SECOND SEMESTER B-TECH DEGREE EXAMINATION

MAY - 2016

PH100 ENGINEERING PHYSICS

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CE-1
NO:55

PART- A

1) Distinguish between free oscillation and damped oscillation.

A motion that repeats at regular interval of time is called periodic motion. Here simple harmonic motion is also a periodic motion where the restoring force is directly proportional to displacement and acts in the direction opposite to displacement. it is the free oscillation. Amplitude is constant

The damped harmonic motion is the SHM in which amplitude is steadily decreased due to the action of damping force like friction or air resistance

2 State the laws of transverse vibrations of a stretched string

(1) Law of length:

The fundamental frequency of vibration of a string is inversely proportional to the length $\nu \propto \frac{1}{l}$ T & μ are constant

(2) Law of tension

frequency of the string is proportional to square root of its tension provided $\nu \propto \sqrt{T}$ length & mass/unit length are same

(3) Law of mass

The frequency of string is inversely proportional to square root of linear mass density $\nu \propto \frac{1}{\sqrt{\mu}}$ or $\left(\nu = \frac{1}{2l} \times \sqrt{T/\mu} \right)$

3) What do you mean by optical path ?

Ans :- Optical path length is the length of path travelled by a light in the optical medium with refractive index μ and thickness t

ie optical path length = refractive index x thickness

(optical path length = μt)

4) What is grating element ? Write down the grating equation in terms of grating element ?

- The distance between corresponding point of adjacent slit is called grating element, if a = slit width and b = line width

Then grating element = $a+b$

If there are N lines per unit length, $N(a+b) = 1$

$(a+b)\sin\theta = n\lambda$ ⇒ grating equation in terms of grating element

Here $N = \frac{1}{a+b}$

5) What is retardation plate ? Write the expression for the thickness of a QWP and HWP ?

When a plane polarised light incident on a crystal there is a phase difference in between o-ray and e-ray Such type plates are called retardation plate

$$t_{HWP} = \frac{\lambda}{2(\mu_0 - \mu_e)}$$

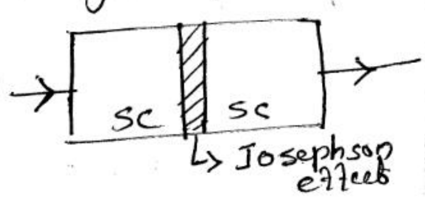
$$t_{QWP} = \frac{\lambda}{4(\mu_0 - \mu_e)}$$

μ_0 : refractive index of o-ray
μ_e : refractive index of e-ray.
λ = wavelength
t : thickness

6) What is DC Josephson effect

Cooper pairs can penetrate from one superconductor to second superconductor with no resistance, producing a DC current without any voltage across the junction. This effect is known as DC Josephson effect
(Here the two superconductors are separated by thin layer of insulator (1-10 nm))

fig:



9) Distinguish between reverberation and echo

The persistance of sound in a hall due to the multiple reflection from various object in the hall even after the sources of sound has cutoff is called reverberations

Echo is the repitition of sound waves due to multiple reflection from the walls ceilings etc. The reflected sound from different distant objects is remain in human ear for $\frac{1}{7}$ of sec.

10 How ultrasonic waves are detected by thermal method ?

- When ultrasonic waves are travelling through gaseous or liquid medium alternate compression and rarefraction are developed
- At antinodes the temperature remains constant but at nodes the temperature changes
- When platinum resistance thermometer is slowly moved in the path of ultrasonic the resistance of wire changes at nodes and remains constant at antinodes .
- If there is such variations in resistance then the waves are ultrasonic

11) 8) How population Inversion is achieved in Ruby laser ?

population inversion is achieved by optical pumping In ruby laser , The chromium ions possess suitable energy levels to produce laser . ruby rod is surrounded by Xenon flash tube . When it is on, the Cr^{3+} ions absorbs the energy get excited into highest energy level. The life time is 10^{-8} sec at that stage so they are suddenly jumps to metastable state where the life time is 10^{-3} sec

That is no . of chromium ion gets increased and population inversion takes place

7) How do you account for the natural line broadening on the basis of heisenberg's uncertainty principle?

- The uncertainty relation can be stated for the frequency and energy of a radiation emitted by an excited atom The average time gap between the excitation of an atom and the consequent photon emission is Δt

$$\Delta E \Delta t \geq \hbar/2$$

we have $\Delta E = h\Delta \nu$

ie $\Delta \nu \Delta t \geq \hbar/2$

$$\Delta \nu = \frac{\hbar}{2\Delta t}$$

The spectral line emitted is not at all sharp, but it has some width or the line emitted will have some broadening in frequency called natural line broadening

8 What do you mean by fermi energy level and fermi energy?

The fermi energy level may be defined as the highest filled energy level by an electron at absolute zero or energy level for which probability of occupancy is 1/2 at non zero absolute temperature

Fermi energy is the average energy possessed by electrons that participate in conduction process in metals at at temperature above zero kelvin

12) Explain the principle of propagation of light through an optic fibre. ?

Total internal reflection. The propagation of light from an optically denser medium of refraction index n_1 into an optically rarer medium of refraction index n_2. If the angle of incidence is less than the critical angle the ray is refracted into the rarer medium.

PART - B.

13) What are the conditions for oscillation of a harmonic oscillator to be over damped, critically damped and under damped. compare the time- displacement curve in the three cases?

