18PH002

Hall Ticket Number:

I/IV B.Tech (Regular) DEGREE EXAMINATION

DECEMBER, 2018 **COMMON TO CIVIL AND MECHANICAL BRANCHES**

First Semester **Advanced optics and Material Testing**

Time: Three Hours **Maximum :** 50 Marks

Answer Question No.1 compulsorily. (1X10 = 10 Marks)

Answer ONE question from each unit. (4X10=40 Marks)

1. ANSWER ***ALL*** QUESTIONS

a) Outline the characteristic properties of lasers.
b) Define V-number in optical fibre.
c) Give the basic principle of optical fibre.
d) State Bloch theorem.
e) Sketch the (110) crystal plane in a cubic lattice.
f) Write the physical significance of wave function Ψ.
g) Mention any two failures of quantum free electron theory.
h) What is quantum tunneling?
i) Define inverse piezoelectric effect.
j) What is the importance of non-destructive testing?

UNIT-I

2. a) Distinguish between spontaneous and stimulated emissions. (CLO1)(4M)
2. b) Describe the construction and working of ruby laser. (CLO1)(6M)

(OR)

3. a) What is numerical aperture of an optical fibre? And derive an expression for it. (CLO1)(5M)
3. b) Give the advantages of fibre optic communication system. (CLO1)(5M)

UNIT-II

4. a) Derive Schrodinger's time independent wave equation. (CLO2)(5M)
4. b) Show that the energies of a particle in one dimensional box are quantized. (CLO2)(5M)

(OR)

5. a) Explain Davisson and Germer electron diffraction experiment to verify the concept of matter waves. (CLO2)(5M)
5. b)Mention the properties of matter waves. (CLO2)(5M)

UNIT-III

6. a) Write down the drawbacks of classical free electron theory? (CLO3) **(5M)**
6. b) What are the silent features of kronig-penney model? (CLO3)(5M)

(OR)

7. a) State and derive Bragg's law for X-ray diffraction. (CLO4)(5M)
7. b) Explain X-ray powder diffraction method to determine the crystal structure. (CLO4)(5M)

UNIT-IV

8. a) Describe the magnetostriction method for the production of ultrasonic waves. (CLO5)(5M)
8. b) Write a short note on pulse echo method. (CLO5)(5M)

(OR)

9. a) What are radio isotopes? Write medical and industrial applications of radio isotopes. (CLO5)(5M)
9. b) Compare the properties of alpha, beta and gamma radiations. (CLO5)(5M)

Bapatla Engineering College::Bapatla
Department of physics
¼ B.Tech - ADVANCED OPTICS AND MATERIAL TESTING - 18PH002 ; Semester-I, 2018

Scheme of Evaluation

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1. ANSWER ***ALL*** QUESTIONS

a) Outline the characteristic properties of lasers.

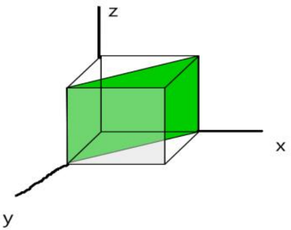
Coherence
Directionality
Monochromaticity
High Intensity

b) Define V-number in optical fibre.
The V-number gives the upper limit of the number of modes that can be transmitted in a multi mode optical fiber.

c) Give the basic principle of optical fibre.
Total internal reflection (TIR)

d) State Bloch theorem.
The solution of Schrodinger wave equation for an moving in a periodic potential can be expressed as a product of two functions 1.a free particle wave function 2.a periodic function u(x) that has the same period as the lattice(a)
$\psi(x) = e^{ikx}\, u(x)$ with $u(x) = u(x+a)$

e) Sketch the (110) crystal plane in a cubic lattice.



f) Write the physical significance of wave function Ψ.
Ψ is a complex quantity and has no direct physical meaning.
It is single valued
Ψ is finite everywhere.
It must be continuous
etc… any two – 1M

g) Mention any two failures of quantum free electron theory.
It failed to explain
the distinction between conductors, semiconductor and semiconductors
positive Hall coefficient of metals
the negative temperature coefficient of resistivity of some solids
lower conductives of divalent metals than mono-valent metals

h) What is quantum tunneling?
Quantum tunneling is a phenomenon in which microscopic particles penetrate a potential energy barrier with a height greater than the total energy of the particles.

i) Define inverse piezoelectric effect.
When potential difference is applied across the opposite faces along electrical axis of piezoelectrical crystals, then a mechanical expansion or contraction takes place along mechanical axis. This is known as piezoelectric effect.

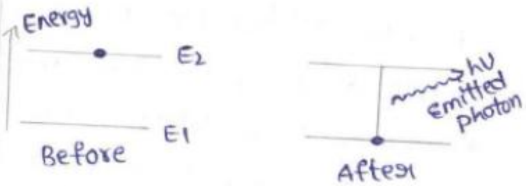
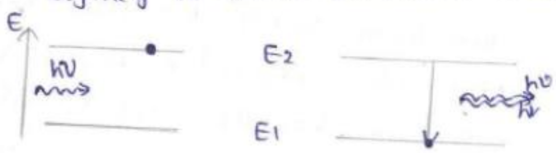
j) What is the importance of non-destructive testing?

It is used to test the materials without changing or destroying their usefulness.

UNIT-I

2. a) Distinguish between spontaneous and stimulated emissions.

