K.V.S. Matriculation Hr. Sec. School, Thoothukudi.

Second Mid Term Test – 2022

Thoothukudi District

PHYSICS [Lesson 7,8]

Time: 1.30 Hours   Marks: 35   Std : XII

PART - I

I. Choose the correct answer: [5 × 1 = 5]

1) b) 500 Å
2) d) polarisation
3) c) thermionic
4) a) 1.0225 Å
5) c) 25 candela

PART - II

II. Answer any 4 questions. (Q. No. 9 is compulsory)   [4×2 = 8]

6) **State Huygen's Principle?**
 ➤ Each point of the wave front is the source of secondary wavelets emanating from these points spreading out in all directions with the speed of the wave. These are called as secondary wavelets.
 ➤ The common tangent, in other words the envelope to all these wavelets gives the position and shape of the new wave front at a later time.

7) **List the uses of polaroids? (Any 2)**
 ➤ Polaroid's are used in goggles and cameras to avoid glare of light.
 ➤ Polaroid's are useful in three dimensional motion pictures i.e., in holography.
 ➤ Polaroid's are used to improve contrast in old oil paintings.
 ➤ Polaroid's are used in optical stress analysis.
 ➤ Polaroid's are used as window glasses to control the intensity of incoming light.
 ➤ Polaroid's are used to produce polarised laser beam acts as needle to read/write in compact discs (CDs).
 ➤ Polaroid's produce polarised lights to be used in liquid crystal display (LCD).

8) **State Brewster's Law.**
   The tangent of the polarising angle for a transparent medium is equal to its refractive index.
   i.e., $n = \tan i_p$

9) **The wavelength of light is 450 nm. How much phase it will differ for a path of 3mm?**
   Solution
   Wavelength, $\lambda = 450$ nm $= 450 \times 10^{-9}$m
   Path difference, $\delta = 3$mm $= 3 \times 10^{-3}$m
   Relation between phase difference and path difference, $\phi = \frac{2\pi}{\lambda} \times \delta$
   Substituting, $\phi = \frac{2\pi}{450 \times 10^{-9}} \times 3 \times 10^{-3} = \frac{\pi}{75} \times 10^6$ rad
   $\phi = 4.19 \times 10^4$ rad.

10) **Define work function of a metal.**
    The minimum energy needed for an electron to escape from the metal surface is called work function(ϕ_0) of that metal. Its unit is electron volt (eV). [$1eV = 1.602 \times 10^{-19}$ J]

11) **Define Stopping potential.**
    The negative potential of the collecting electrode at which photocurrent gets zero is called stopping or Cut off potential (V_0) .

Kindly send me your district question papers to our whatsapp number: 7358965593

PART – III
III. Answer any 4 questions. (Q. No. 17 is compulsory)   [4×3 = 12]

12. Mention the differences between interference and diffraction.

Interference	Diffraction
i. Superposition of two Waves	Bending of waves around Edge
ii. Superposition of waves from two coherent sources.	Superposition of waves emitted from various points of the same wave front.
iii. Equally spaced fringes.	Unequally spaced fringes
iv. Intensity of all the bright fringes is almost same	Intensity falls rapidly for higher orders
v. Large number of fringes are obtained	Less number of fringes are obtained

13. State and obtain malus law.

The light transmitted of intensity I from the analyser varies directly as the square of the cosine of the angle θ between the transmission axis of polariser and analyser.

$$I = I_0 \, Cos^2\theta$$

14. Discuss about pile of plates.
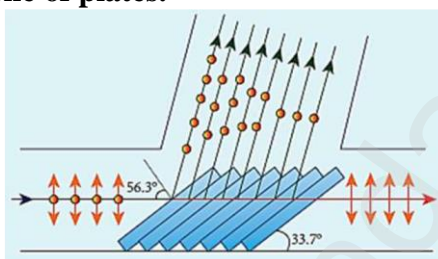
- ➤ The phenomenon of polarisation by reflection is used in the construction of pile of plates.
- ➤ It consists of a number of glass plates placed one over the other in a tube as shown in figure.
- ➤ The plates are inclined at an angle of 33.70 to the axis of the tube.
- ➤ A beam of unpolarised light is allowed to fall on the pile of plates along the axis of the tube.
- ➤ So, the angle of incidence of light will be at 56.30 which is the polarising angle for glass.
- ➤ The vibrations perpendicular to the plane of incidence are reflected at each surface and those parallel to it are transmitted.
- ➤ The larger the number of surfaces, the greater is the intensity of the reflected plane polarised light.
- ➤ The pile of plates is used as a polarizer and also as an analyser.