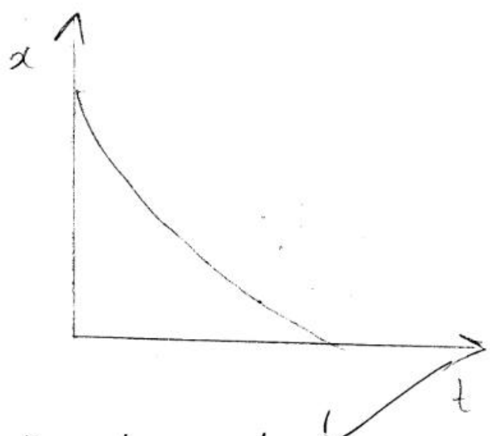
(a) Over damped

$$r > \omega_0$$

Here $x = A_1 e^{-r + \sqrt{r^2 - \omega_0^2}} + A_2 e^{-r - \sqrt{r^2 - \omega_0^2}}$

Here the displacement decreases exponentially to zero without any oscillations

The graph is



(b) Critically damped

$$r = \omega_0$$

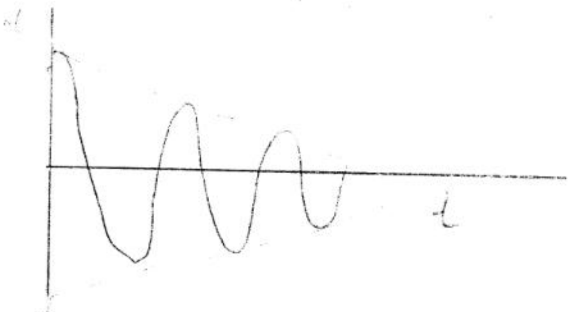
$x = c e^{-rt}$ $\Rightarrow$ here displacement decreases to zero without any oscillations they aquires eqm position quickly

(c) Underdamped (low damping)

condition $r < \omega_0$

Here $x = a_0 e^{-rt} \sin(\omega t + \phi)$

(This motion is oscillatory)



14) A piece of wire 50 cm long is stretched by load of 2.5 kg and has mass of 1.44 g find the frequency of 2nd harmonic

$m = 1.44\,g = 1.44 \times 10^{-3}\,kg$

$l = 50\,cm = 50 \times 10^{-2}\,m$

$M = 2.5\,kg$

$T = mg$

$= 2.5 \times 9.8$

$= 24.5\ kg\,m/s^2$

$$\nu = \frac{1}{l}\sqrt{\frac{T}{\mu}} = \frac{1}{50 \times 10^{-2}} \times \sqrt{\frac{2.5 \times 9.8}{2.88 \times 10^{-3}}}$$

$$\nu = \frac{1}{50 \times 10^{-2}} \sqrt{\frac{24.5}{2.88 \times 10^{-3}}}$$

$$\nu = 184.466\ Hz$$

15) Light of wavelength 6000 A° falls normally on two glass plates enclosing a wedge shaped film. The plates touch at one end and are separated at 10 cm from that end by a wire. If the band width of the interference pattern is 0.05 mm find the diameter of the wire?

$$\beta = \frac{\lambda l}{2d}$$

$\lambda = 6000\ A^\circ = 6000 \times 10^{-10} m$

$\beta = 0.05\ mm = .05 \times 10^{-3} m$

$d = ?$

$l = 10\ cm = 10 \times 10^{-2} m$

$$d = \frac{l \lambda}{2\beta}$$

$$d = \frac{10 \times 10^{-2} \times 6000 \times 10^{-10}}{2 \times .05 \times 10^{-3}}$$

$d = 6 \times 10^{-4} m$ ✓

16) Light of wave length 589.3 nm is incident normally on a plane transmission grating having 6000 lines/cm calculate the angle at which the principal maxima of the first order is formed

$\lambda = 589.3 nm = 589.3 \times 10^{-9} m$

$N = 6000\ lines/cm = 6000 \times 10^{2}\ lines/m$

$n = 1$

$\sin\theta = nN\lambda$

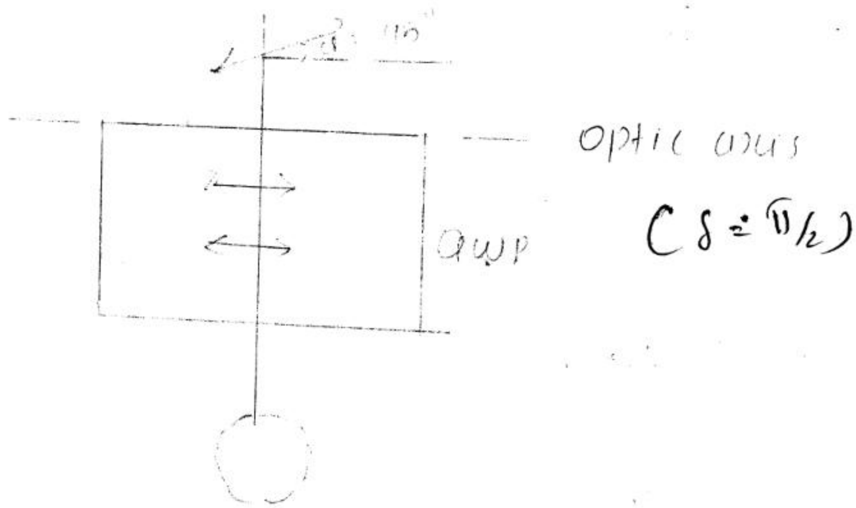
$= 1 \times 6000 \times 10^{2} \times 589.3 \times 10^{-9}$