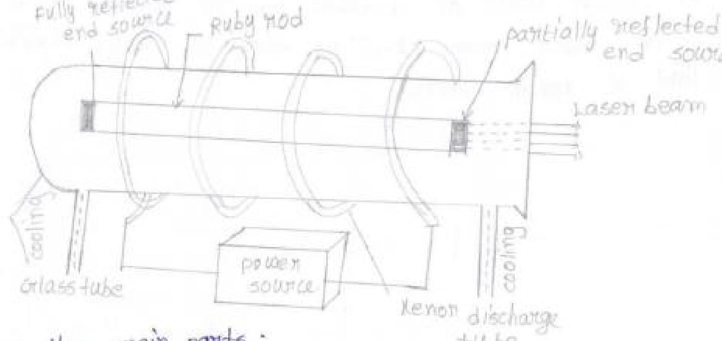
Any Four – 4M

spontaneous Emission	stimulated Emission.
• Emission of a photon by an atom without any External impetus is called spon emission.	• the phenomenon of forced photon Emission by an Excited atom due to the action of an External agency is called stimulated Emission
	
• This is a random and probabilistic process	• Not a random process (or)
• Not amenable for control from outside	• Amenable for control from outside (or)
• the instant of Emission direction of Emission, phase polarization state of photon are all random quantities and cannot be controlled	• The stimulating photon imposes its characteristics on the photon Emitted (or)
• No need of population inversion	• It requires inverted population (or)
• It is not monochromatic	• It is monochromatic (or)
• It is incoherent	• It is coherent (or)
• Ex. ordinary light	• Laser

2. b) Describe the construction and working of ruby laser.

Cconstruction 2M;diagram-1M; working-3M

let us consider the case of an actual laser known as Ruby laser. It uses a crystalline substances of the active metertial. The different parts are shown.

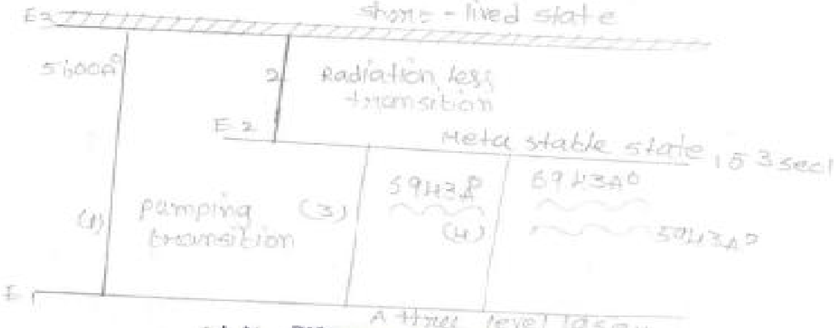


It consists of three main parts:

1. An active working material: A rod of ruby crystal
2. A resonant cavity made of fully reflecting plate at the left of ruby crystal and a partially reflecting plate at the right of ruby crystal. Both the plates are optically plane and exactly parallel to each other
3. Exciting system: a helical xenon flash tube with power supply source

Ruby (Al_2O_3, Cr_2O_3) is a crystal of aluminium oxide Al_2O_3 in which some aluminium atoms are replaced by chromium atoms (Cr_2O_3). The active material in the ruby are chromium ions Cr^{3+} when ruby crystal contains about 0.5% of chromium, It's colour is pink. The ruby crystals are grown in special furnaces with varying length and diameter, In a ruby laser, a pink rod of 4cm length and 0.5 cm in diameter is generally used. the end faces of the rod are made strictly parallel grounded and polished to a high degree. The end faces are then silvered in such a way that one end face becomes fully reflecting while the other end partially reflecting. some times separate pieces are attached at the end faces. The ruby rod is surrounded by a helical xenon flash tube which provides the pumping the pumping light to raise the chromium ions to upper energy level the flash of the xenon tube lasts several mil-liseconds and the tube consumes several thousand Joules of energy. only a part of this energy is used in pumping the cr^{+3} ions while the rest heats up the (15) apparatus. For this purpose a cooling arrangement is used.

working :- An energy diagram illustrating the operation principle of ruby laser is shown in fig. 31.4 In the figure E_1, E_2 and E_3 represent the energy levels of chromium ion. In normal state, the chromium ion is in lower energy level E_1 when the ruby crystal is irradiated with light of xenon flash.



31.4 Energy levels of ruby

The chromium atoms are excited to upper energy level E_3 where light absorption band is 5600A°

The transition 1 is optical pumping transition. the excited ions give up by collision, part of their energy to crystal lattice and decay to the metastable state E_2. The corresponding transition 2 is thus radiation less transition. we know that metastable state has relatively longer life time ($\approx 10^{-3}$ sec) than usual life time ($\approx 10^{-3}$sec). thus the number of ions in state E_2 goes on increasing while due to pump-ing, the number of ions in ground state E_1 goes on decreasing. In this way, population inversion is established between metastable state E_2 and ground state E_1.

E_1.