**15. What is Fresnel's distance? Obtain the equation for Fresnel's distance.**

Fresnel's distance is the distance up to which the ray optics is obeyed and beyond which the ray optics is not obeyed; but, the wave optics becomes significant.

The diffraction equation for first minimum is, $\sin \theta = \dfrac{\lambda}{a}$; when θ is small, $\theta = \dfrac{\lambda}{a}$

From the definition of Fresnel's distance, $2\theta = \dfrac{a}{z}$ (or) $\theta = \dfrac{a}{2z}$

Equating the above two equation for θ gives , $\dfrac{\lambda}{a} = \dfrac{a}{2z}$

After rearranging, we get Fresnel's distance z as, $z = \dfrac{a^2}{2\lambda}$
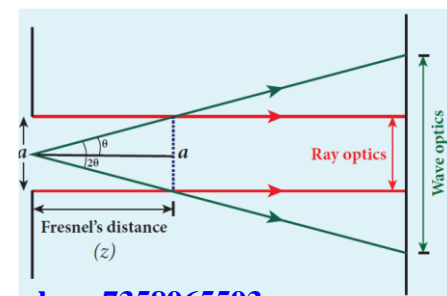
16. List out the characteristics of photons.

According to particle nature of light, photons are the basic constituents of any radiation and possess the following characteristic properties:

i) The photons of light of frequency v and wavelength λ will have energy, given by

$$E = hv = \frac{hc}{\lambda}$$

ii) The energy of a photon is determined by the frequency of the radiation and not by its intensity and the intensity has no relation with the energy of the individual photons in the beam.

iii) The photons travel with the speed of light and its momentum is given by

$$p = \frac{h}{\lambda} = \frac{hv}{c}$$

iv) Since photons are electrically neutral, they are unaffected by electric and magnetic fields.

v) When a photon interacts with matter (photon-electron collision), the total energy, total linear momentum and angular momentum are conserved. Since photon may be absorbed or a new photon may be produced in such interactions, the number of photons may not be conserved.

17. Calculate the cut-off wavelength and cut-off frequency of X rays from an X-ray tube of accelerating potential of 20,000 V.

Solution

The cut-off wavelength of the x-rays in the continuous spectrum is given by

$$\lambda_0 = \frac{12400}{V}\text{Å} = \frac{12400}{20000}\text{ Å}$$
$$= 0.62 \text{ Å}$$

The corresponding frequency is

$$v_0 = \frac{c}{\lambda_0} = \frac{3 \times 10^8}{0.62 \times 10^{-10}}$$
$$= 4.84 \times 10^{18} \text{ Hz}.$$

PART – IV

IV. Answer all the questions.   **[2×5 = 10]**

18. a) Obtain the equation for resultant intensity due to interference of light.

The phenomenon of superposition of two light waves which produces increase in intensity at some points and decrease in intensity at some other points is called interference of light.

Superposition of waves refers to addition of waves. The concept of superposition of mechanical waves is studied in (XI Physics 11.7). When two waves simultaneously pass through a particle in a medium, the resultant displacement of that particle is the vector addition of the displacements due to the individual waves. The resultant displacement will be maximum or minimum depending upon the phase difference between the two superimposing waves. These concepts hold good for light as well.

Let us consider two light waves from the two sources S1 and S2 meeting at a point P as shown in Figure 7.6.