$= .35358$

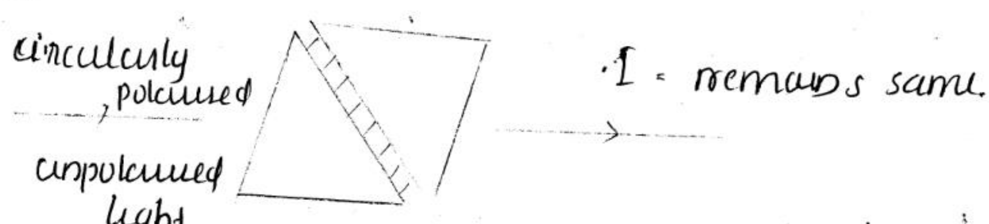
$\theta = \sin^{-1}(.35358) = 20.706 = 20^{\circ} 42' 23.19''$

17) How do you distinguish circularly polarised light from unpolarised light

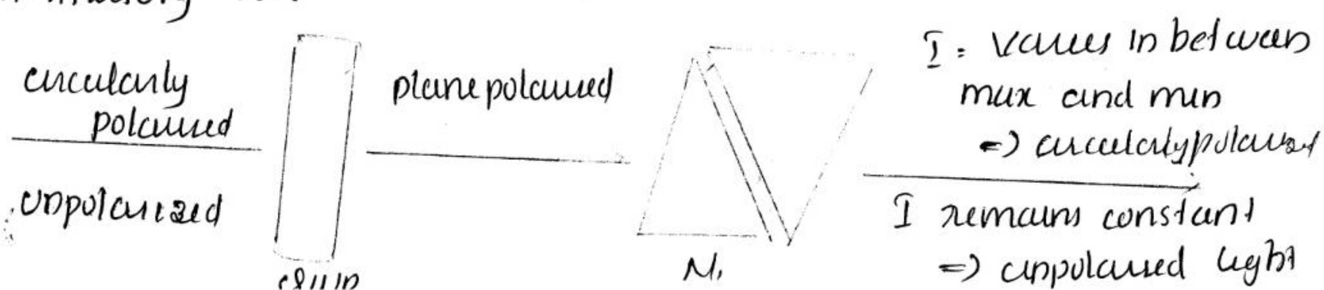
When a plane polarised light having angle of vibration $\theta = 45^{\circ}$ is incident normally on a QWP then the emergent light circularly polarized



Detection



Confirmatory test



* If intensity varies in between maximum and zero minimum then the given light is circularly polarised
* If intensity remains same. Then the given light is unpolarised

18) Write any four applications of super conductors

① Super conductors are used to produce a very strong and powerful magnetic field in the order of 20T, these high field is used in particle accelerators, cyclotrons controlled nucleus fusion etc

② Medical application.
Important medical application in MRI
Group of squids are used for the diagnosis epilepsy

③ Electronics and small devices
* SQUID
* Frictionless bearing magnetically controlled Superconducting Switches, super conductor fuses, breaker

④ Computers
Super computers are buildup with super conductors

21) ~~Given that the~~ The dimensions of an auditorium are 60m x 15m x 10m and its interior surfaces have an average absorption co-efficient of ·25 find the reverberation time of the auditorium

$$T = \frac{0.163V}{A}$$

$$= \frac{.163 \times 9000}{3300 \times 0.25}$$

$$T = 1.77 \text{ sec}$$

$a = .25$

$V = 60 \times 15 \times 10 = 9000 m^3$

$S = 2(lb + bh + hl)$

$= 2 \times (60 \times 15 + 60 \times 10 + 15 \times 10)$

$= 3300 m^2$

22) Given that the velocity of ultrasonic waves in sea water is equal to 1440 m/s. Find the depth of submerged submarine. If ultrasonic pulses reflected from the submarine is received .33s after sending ultrasonic wave

here $t = .33s$

$V = 1440 m/s$

$$d = \frac{Vt}{2}$$

$$= \frac{.33 \times 1440}{2}$$

$$d = 237.6 \text{ m}$$

19) What are the conditions to be satisfied by a wave function.

- The wave function is a complex quantity
- $\psi(x,t)$ must be single valued and continuous everywhere
- Its derivatives $\frac{\partial \psi}{\partial x}, \frac{\partial \psi}{\partial y}, \frac{\partial \psi}{\partial z}$ must be continuous and single valued everywhere
- The wave function ψ itself has no physical meaning but the square of absolute magnitude $|\psi|^2$ $(\psi\psi^*)$ is the probability of finding the particle
- ψ must be a normalised function

$$\int_{-\infty}^{+\infty} \psi\psi^* \, dx\,dy\,dz = 1$$ Total probability of finding the particle in overall space

- It must be ~~sta~~ satisfy boundary condition.

i.e. $x, y, z \rightarrow \pm\infty$, $\psi(x,y,z) \longrightarrow 0$

This is called boundary condition.