The state of inverted population is not a stable one the probability of spontaneous transition at any moment is very high. when the ions passes spontaneously from the metastable state to ground state, It emits a photon of wavelengths 6943 A°. This photon travels through the ruby rod. If this photon is moving parallel to the axis of the crystal, It is reflected back and forth by the silver ends until it stimulates an excited atom. Now it causes the ion to emit a fresh photon. The excited atom after emitting photon returns to ground level. The emitted photon is in phase with the stimulating photon. The stimulated transition is laser transition. The process is repeated again and again because the photons repeatedly move along the crystal being reflected from its ends. 16

Now the stimulated radiation along the axis starts dominating due to multiple reflected i.e photon travelling parallel to the axis of the tube (crystal) will starts a cascade of photon emission while the photons travelling in any direction other than this will passout of ruby. Photon beam parallel to the axis of the crystal grows in strength and some of it bursts through the partial reflector and serves as the output laser beam. A stage is reached where the population inversion caused by one flash of xenon tube is used up the laser beam then ceases till the next flash of xenon tube repeats the process. Thus the ruby laser is pulsed laser, of course, continuous wave lasers are also in use.

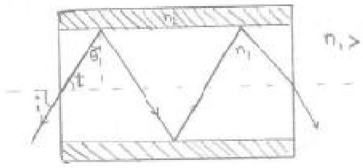
(OR)

3. a) What is numerical aperture of an optical fibre? And derive an expression for it.

Definition-1M; diagram-1M; Derivation-3M

ANS:- Definition:- Numerical aperture determines the light gathering ability of the fibre. The numerical aperture (NA) is defined as the sine of the acceptance angle.

Consider a ray which is incident on the entrance aperture of the fibre making an angle i with the axis as shown in fig. let r be the angle of refraction and θ the angle of incidence at the core cladding interface for the above ray.



The condition for total internal reflection to take place is $$\sin\theta \geq \left(\frac{n_2}{n_1}\right) \quad \text{—①}$$

Further $\sin\theta = \sin(90 - r) = \cos r$ —②

Now $\sin r = \sqrt{(1 - \cos^2 r)} = \sqrt{(1 - \sin^2\theta)}$

$$= \sqrt{\left(1-\frac{n_2^2}{n_1^2}\right)} = \sqrt{\left\{\frac{n_1^2-n_2^2}{n_1^2}\right\}} \quad (3)$$

From Snell's law, $\frac{\sin i}{\sin r} = n_1$ or $\sin r = \frac{\sin i}{n_1}$

The condition of total internal reflection can be expressed as.

$$\sin r \leq \sqrt{\left\{\frac{n_1^2-n_2^2}{n_1^2}\right\}} \quad (4)$$

From Eq (3) and (4) we have

$$\frac{\sin i}{n_1} \leq \sqrt{\left\{\frac{n_1^2-n_2^2}{n_1^2}\right\}}$$

or $\sin i \leq \sqrt{(n_1^2-n_2^2)}$ — (5)

let i_m be the maximum angle of incidence for which total internal reflection may occur. we have

$$\sin i_m = \sqrt{(n_1^2-n_2^2)} \quad \text{for } n_1^2-n_2^2<1$$
$$= 1 \quad \text{for } n_1^2-n_2^2>1 \quad (6)$$

Thus if a cone of light is incident on one end of the fibre, it will be guided through it provided the semiangle of the cone is less than i_m. $\sin i_m$ is known as numerical aperture (NA) of the fibre. The numerical aperture represents a measure of the light gathering power of the fibre. For all practical situations $n_1^2<n_2^2+1$ thus one defines the numerical aperture of the fibre by the equation

$$NA = (n_1^2-n_2^2)^{1/2} \quad (7)$$

3. b) Give the advantages of fibre optic communication system. Any five – 5M

Optical fibre has following advantages,

Security – almost impossible to tap the signal
Weight – lightweight , small size
Durability – high
Transmission loss – low
cost – low
power consumption – low
bandwidth – high
ect…

UNIT-II

4. a) Derive Schrodinger's time independent wave equation.

Derivation-5M

According to de Broglie theory, a particle of mass m is always associated with a wave whose wave length is given by $\lambda = \frac{h}{mv}$. If the particle has wave properties, it is expected that there should be some sort of wave equation which describes the behaviour of the particle. Consider a system of stationary waves associated with a particle Let x, y, z be the co-ordinates of the particle and "ψ", the wave displacement for the de Broglie waves at any time t. The classical differential equation of a wave motion is given by

$$\frac{\partial^2\psi}{\partial t^2} = v^2 \left[\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} \right] = v^2 \nabla^2\psi \longrightarrow (1)$$

where $\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}$

[∇^2 being Laplacian operator and v is the wave velocity]

The Solution of equation (1) gives φ as a periodic displacement interms of time i-e

$$\varphi(x,y,z,t) = \varphi_0(x,y,z)\, e^{i\omega t} \longrightarrow (2)$$

where $\varphi_0(x,y,z)$ is a function of x,y,z and gives-amplitude at the point considered. equation (2) can al be expressed as.

$$\varphi(\vec{r},t) = \varphi_0(\vec{r})\, e^{i\omega t} \longrightarrow (3)$$

Differentiating eqaution (3) twice weget.

$$\frac{\partial^2\varphi}{\partial t^2} = -\omega^2 \vec{\varphi_0}(r)\, e^{i\omega t} = -\omega^2\varphi$$

Substituting the value of $\frac{\omega}{v}$ in equation(4), we have.

