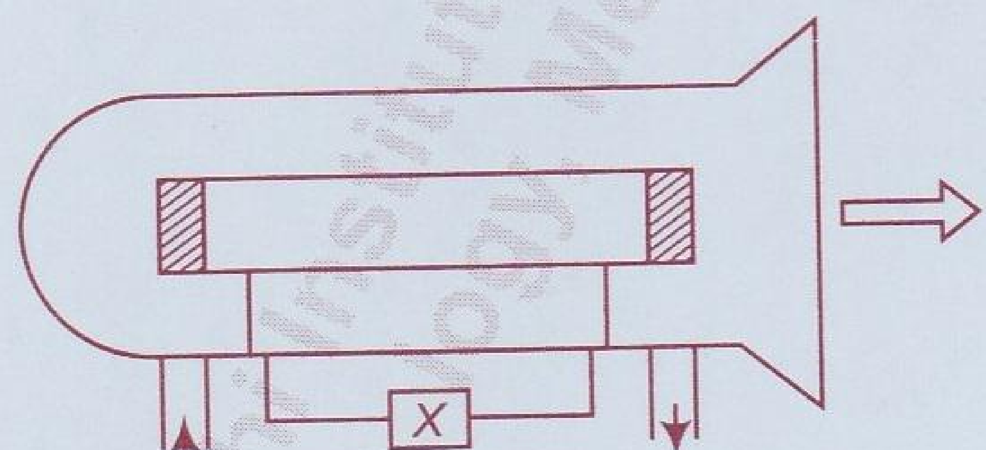
In fig. an atom in its excited state and another photon incident on it. This photon force the atom to undergo transition to the ground state, it emit a two photon of same phase wave length.

Pumping

The atom jump from lower energy state to higher energy state is called pumping.

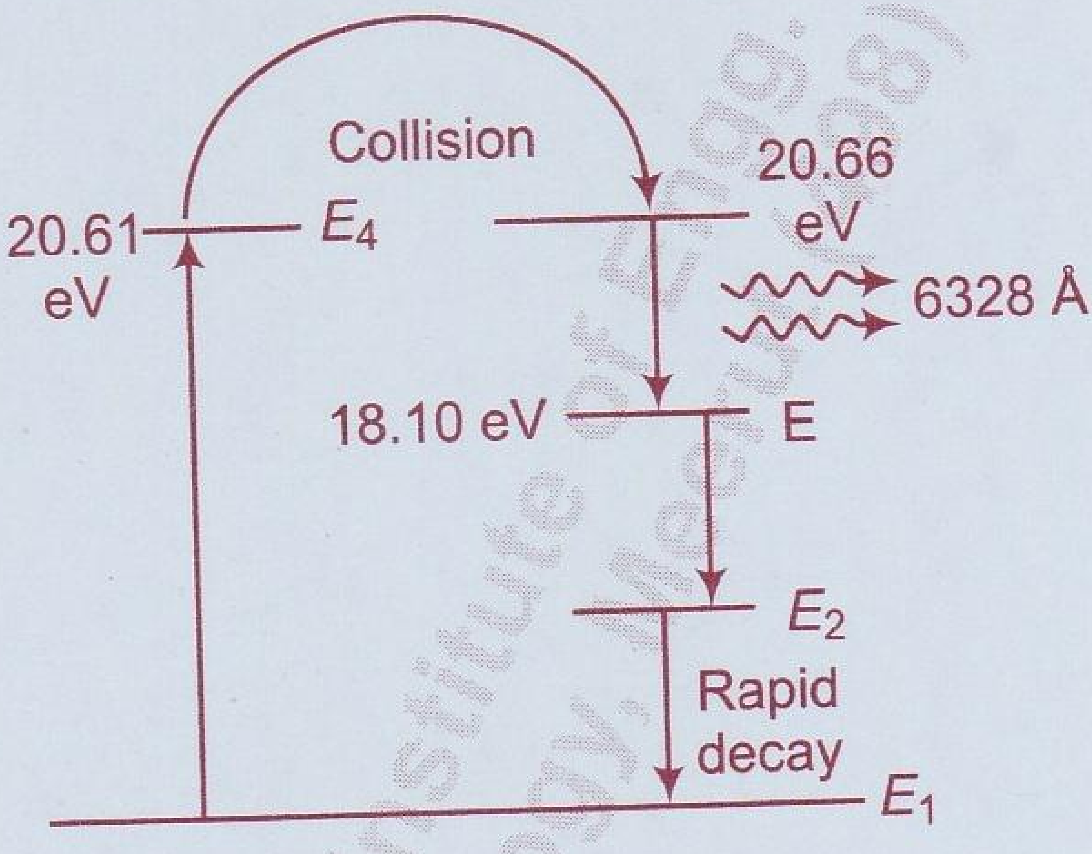
Ruby Laser

Ruby is a crystal of Al_2O_3 + 0.05% Cr^{3+}.