20) What is phase space. With the help of heisenberg uncertainty principle, show that the minimum size of the unit cell in quantum statistics is h^f. where h is the planck's constant and f is the degree of ~~the system~~ freedom of the system.

phase space is a six dimensional space with six mutually perpendicular co-ordinates x, y, z P_x, P_y, P_z used to describe a single particle

Here $x, y, z \rightarrow$ position co-ordinates

$p_x, p_y, p_z \rightarrow$ momentum co-ordinates

If there are "N" Numbers of particles with 'f' numbers position co-ordinates $q_1\ q_2\ q_3 \cdots q_f$ and f numbers of momentum co-ordinates $p_1, p_2 \cdots p_f$ then phase space is a 2f dimensional space formed by f number of position co-ordinates and f number of momentum co-ordinates

A small volume $d\tau = dq_1\, dp_1 \cdot dq_2\, dp_2 \cdots\cdots dq_f\, dp_f$

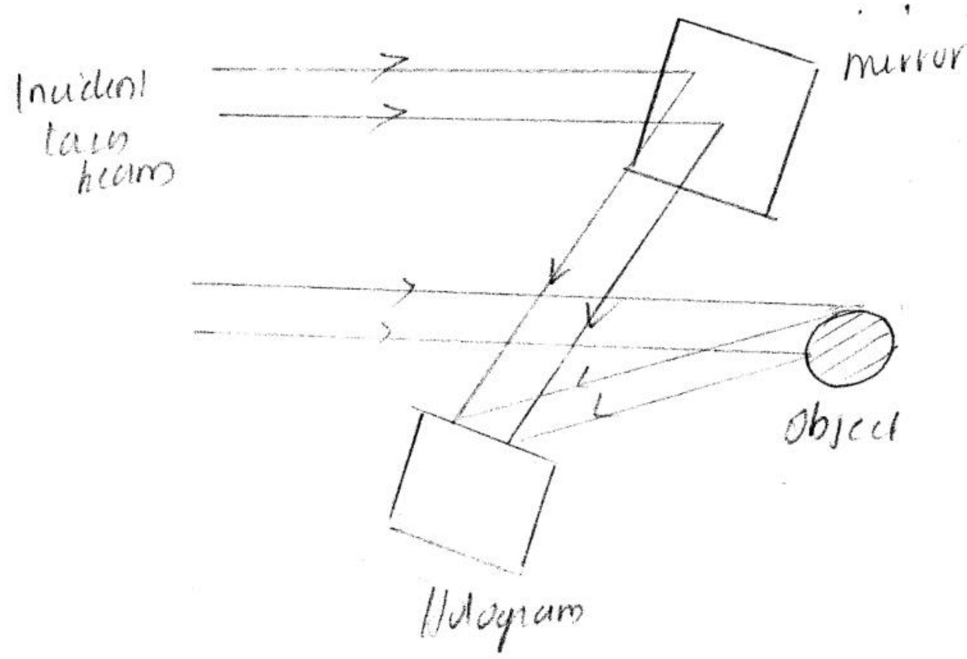
according to uncertainty principle,

$$dq_1\, dp_1 \geq \hbar/2$$
$$dq_2\, dp_2 \geq \hbar/2$$
$$\cdots\cdots\cdots$$

$$d\tau = dq_1\, dp_1 \cdot dq_2\, dp_2 \cdots dq_f\, dp_f \approx \underline{\underline{h^f}}$$

$\therefore$ The minimum size of unit cell in equilibrium statistics is h^f

23 With the help of neat diagram explain how a hologram is recorded.



Wave directly reached to the hologram

is reference wave.

wave reflected from object => object wave

The reference wave and object wave are superimposed on hologram and interference pattern is recorded on the hologram

- This interference pattern contains all informations about the object

Q4) A fibre cable has an acceptance angle of 30° and a core of refractive index 1.4 calculate the refractive index of cladding

$$\sin a_m = \sqrt{n_1^2 - n_2^2}$$

Here $\alpha_m = 30^\circ$, $n_1 = 1.4$

$\sin 30 = \frac{1}{2}$

$$\sqrt{n_1^2 - n_2^2} = \frac{1}{2}$$

$$n_1^2 - n_2^2 = \frac{1}{4}$$

$$(1.4)^2 - \frac{1}{4} = n_2^2$$

$$n_1^2 = 1.71$$

$$n_1 = \underline{\underline{1.307}}$$

PART- C

28) Compare M-B, B-E and FD statistics

Maxwell-Boltzmann	Bose Einstein	Fermi-Dirac
It is a classical statistics	It is a quantum statistic	It is a quantum statistics
particle are identical and indistinguishable	particles are identical and distinguishable	particles are identical & distinguishable
No spin consideration	zero spin & integral spin	half spin
Does not obeys paulis exclusion principle	Does not obeys paulis exclusion principle	Obeys paulis exclusion principle

Energy levels are continuously distributed	energy levels are discrete	energy levels are discrete
Does not obey Uncertainty principle	obey uncertainty principle	obeys uncertainty principle
$f_{MB}(E) = \frac{1}{e^{\alpha} e^{E/kT}}$	$f_{BE}(E) = \frac{1}{e^{\alpha} \cdot e^{E/kT} - 1}$	$f_{FD}(E) = \frac{1}{e^{\alpha} \cdot e^{E/kT} + 1}$ $\alpha = -E_F/kT$

31) Lasing medium with metastable state, optical resonator and pumping mechanism are the essential requirement of a laser. How it is satisfied in He-Ne laser

He-Ne laser is a four level laser.