$$\frac{\partial^2\varphi}{\partial x^2} + \frac{\partial^2\varphi}{\partial y^2} + \frac{\partial^2\varphi}{\partial z^2} + \frac{4\pi^2}{\lambda^2}\varphi = 0.$$

$$\nabla^2\varphi + \frac{4\pi^2}{\lambda^2}\varphi = 0 \longrightarrow (5)$$

Now from de Broglie relation $\lambda = \frac{h}{mv}$

$$\nabla^2\varphi + \frac{4\pi^2}{h^2} m^2 v^2 \varphi = 0 \longrightarrow (6).$$

If E and v be the total and potential energies of the particle respectively, then its kinetic energy $\frac{1}{2}mv^2$ is given by.

$$\frac{1}{2} mv^2 = E - V$$

(or)

$$m^2 v^2 = 2m(E-V) \longrightarrow (7).$$

from equation (6) and (7), we have.

$$\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} + \frac{\partial^2 \psi}{\partial z^2} + \frac{4\pi^2}{h^2} \times 2m(E-V)\psi = 0.$$

(or)

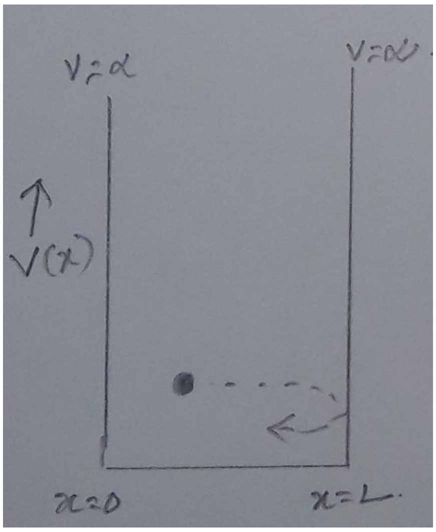
$$\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} + \frac{\partial^2 \psi}{\partial z^2} + \frac{8\pi^2 m}{h^2}(E-V)\psi = 0 \longrightarrow (8).$$

∴ Schrodinger one dimension time-independent wave equation is

$$\frac{\partial^2 \psi(x)}{\partial x^2} + \frac{8\pi^2 m}{h^2}(E-V)\psi(x) = 0.$$

4. b) Show that the energies of a particle in one dimensional box are quantized.

Derivation-5M



→ The schrodinger eqn (for $V=0$)

$$\frac{d^2\psi}{dx^2} + \frac{8\pi^2 mE}{h^2}\psi = 0$$

let $K^2 = \frac{8\pi^2 mE}{h^2}$

$$\therefore \frac{d^2\psi}{dx^2} + K^2\psi = 0.$$

The Solution.

$$\psi(x) = Ae^{iKx} + Be^{-iKx}$$

The boundary condition are

$\psi(x) = 0$ at $x = 0$

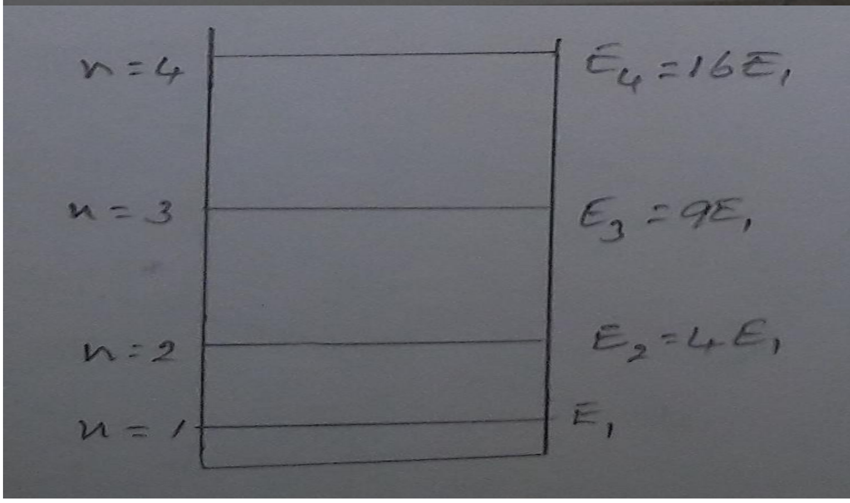
$\psi(x) = 0$ at $x = L$

$\sin KL = 0$

$KL = n\pi$

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

∴ The energy is quantised.

