Session - 2022 - 23

BTech CSE (1-year)

1- Distinguish between single slit and double slit diffraction patterns.

Ans → In single - slit diffraction, light waves passing through a narrow slit spread out and interfere with each other, creating a pattern of bright and dark fringes on a screen. The central fringe is the brightest and widest, with the intensity of the light decreasing for fringes further from the centre.

On the other hand, double - slit interference involves light passing through two closely spaced slits. The light waves from each slit spread out and overlap, creating an interference pattern of evenly spaced bright fringes on a screen. This pattern is also due to constructive and destructive interference.

~~6~~ 2- Discuss the condition for missing order with a diffraction grating.

Ans → when light is diffracted, it can also produce an inference pattern, e.g with 2 slits. The two patterns superimpose, or the interference pattern appears within the diffraction pattern envelope. So, a diffraction minimum may appear at the same place as an interference maximum and so will cancel out, giving a missing order.

3.- Distinguish Between Spontaneous and Stimulated emissions.

Ans → Spontaneous Emission → An atom in the excited state is unstable due to its tendency to restore its lower energy state configuration, so it does not stay in excited state for longer time (10^{-8} s) But return to the lower energy state by releasing energy $h\nu = E_2 - E_1$ in the form of radiation, this transition is known as spontaneous Emission.

Stimulated emission → There is another mechanism by which an atom returns back to lower energy state by releasing radiation. In this mechanism, a incident photon of Energy $h\nu = E_2 - E_1$ induces the excited atom to make a downward transition with the release of photon of same frequency. so for one photon induction there are 2 photons emitted. This phenomena is called stimulated Emission.

4- Explain the phenomena of optical rotation.

Ans → Optical rotation, also known as optical activity, is a phenomenon observed in certain substances, particularly chiral (asymmetric) molecules, where the plane of polarizied light is rotated as it passes through the substance. This effect occurs due to the interaction between the polarized light and the chiral molecules in the material.

5- Define optic axis and principle section of the crystal.

Ans→. The optic axis of a crystal is a direction along which light can propogate without experiencing double refraction. In other words, when light travel along the optic axis, it behaves as if it were in an isotropic medium, meaning that it does not split into two rays with different velocities and polarizations.

• The Principle Section of a crystal refers to a specific plane that contains the optic axis and is perpendicular to the plane of polarization of the light being analyzed

6- Explain the applications of holograms in industrial and medical field.

Ans→(i) Holography is used in advanced imaging techniques to create three-dimensional images of internal structures of the body, such as organs or tissues.

(ii) Holographic imaging can assist surgeons by providing real-time 3D visualization of the surgical field, improving precision during procedures such as minimally invasive surgeries.

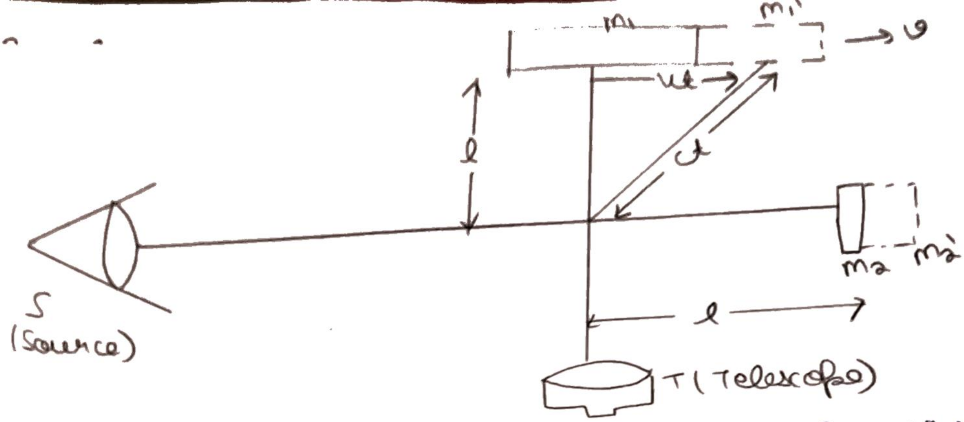
(iii) In dentistry, holography can be used for creating accurate 3-D models of teeth and gums for planning treatments like implants or orthodontics.

Section - B

(Long Answer Type Questions)

1- Discuss briefly michelson- Morley experiment and mention its outcome.

Ans → The experiment by michelson Morley in 1887 performed extremely sensitive experiment for measuring the absolute velocity of the earth with respect to stationary ether. michelson morley was Aimed at detecting the earth relative motion and ether while measuring the speed of light in different direction on the earth surface. The apparatus used in experiment used is michelson interferometer because it is based on interference of light. Therefore they assumed the entire space of universe is filled by hypothetical medium called ether.