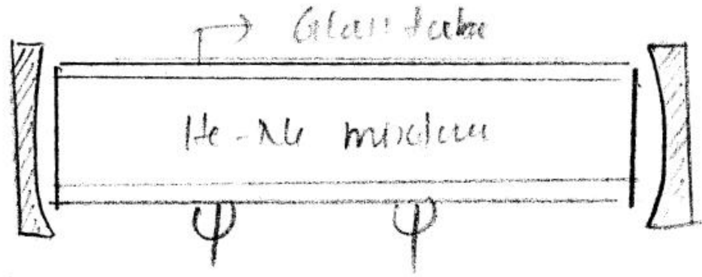
Energy source is RF discharge power

pumping is the electric discharge pumping

Lasing medium is He-Ne gas mixture (10:1 ratio)

Optical resonator: Two mirrors m_1 & m_2

Here He is a pumping agent ~~He~~ Ne is lasing agent



Working

. When power is ON, He atoms are excited to level F_2.

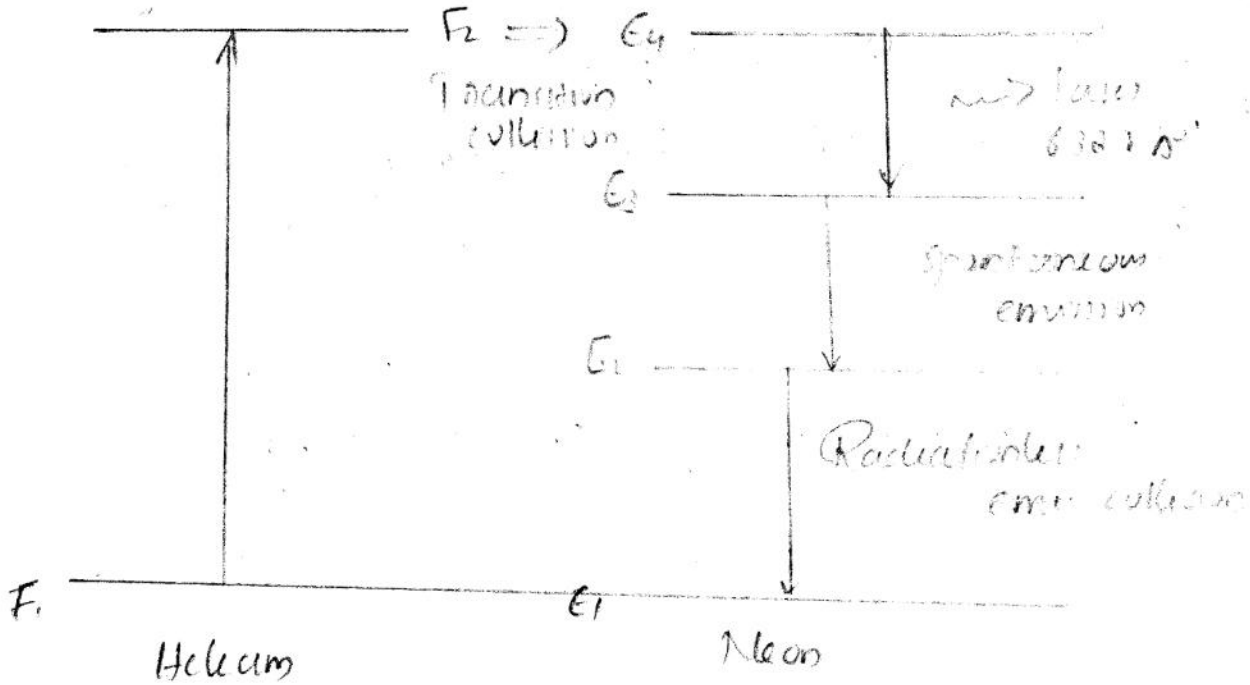
· The energy of He atom can be transferred to Ne atoms when they collide

Due to the collision, Ne atoms are excited to E_4 level and population inversion is achieved at E_4 level

- Spontaneously emitted photon in the system triggers the stimulated emission
- Stimulated emission takes place from E_4 to E_3. These photons are shuttled between M_1 & M_2 then highly coherent laser beam is produced $\lambda = 6328\ \text{Å}$ (red)

The transition $E_3 \longrightarrow E_2$ is spontaneous

The Ne atoms at E_2 are de-excited to E_1 by colliding with walls of the tube. (Radiationless transition)



Part-C

Q5) Write the differential equation of a forced harmonic Oscillator and write its solution. Derive the expression for the amplitude and phase difference in terms of the natural frequency of the body and frequency of applied periodic force.?

$$\frac{d^2x}{dt^2} + 2\sigma\frac{dx}{dt} + \omega_0^2 x = f_0 \sin\omega_f t \quad \text{—} (1)$$

It is the differential equation of a forced harmonic Oscillator.

We assume the solution of differential equation of a forced harmonic oscillator as

$$x = A\sin(\omega_f t - \theta)$$

So here

$$\frac{dx}{dt} = A\omega_f \cos(\omega_f t - \theta)$$

$$\frac{d^2x}{dt^2} = -A\omega_f^2 \sin(\omega_f t - \theta)$$

$(1) \Rightarrow$ $-A\omega_f^2 \sin(\omega_f t - \theta) + 2\sigma A\omega_f \cos(\omega_f t - \theta)$

$+ \omega_0^2 A\sin(\omega_f t - \theta) = f_0 \sin(\omega_f t - \theta + \theta)$

$-A\omega_f^2 \, f \sin(\omega_f t - \phi) + 2r A\omega_f \cos(\omega_f t - \phi) + \omega_0^2 A \times$

$\sin(\omega_f t - \phi) = f_0 [\sin(\omega_f t - \phi)\cos\phi + \cos(\omega_f t - \phi)\sin\phi]$