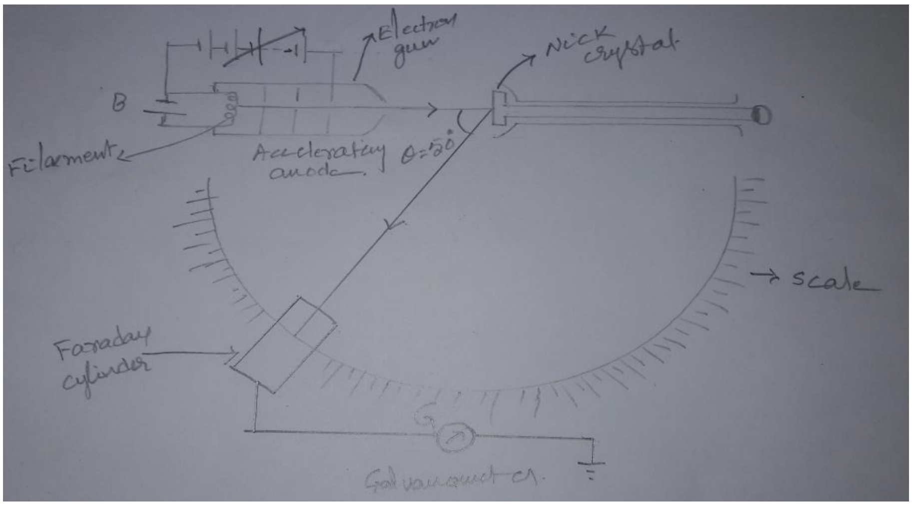


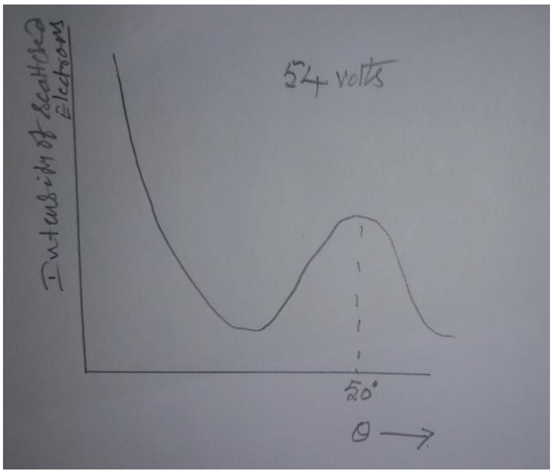
(OR)

5. a) Explain Davisson and Germer electron diffraction experiment to verify the concept of matter waves.

Procedure – 2M;Diagram-1M; Conclusion-2M

Davison and Germer Experiment:





When electron beam accelerated by 54 V was directed to strike the given nickel crystal, a sharp max in the electron diffraction occurred at an angle of 50^0 with the incident beam. The incident beam and the diffracted beam make an angle of 650 with the family of Bragg's planes. The whole instrument is kept in an evacuated chamber. The spacing of planes in Nickel crystal as determined by x-ray diffraction is 0.091nm From Bragg's law $2d\sin\theta = n\lambda$ i.e $2 \times 0.091 \times 10{-}9 \times sin65° = 1 \times \lambda$; λ =0.165nm Therefore for a 54 V electron beam, the de-Broglie wavelength associated with the electron is given by λ.= 12.27 √54 A°= 0.166nm This wavelength agrees well with the experimental value. Thus division experiment provides a direct verification of de-Broglie hypothesis of wave nature of moving particles.

5. b)Mention the properties of matter waves. Any five ---5M

1. The de-Broglie's wavelength is $\lambda = h/mv$
2. They can travel through vacuum
3. The wavelength associated with these waves decreases with increase in the mass of the microscopic particle
4. These waves are not electromagnetic waves.
5. They exhibit diffraction phenomenon.
6. The velocity of propagation of matter waves is greater than velocity of light c.

Etc…. any five ---5M

UNIT-III

6. a) Write down the drawbacks of classical free electron theory? Any five ---5M

This theory fails to explain

-- ferromagnetism, photoelectric effect, Compton effect and blackbody radiation.

-- temperature dependence of conductivity.

-- dependence of conductivity on electron concentration.

-- the theoretically predicted value of specific heat of a metal does not agree with the experimentally obtained value.

-- the theoretical value of paramagnetic susceptibility is greater than the experimental value.

-- the conductivity of semiconductors and insulators

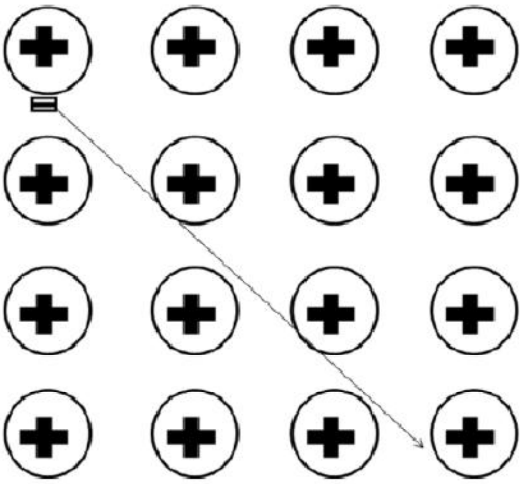
Etc…….

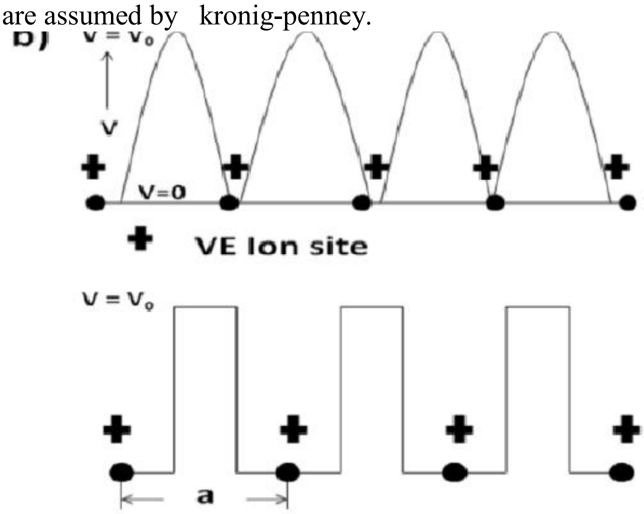
Any five ---5M

6. b) What are the silent features of kronig-penney model?