The wave from S1 at an instant t at P is,

$$y_1 = a_1 \sin \omega t \text{ ------------- 1}$$

The wave form S2 at an instant t at P is,

$$y_2 = a_2 \sin (\omega t + \phi) \text{ -------- 2}$$

The two waves have different amplitudes a1 and a2, same angular frequency ω, and a phase difference of ϕ between them. The resultant displacement will be given by,

$$y = y_1 + y_2 = a_1 \sin \omega t + a_1 \sin (\omega t + \phi) \text{ ------------------- 3}$$

The simplification of the above equation by using trigonometric identities.

$$y = A \sin (\omega t + \theta) \text{ ----------- 3}$$

Where, $A = \sqrt{a_1^2 + a_2^2 + 2a_1 a_2 \cos \phi}$ ------------ 4

$$\theta = \tan^{-1} \frac{a_2 \sin \phi}{a_1 + a_2 \cos \phi} \text{ ---------- 5}$$

The resultant amplitude is maximum,

$$A_{max} = \sqrt{(a_1 + a_2)^2} \; ; \text{when } \phi = 0, \pm 2\pi, \pm 4\pi. \, . \, . \text{ ---------- 6}$$

The resultant amplitude is minimum,

$$A_{min} = \sqrt{(a_1 - a_2)^2} \text{ when } \phi = \pm\pi, \pm 3\pi, \pm 5\pi..., \text{ ------------ 7}$$

The intensity of light is proportional to square of amplitude,

$$I \propto A_2 \text{ ------------------- 8}$$

Now, squaring equation (4) on both sides,

$$I = I_1 + I_2 + 2\sqrt{I_1 + I_2} \, Cos\phi \text{ -------------------- 9}$$

In equation (9) if the phase difference, $\phi = 0, \pm 2\pi, \pm 4\pi. \, . \, .$, it corresponds to the condition for maximum intensity of light called **constructive interference**.

The resultant maximum intensity is,

$$I_{max} \propto (a_1 + a_2)^2$$

$$I_{max} \propto I_1 + I_2 + 2\sqrt{I_1 + I_2} \text{ --------------------- 10}$$

In equation (9) if the phase difference, $\phi = \pm\pi, \pm 3\pi, \pm 5\pi. \, . \, .$, it corresponds to the condition for minimum intensity of light called *destructive interference*.

The resultant minimum intensity is,

$$I_{min} \propto (a_1 - a_2)^2$$

$$I_{min} \propto I_1 + I_2 - 2\sqrt{I_1 + I_2} \text{ --------------------- 11}$$

As a special case, if $a_1 = a_2 = a$, then equation (4). becomes,

$$A = \sqrt{2a^2 + 2a^2 \, cos}\phi = \sqrt{2a^2(1 + cos}\phi) = \sqrt{2a^2 2cos^2}(\tfrac{\phi}{2})$$

$$A = 2a \, cos(\tfrac{\phi}{2}) \text{ ---------------------- 12}$$

$$I \propto 4a^2 \, cos^2(\tfrac{\phi}{2}) \qquad [\because I \propto A^2] \text{ ----------------- 13}$$

$$I \propto 4 \, I_0 \, cos^2(\tfrac{\phi}{2}) \qquad [\because I_0 \propto a^2] \text{ ----------------- 14}$$

$$I_{max} = 4 \, I_0 \text{ when, } \phi = 0, \pm 2\pi, \pm 4\pi. \, . \, . \, , \text{ --------------- 15}$$

$$I_{min} = 0 \text{ when, } \phi = \pm\pi, \pm 3\pi, \pm 5\pi. \, . \, . \, , \text{ ----------------- 16}$$

We conclude that the phase difference ϕ, between the two waves decides the intensity of light at that point where the two waves meet.

18. b) Explain about compound microscope and obtain the equation for the magnification.

The lens near the object is called as *objective*. It forms a real, inverted and magnified image of the object. This serves as the object for the lens close to the eye called as *eyepiece*. The eyepiece serves as a simple microscope that produces finally an enlarged and virtual image. The first inverted image formed by the objective is to be adjusted within the focus of the eyepiece so that the final image is formed nearly at infinity (or) at the near point. The final image is inverted with respect to the object.