$\Rightarrow \sin(\omega_f t - \phi)[-A\omega_f^2 - f_0\cos\phi + A\omega_0^2] + \cos(\omega_f t - \phi)[2rA\omega_f - f_0\sin\phi] = 0$

To find amplitude A

the coefficient of $\sin(\omega_f t - \phi)$ and $\cos(\omega_f t - \phi)$ are separately equal to zero

$-A\omega_f^2 - f_0\cos\phi + A\omega_0^2 = 0$ or $A\omega_0^2 - A\omega_f^2 = f_0\cos\phi$ — ②

$2rA\omega_f - f_0\sin\phi = 0$ $\quad$ $2rA\omega_f = f_0\sin\phi$ — ③

Squaring and adding

$$(A\omega_0^2 - A\omega_f^2)^2 + (2rA\omega_f)^2 = f_0^2$$

$$A^2 = \frac{f_0^2}{(\omega_0^2 - \omega_f^2)^2 + 4r^2\omega_f^2}$$

$$A = \frac{f_0}{\sqrt{(\omega_0^2 - \omega_f^2)^2 + (4r^2\omega_f^2)}}$$

" The amplitude of forced harmonic Oscillator

$$A = \frac{f_0}{\sqrt{(\omega_0^2 - \omega_f^2)^2 + 4r^2\omega_f^2}}$$

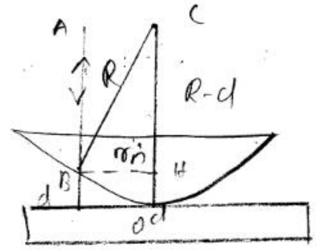
deviding ② and ③ we get

$$\tan \phi = \frac{2 r \omega_f}{\omega_0^2 - \omega_f^2}$$

$$\cancel{\phi = \tan^{-1}\left(\frac{2 r \omega_f}{\omega_0^2 - \omega_f^2}\right)}$$

ϕ is the phase difference between forced oscillation and applied force

Q6) Derive the expression for the diameter of the n^{th} dark ring in newton's ring interference pattern. with necessary equation explain briefly the experimental procedure to determine the refractive index of a liquid.



AB → Incident wave normally at the point B

R → radius of curvature of the lens

d - thickness of the film at 'B'

r_n - radius of n^{th} ring

From figure, $\triangle CHB$

$$r_n^2 + (R-d)^2 = R^2$$

$$r_n^2 + R^2 - 2Rd + d^2 = R^2$$

d is too small d^2 can be neglected.

$$r_n^2 = 2Rd$$

For dark ring we know,

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

$$2\mu d = n\lambda$$

$$2d = \frac{n\lambda}{\mu}$$

$$r_n = \sqrt{2Rd}$$

$$r_n = \sqrt{\frac{nR\lambda}{\mu}}$$ $D_n = 2r_n$

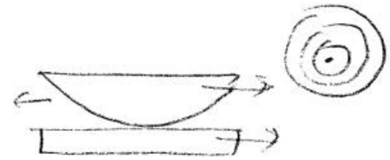
ie diameter of nth dark ring $D_n = 2\sqrt{\frac{Rn\lambda}{\mu}}$

⇒ refractive index

- 1st we place plano convex lens on a plane glass plate
- Monochromatic light is allowed to fall normally on the newton's ring arrangement
- Due to Interference, large no of concentric rings are formed
- By using travelling microscope, the diameters of 2nd, 4th ... 20th dark rings are measured
- $D_{n+k}^2 - D_n^2$ is calculated in the air film
- secondly we place a drop of liquid on plane glass plate and then place planoconvex lens so a liquid film is formed between glass plate and the lens
- Here also we get determine the diameter of $2^{nd}, 4^{th} \ldots 20^{th}$ by using travelling microscope. measure $d_{n+k}^2 - d_n^2$

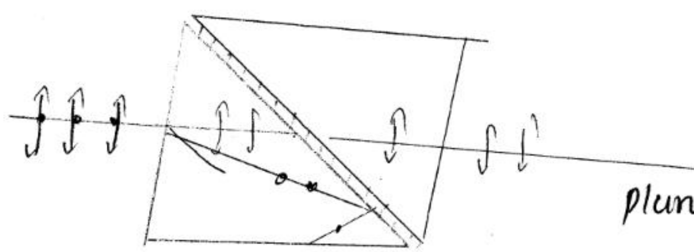
By using equation

$$\mu = \frac{D_{n+k}^2 - D_n^2}{d_{n+k}^2 - d_n^2}$$ we can determine the values of refractive index.



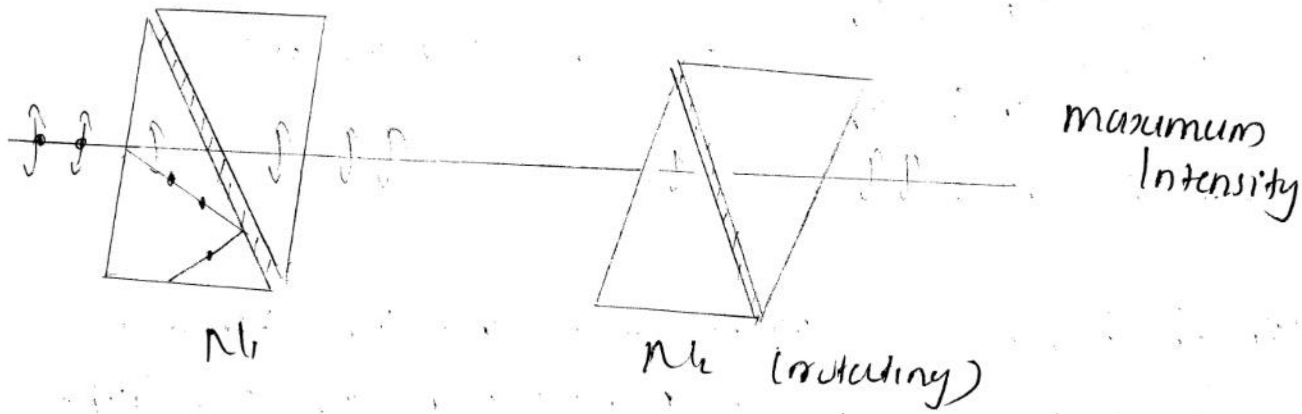
27) With the help of neat diagram of the principal section of a nicol prism write how it produces plane polarised light and how it can be used for the analysis of plane polarised light.