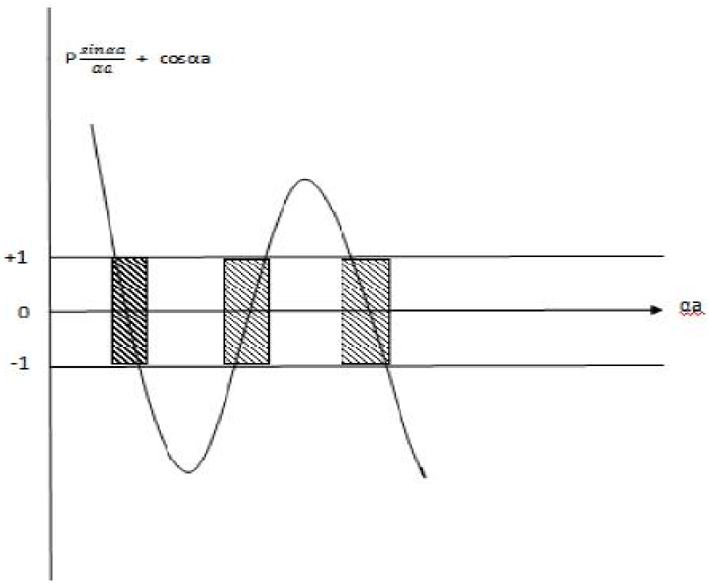
Any five ---5M

1. The rectangular potential wells and potential barriers are assumed by kronig-penney.





2,The allowed energy values of αa for which wave mechanical solutions exist are indicated by shadow Portions.

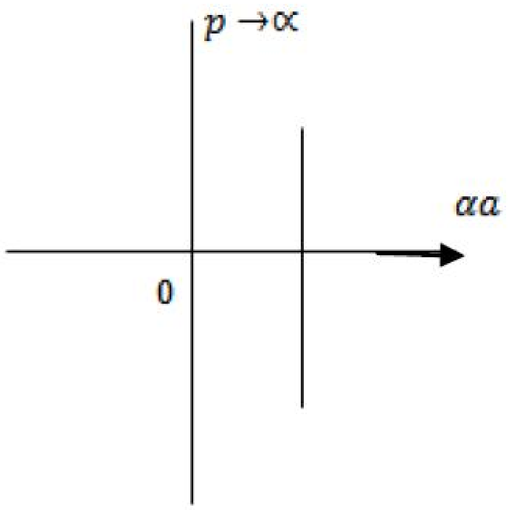


3. As αa increases

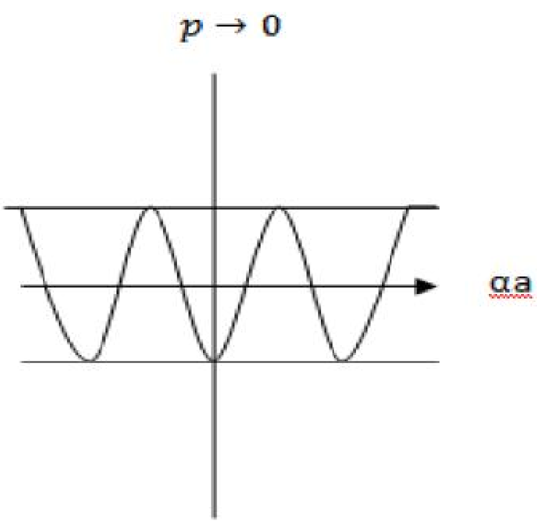
i) The width of allowed bands increases

ii) the width forbidden bands decreases

4. The allowed band reduces to one single energy level (isolated atom) when p→ infinite.



5. When p → zero, all energies are allowed.



6. The energies of electron will change from free electron to bound electron by varying p from zero to infinity.

Any five ---5M

(OR)

7. a) State and derive Bragg's law for X-ray diffraction.

Statement -2M; Derivation-3M

Bragg's law states that the path difference between the two reflected Xrays by the crystal planes must be an integral multiple of wave length of incident X-rays for producing constructive interference. Path difference = n λ

$$2d \sin\theta = n \lambda$$

Consider X-rays of wave length λ incident on a crystal at a glancing angle θ. The incident rays AB and DE after reflection from the lattice planes Y and Z travel along BC and EF respectively as shown in Fig

.

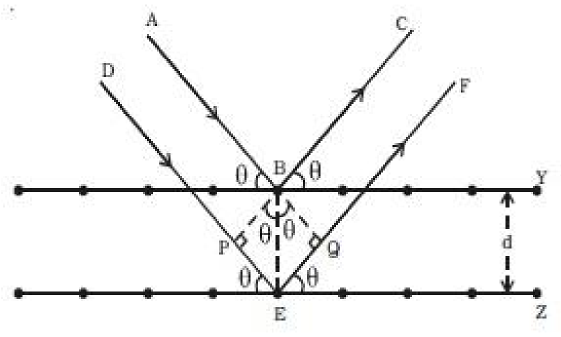


Fig *Bragg's law*

Let the crystal lattice spacing between the planes be *d*. BP and BQ are perpendiculars drawn from *B*on *DE* and *EF* respectively. Therefore, the path difference between the two waves ABC and DEF is equal to *PE* + *EQ*.