Two mirrors m_1 and m_2 be at equal distance (l) from Plate (P) m_1 and m_2 are highly silvered mirrors. a beam of light source (monochromatic source) is incident on semi silvered glass Plate 'P' which is inclined at 45° to beam of light. This plate splitts light into two parts one part of the beam travel through plate 'P' and falls normally on mirror 'm_2' which reflect light back to point 'P' the other part of the beam after reflecting through plate 'P' falls normally on mirror 'm_1' which also reflects light back to 'P'. The two part of the beam returns to 'P' are directed towards Telescope (T). Let 'c' be the speed of light

Light velocity

$c-v \rightarrow$ forward trip

$c+v \rightarrow$ backward trip

If t_1 is time taken by the ray from $P \rightarrow m_2$ and back $m_2 \rightarrow P$ given by

$$t_1 = \frac{l}{c-v} + \frac{l}{c+v} \Leftrightarrow \frac{l(c+v) + l(c-v)}{(c-v)(c+v)} \Leftrightarrow t_1 = \frac{2lc}{(c^2-v^2)}$$

$$\boxed{t_1 = \frac{2l}{c\left(1-\frac{v^2}{c^2}\right)}} \quad -(1)$$

on using triangle $P m_1 m_1'$ by Pythagorus theorem -

$$(P m_1')^2 = (P m_1)^2 + (m_1 m_1')^2$$

$$c^2 t'^2 = l^2 + v^2 t'^2$$

$$t'^2 (c^2 - v^2) = l^2$$

$$t'^2 = \frac{l^2}{c^2 - v^2} \Leftrightarrow \frac{l^2}{c^2\left(1-\frac{v^2}{c^2}\right)}$$

$$t_1 = \frac{l}{c\sqrt{1-\frac{v^2}{c^2}}}$$

, Therefore total time taken by beam travelling from $P \rightarrow m_1'$ and back then $t_2 = 2t'$

$$\boxed{t_2 = \frac{2l}{c\sqrt{1-\frac{v^2}{c^2}}}} \quad -(2)$$

time difference (Δt)

$$\Delta t = t_1 - t_2$$

$$\Delta t = \frac{2l}{c}\left(\frac{1}{1-\frac{v^2}{c^2}} - \frac{1}{\left(1-\frac{v^2}{c^2}\right)^{1/2}}\right) \Leftrightarrow \Delta t = \frac{2l}{c}\left(\left(1-\frac{v^2}{c^2}\right)^{-1} - \left(1-\frac{v^2}{c^2}\right)^{-1/2}\right)$$

(using binomial Expansion)

$$\Delta t = \frac{2l}{c}\left(1+\frac{v^2}{c^2} - \left(1+\frac{v^2}{2c^2}\right)\right)$$

$$t = \frac{2l}{c}\left(\cancel{1} + \frac{v^2}{c^2} - \cancel{1} - \frac{v^2}{2c^2}\right) \Leftrightarrow \Delta t = \left(\frac{\cancel{2}l}{c}\right)\left(\frac{v^2}{\cancel{2}c^2}\right) \Leftrightarrow \boxed{\Delta t = \frac{lv^2}{c^3}} \quad -(3)$$

Hence, corresponding path difference

$$\Delta\delta = c\Delta t$$

$$\Delta\delta = c \times \frac{lv^2}{c^3} \Leftrightarrow \boxed{\frac{lv^2}{c^2} = \Delta\delta} - (4)$$

If the path difference between the two interference rays changes by 'λ' the shifting of one fring in the field of view of telescope is observed therefore. If 'n' be the number of fringes then from eq-(4) we have $n = \frac{\delta}{\lambda} \Leftrightarrow \boxed{n = \frac{lv^2}{c^2\lambda}}$

In actual experiment whole apparatus rotated by 90°, Total fringe shift $\boxed{\frac{2lv^2}{c^2\lambda}}$ where $l \to 11m$

$v \to 3\times10^4 m/s$

$c \to 3\times10^8 m/s$

$\lambda \to 5.5\times10^{-7} m$

$\boxed{\Delta n = 0.4}$

Michelson and Morley were surprised to see that no shift in fringe was observed when interferometer was rotated through 90°. They repeated experiment at different places, time, year and at different height but they always found no shift. They could not detect the relative velocity of earth wrt stationary ether.

3- Explain the action of Helium - Neon Laser. How is it superior to a Ruby Laser?

Ans → The Helium - Neon (He-Ne) Laser is a type of gas laser that produces coherent light through a process called stimulated emission. It is one of the most common type of lasers and is widely used in various applications, including barcode devices. ~~Heres~~

1- Components of the He-Ne Laser

- Gas mixture: The laser uses a mixture of helium (Ne) and neon (Ne) gases, typically in a ratio of about 10:1. The helium gas helps to excite the neon atoms.

- Laser cavity: The laser cavity is a sealed tube that contains the gas mixture. It has mirrors at both ends, one fully reflective and the other partially reflective.

- Electrical Discharge - An electrical current is passed through the gas mixture to create an electric discharge, which ionizes the gas and excites the helium and neon atoms.

<u>Applications</u> -

- Barcode scanners - Used for reading barcodes in retail environments.

- Optical Devices - Employed in interferometers and holography

- Laser pointers - commonly used for presentations and demonstrations

• He-Ne Laser - Typically operates as a continuous wave (CW) laser, providing a constant output of coherent light. This makes it suitable for applications that require ~~unint~~ uninterrupted laser output, such as in optical devices and laser pointers. Commonly emits light at 632.8 nm in the red spectrum, which is visible to human eye. The wavelength can also be varied slightly with different gas mixtures.

• Ruby Laser - operates in a pulses mode, emitting short bursts of light rather than a continuous beam. This can limit its use in applications where a steady output is needed. Emits light at 694.3 nm, which is also in the red range but may not be as easily perceived as the He-Ne Laser's output. The specific wavelength of the Ruby Laser can also limit its applications in certain optical system.

By these we can say that He-Ne Laser is superior than Ruby Laser.