Polariser



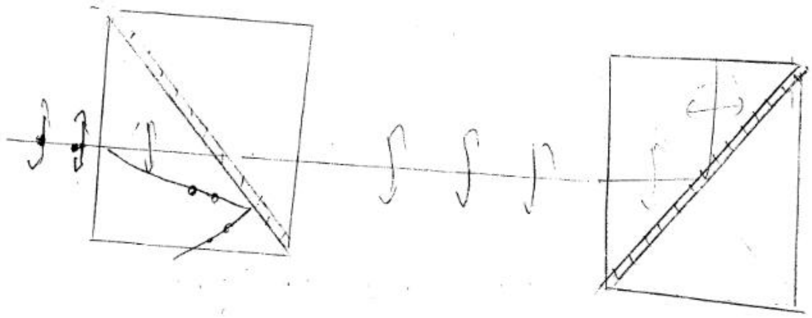
- When an unpolarised light is passed through a nicol Inside the nicol it splits into two o ray & e-ray (double refrac?
- For o-ray it travels from denser to ($\mu_o = 1.66$). rarer ($\mu_{CB} = 1.54$) so o-ray undergoes total internal reflection
- Internal reflection and reflected back to the same medium & it is absorbed by the back surface.
- But e-ray travels from rarer (1.49) to denser ($\mu_{CB} = 1.54$) medium. so e-ray is refracted through the crystal
- So we get plane polarized light ⇒ Hence Nicol acts as a polarizer

Nicol acts as an analyser



⇒ Angle between N_1 & N_2 $(\theta) = 0$

⇒ so we get maximum Intensity



Angle between N_1 & N_2 $= 90°$ ⇒ Intensity $= 0$

For analysing, the light from N_1 is allowed to passed through rotating nicol (N_2) when N_1 & N_2 are parallel ($\theta = 0$) intensity is maximum and when $N_1 \perp N_2$. Thus we get zero Intensity

- Reason: when $N_1 \perp N_2$ the refractive index reaches a value $\mu_E = \mu_O = 1.66$, so e-ray travels from denser to rarer and undergoes total internal reflection.

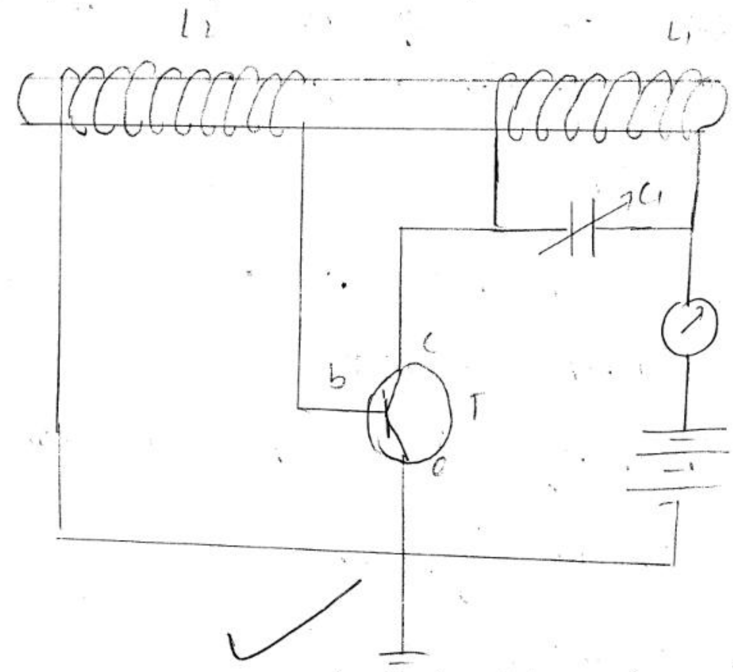
So Nicol acts as an analyser

29) What are ultrasonic waves? Write the principle of production of ultrasonic waves by magnetostriction effect. Draw the circuit diagram of the magnetostriction oscillator. Write any two applications of ultrasonic waves.

· Ultrasonic waves are the waves with frequency greater than 20 KHz. They travels through any medium like solid, liquid & gas, they can not travel through vaccum

production of ultrasonic waves by magnetostriction effect

· When a ferromagnetic wave rod is subjected to a magnetic field parallel to its length, the length increases or decreases. This effect is called magnetostriction effect



Applications

· ultrasonics is used in the process of diagnosis and in treatments

· mainly used in ultrasonic imaging systems

· By using it, we can find the deposition of lipid &

cholestrol particle

- used for bloodless surgery

30 Define Intensity of sound wave. Write the expression for SIL in dB scale. Distinguish between threshold minimum intensity and threshold pain intensity.