In the ΔPBE, sin θ = PE/BE (or) $PE = BE \sin\theta = d \sin\theta$

In the ΔQBE, sin θ = EQ/BE (or) $EQ = BE \sin\theta = d \sin\theta$

Path difference = $PE + EQ = d \sin\theta + d \sin\theta = 2d \sin\theta$

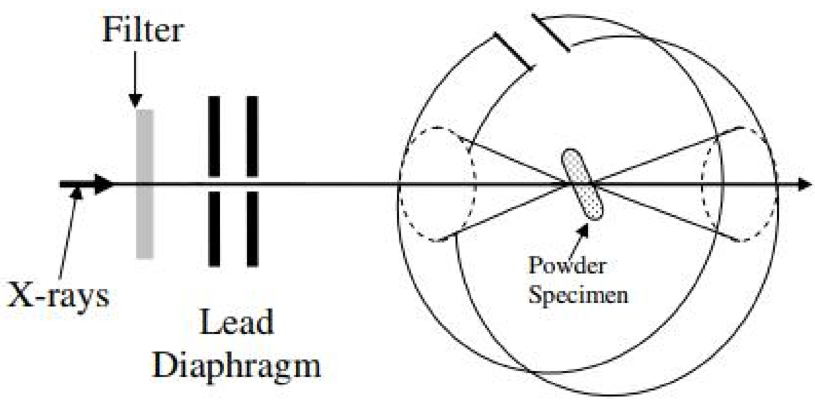
If this path difference $2d \sin\theta$ is equal to integral multiple of wavelength of X-ray i.e. $n\lambda$□ then constructive interference will occur between the reflected beams and they will reinforce with each other. Therefore the intensity of the reflected beam is maximum.

$2d \sin\theta = n\lambda$ where, n = 1, 2, 3

7. b) Explain X-ray powder diffraction method to determine the crystal structure.

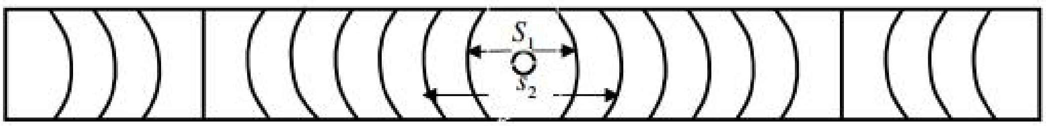
Explanation -2M; Diagram-1M; Procedure-2M

Powder method The powder method was developed by Debye and Sherrer in Germany and by hill in America simultaneously. This method is used to study the structure of crystals which cannot be obtained in the form of perfect crystals of appreciable1 size. This method can be used for pure metals, compounds and alloys. Basic Principle The basic principle underlying this powder technique is that, the specimen contains a large number of micro crystals (~ 12 10 in 3 1mm of powder sample) with random orientations, almost all the possible θ and d values are available. The diffraction takes place for these values of θ and d which satisfy Bragg's condition, i.e., 2d sinθ = nλ . Experimental arrangement:-



The experimental arrangement is shown in figure. The finely powdered sample is filled in a thin capillary tube and mounted at the center of the drum shaped cassette with photographic film at the inner circumference.

Collect the X-rays (non-monochromatic) from an X-ray tube. We obtain the monochromatic X-ray radiation by passing through the filter. This monochromatic X-ray radiation can be converted into fine pencil beam by passing through the lead diaphragms or collimators. The pencil beam of X-rays is allowed to fall on the thin walled capillary tube P containing the powdered crystal. The basic principle underlying this powder technique is that, the specimen contains a large number of micro crystals (~ 12 10 in 3 1mm of powder sample) with random orientations, almost all the possible θ and d values are available. The diffraction takes place for these values of θ and d which satisfy Bragg's condition, i.e., 2d sinθ = nλ . . For the value ofθ , the beam appears at the corresponding 2θ deviation. The pattern recorded on the photographic film is shown in the figure when the film is laid flat. Due to the narrow width of the film, only parts of circular rings are register on it. The curvature of arcs reverses when the angle of diffraction exceeds 0 90 .



Knowing the distances between the pair of arcs, various diffraction angles s 4θ ′ can be calculated by using the formula. $4\theta = \frac{S}{R}\frac{180}{\pi} = 57.296\frac{S}{R}$ Where r, is the radius of the camera. By knowing the value of θ from the above equation, the interplanar spacing (d) can be calculated for first order diffraction from Bragg's equation. $d = \frac{n\lambda}{2\sin\theta}$ Knowing all parameters, the crystal structure can be studied. Merits:- • Using filter, we get monochromatic x-rays • All crystallites are exposed to x-rays and diffraction takes place with all available planes. • This method is used for determination of crystal structure, impurities, dislocation density etc.,

UNIT-IV

8. a) Describe the magnetostriction method for the production of ultrasonic waves.

Definition – 1M; Procedure-2M;Circuit-1M;Equation-1M

MAGNETO-STRICTION GENERATOR

Principle: Magnetostriction effect: When a ferromagnetic rod like nickel or iron is placed in a magnetic field parallel to its length, the rod undergoes a small change in its length. This is called magnetostriction effect.

the frequency of the oscillatory circuit, f =1/2π $\sqrt{lc}$

This alternating current flowing through the coil L produces an alternating magnetic field along the length of the rod. The result is that the rod starts vibrating due to magnetostrictive effect.