Magnification in compound microscope

The lateral magnification produced by the objective is given by the equation (6.66),

$$m_0 = \frac{h'}{h}$$
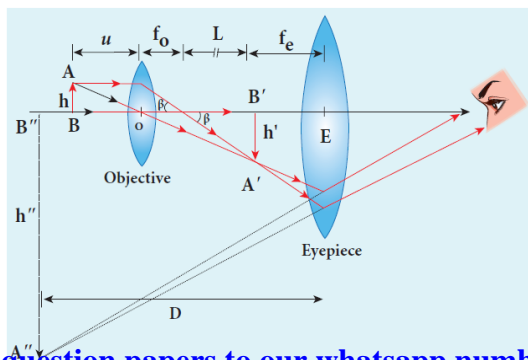
From the Figure 7.39, $\tan\beta = \dfrac{h}{f_o} = \dfrac{h'}{L}$, then

$$\frac{h'}{h} = \frac{L}{f_o} \tag{7.74}$$

$$m_o = \frac{L}{f_o} \tag{7.75}$$

Here, the distance L is measured between the focal point of the eyepiece to the focal point of the objective. This is called the tube length of the microscope as f_o and f_e are comparatively smaller than L.

If the final image is formed at the near point, the magnification m_e of the eyepiece is,

$$m_e = 1 + \frac{D}{f_e} \tag{7.76}$$

The total magnification m for near point focusing is,

$$m = m_o m_e = \left(\frac{L}{f_o}\right)\left(1 + \frac{D}{f_e}\right) \tag{7.77}$$
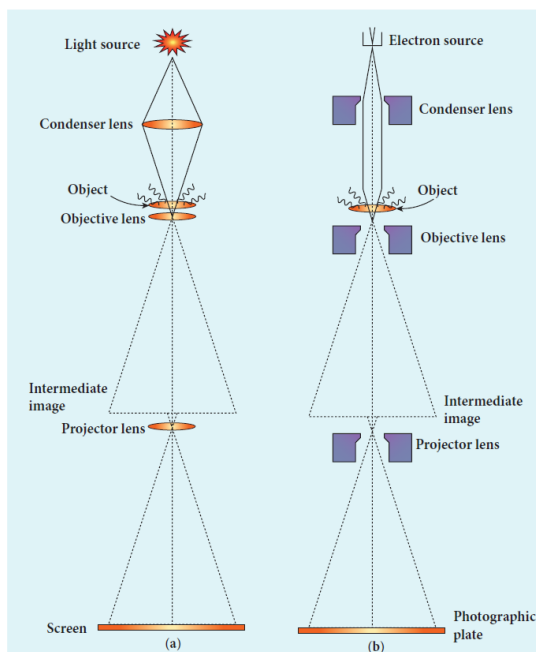
If the final image is formed at infinity (normal focusing), the magnification m_e of the eyepiece is,

$$m_e = \frac{D}{f_e} \tag{7.78}$$

The total magnification m for normal focusing is,

$$m = m_o m_e = \left(\frac{L}{f_o}\right)\left(\frac{D}{f_e}\right) \tag{7.79}$$

19) a) Briefly explain the principle and working of electron microscope.

Principle

This is the direct application of wave nature of particles. The wave nature of the electron is used in the construction of microscope called **electron microscope**.

The resolving power of a microscope is inversely proportional to the wavelength of the radiation used for illuminating the object under study. Higher magnification as well as higher resolving power can be obtained by employing the waves of shorter wavelengths.

Louis de Broglie wavelength of electron is very much less than (a few thousands less) that of the visible light being used in optical microscopes. As a result, the microscopes employing de Broglie waves of electrons have very much higher resolving power than optical microscope. Electron microscopes giving magnification more than 2,00,000 times are common in research laboratories.