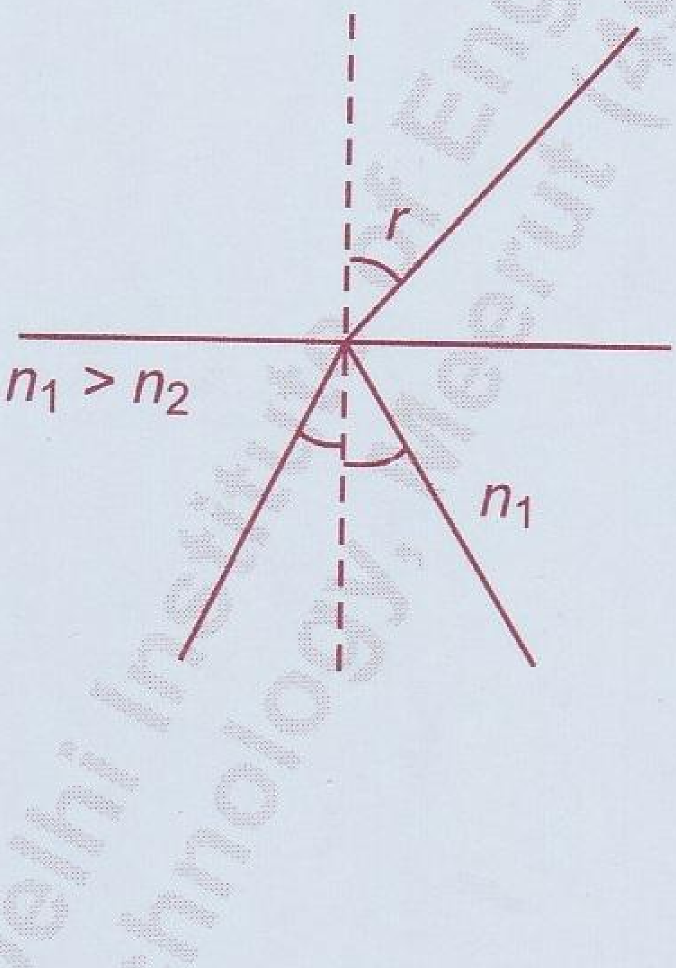
Working : It working on three level system.

Working : It is working on four level system.

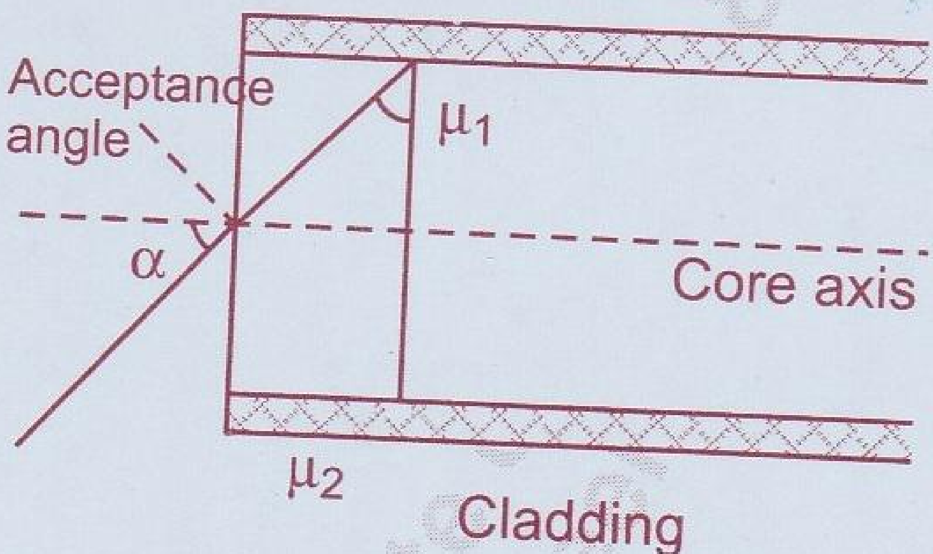


ENGG. PHYSICS EP-61

Propagation Mechanisms in Optic Fibre



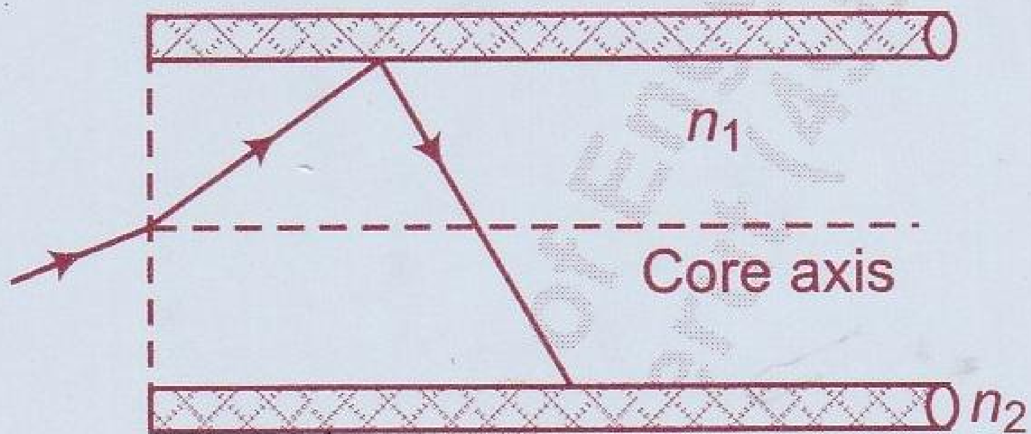
ACCEPTANCE ANGLE AND ACCEPTANCE CONE



The external angle of incidence made by a ray with the axis of the fibre, corresponding to the critical angle of incidence at the core cladding boundary is known as acceptance angle.

$$\alpha = \sin^{-1}\sqrt{\mu_1^2 - \mu_2^2}$$

be propagated. It is in the range 5 μm – 10 μm. The cladding diameters is 125 μm.



Step Index Multimode Fibre

Such fibre have a core of refractive index n and cladding of refractive index n_1 there is an abrupt change in refractive a index at the core cladding interface due to