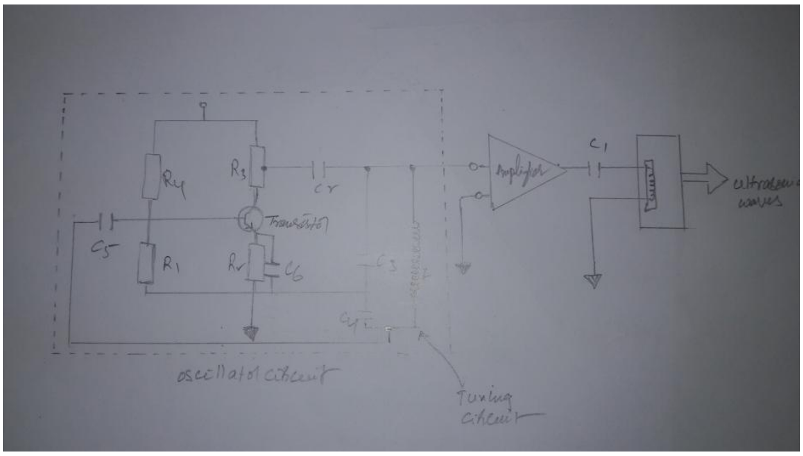
the frequency of vibration of the rod is given by f – 1/2l $\sqrt{y/p}$

where l = length of the rod

y = Young's modulus of the rod material and

p = density of rod material

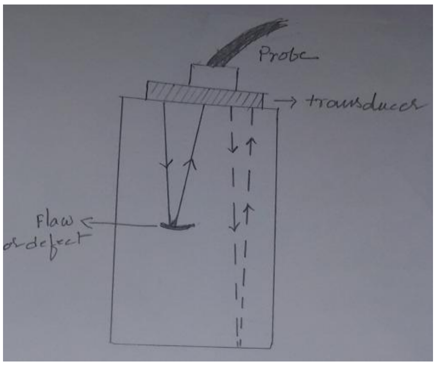
The capacitor C is adjusted so that the frequency of the oscillatory circuit is equal to natural frequency of the rod and thus resonance takes place. Now the rod vibrates parallel to length with amplitude and generates ultrasonic waves of high frequency from its ends.

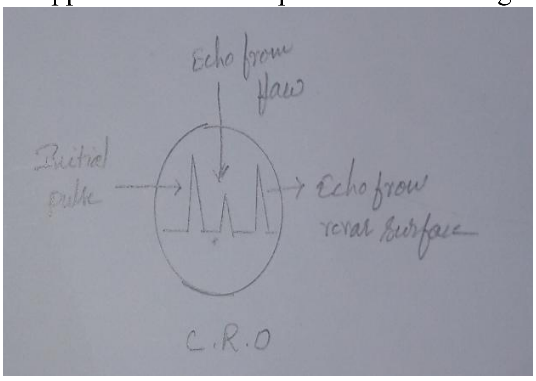


8. b) Write a short note on pulse echo method.

Principle-1M;Diagram-1M; Procedure-3M

When ultrasonic waves are transmitted through, it gets reflected by the flaw in the material and rarer surface and echoes are collected by by transducer. The distance of flaw from fron transducer can be claculated by the time interval between the generation ultrasonic ppluse and the reception of the echo signal.





(OR)

9. a) What are radio isotopes? Write medical and industrial applications of radio isotopes.

Definition-1M;Industrial app-2M; Medical app-2M

Isotopes:- Nuclei having same atomic number Z but different mass number A are called isotopes

Iodine-123 and Iodine-125 are used in medicine as tracers for imaging and evaluating the function of the thyroid.

Iodine-131 is used in medicine for treatment of thyroid cancer and Grave's disease.3

Cobalt-60 is largely used in radiotherapy.

Strontium-89 and Samarium-153 are used for the relief of cancer-induced bone pain.

Boron-10 is used in Boron neutron capture therapy a recent technique in cancer treatment.

Thallium-201 and Technetium-99 are used to detect the coronary artery disease and myocardial imaging.

Phosphorous-32 is used to control the growth of excess red blood corpuscles in bone marrow.

Chromium-51 is used to label red blood cells and quantify gastro-intestinal protein loss.

Copper-64 is used to study genetic diseases affecting copper metabolism.

Xenon-133 is used for pulmonary (lung) ventilation studies.

Applications of radioisotopes in Industries

1. The thickness of paper, plastics, clothes and metal sheets need to be standardised and this is done by placing a raioactive source at one side of the material and a detector on the other side.
2. For sheets of metal, gamma ray is used. For plastics, clothes and paper, beta particles are used.

3. The detector will register a higher count if the material is too thin and lower register if too thick. The computer will make adjustments according to the thickness of the material.
4. This mechanism is also used to ensure that containers such as cans and food packages are filled to the specified amount.
5. Radioisotope is added to engine oil so that its level of wear and tear can be determined.
6. In order to kill germs that cause food to spoil quickly, gamma rays are used.

Def-1M Any 3+3 application --- 4M

9. b) Compare the properties of alpha, beta and gamma radiations.

Any five comparisons– 5M

	Alpha	Beta	Gamma
Nature of radiation	Helium nucleus 2 protons + 2 neutrons	High energy electrons	High frequency electromagnetic radiation
Charge	+2	-1	0
Ionizing power	Very high	moderate	low
Penetration	least	medium	Very high
Effect of electric and magnetic field	Less deflected	More deflected	uneffected