It is the amount of sound energy transported per second per unit area of cross section normal to the direction of propagation

$$\text{Intensity} \propto (\text{amplitude})^2 \text{ of sound wave}$$

Unit of loudness (sound Intensity level)

we know that Bel is the large unit so a smaller unit called decibel (dB) is used as standard

$$10\ dB = 1\ Bel$$

Threshold minimum Intensity is $I_0 = 10^{-12}\ W/m^2$

or corresponding loudness = 0 dB

Threshold pain Intensity is $I = 1\ W/m^2$ corresponding

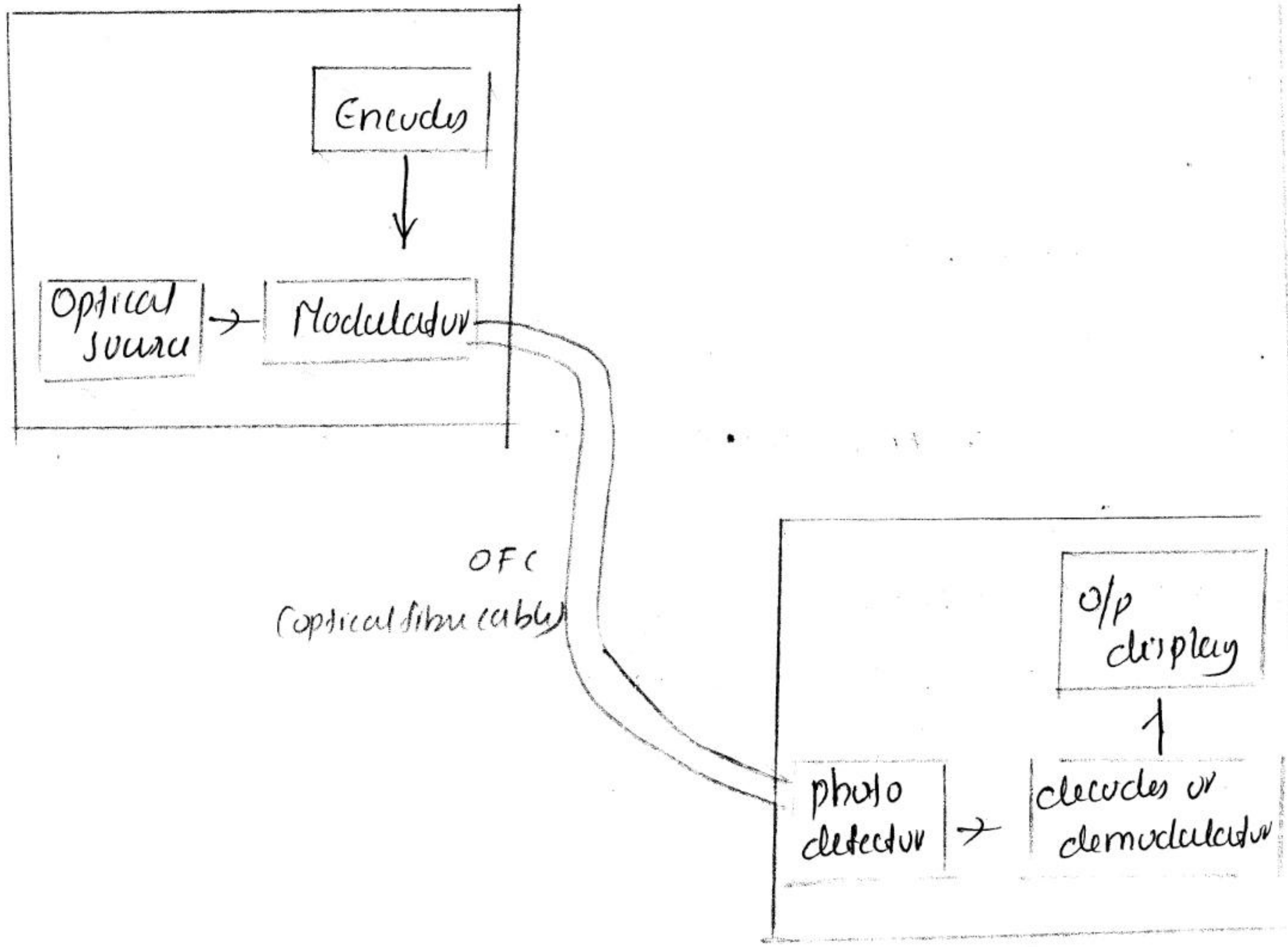
loudness $L = 10 \log \frac{1}{10^{-12}}\ dB$

$= 10 \times \log 10^{12}\ dB$

$= 120\ dB$

A

32) With a block diagram explain fibre optic communication system.



The optic communication system consists of ① Transmitter ② Information channel (Optic fibre cable) ③ Receiver

The transmitter converts electrical signal into optical signal. It consists of

(i) i/p signal from microphone or audio signal

(ii) Encoder ⇒ converts the electrical signal into digital signal

(iii) optical source ⇒ provide light for transmission through optic fibre cable

(iv) Modulator ⇒ Modulate o/p of light source w.r.t information signal

② Optical fibre cable (OFC)

Transmit information containing light by multiple total internal reflection

③ Receiver

It consists of, (i) photodetector: converts light into electrical signal

(ii) decoder - demodulate information from electrical signal and amplify it

(iii) o/p display - microphone, TV, computer etc