Working

The construction and working of an electron microscope is similar to that of an optical microscope except that in electron microscope focussing of electron beam is done by the electrostatic or magnetic lenses. The electron beam passing across a suitably arranged either electric or magnetic fields undergoes divergence or convergence thereby focussing of the beam is done (Figure 8.19).

The electrons emitted from the source are accelerated by high potentials. The beam is made parallel by magnetic condenser lens. When the beam passes through the sample whose magnified image is needed, the beam carries the image of the sample.

With the help of magnetic objective lens and magnetic projector lens system, the magnified image is obtained on the screen. These electron microscopes are being used in almost all branches of science.

19. b) Describe briefly Davisson – Germer experiment. Which demonstrated the wave nature of electrons.
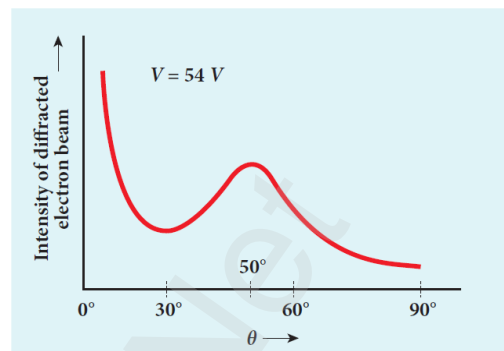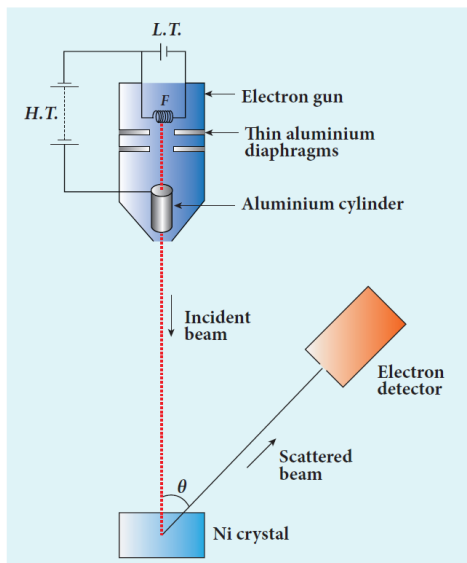
Louis de Broglie hypothesis of matter waves was experimentally confirmed by Clinton Davisson and Lester Germer in 1927. They demonstrated that electron beams are diffracted when they fall on crystalline solids. Since crystal can act as a three-dimensional diffraction grating for matter waves, the electron waves incident on crystals are diffracted off in certain specific directions. Figure 8.17 shows a schematic representation of the apparatus for the experiment.

The filament F is heated by a low tension (L.T.) battery. Electrons are emitted from the hot filament by thermionic emission. They are then accelerated due to the potential difference between the filament and the anode aluminium cylinder by a high tension (H.T.) battery. Electron beam is collimated by using two thin aluminium diaphragms and is allowed to strike a single crystal of Nickel.

The electrons scattered by Ni atoms in different directions are received by the electron detector which measures the intensity of scattered electron beam. The detector is capable of rotation in the plane of the paper so that the angle θ between the incident beam and the scattered beam can be changed at our will. The intensity of the scattered electron beam is measured as a function of the angle θ.

Figure 8.18 shows the variation of intensity of the scattered electrons with the angle θ for the accelerating voltage of 54V. For a given accelerating voltage V, the scattered wave shows a peak or maximum at an angle of 50° to the incident electron beam. This peak in intensity is attributed to the constructive interference of electrons diffracted from various atomic layers of the target material. From the known value of interplanar spacing of Nickel, the wavelength of the electron wave was experimentally calculated as 1.65Å.

The wavelength can also be calculated from de Broglie relation for V = 54 V from equation (8.18).

$$\lambda = \frac{12.27}{\sqrt{V}}\text{Å} \quad = \frac{12.27}{\sqrt{54}}\text{ Å}$$

$$\lambda = 1.67 \text{ Å}$$

This value agrees very well with the experimentally observed wavelength of 1.65Å. Thus this experiment directly verifies de Broglie's hypothesis of the wave nature of moving particles.

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