PROBLEMS FROM PRACTICALS

Applied Physics for EEE Stream (BPHYE102/202) &

Applied Physics for CSE Stream (BPHYS102/202)

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1. In an optical fiber experiment, the distance between the fiber and the screen is **45 mm** and radius of the spot is **6 mm**. Calculate the angle of acceptance and numerical aperture. (EEE Stream JAN/FEB - 2023)

Given: $r = 6$ mm & $l = 45$ mm.

Angle of acceptance is given by $\tan\theta_o = \frac{r}{l}$ or $\tan\theta_o = \frac{D}{2l}$

$$\therefore \theta_o = \tan^{-1}\left(\frac{r}{l}\right) = \tan^{-1}\left(\frac{6}{45}\right) = \tan^{-1}(0.133) = \mathbf{7.6^o}$$

Numerical aperture NA = $\sin\theta_o$

NA = $\sin(7.6^o)$ = **0.13**

2. Calculate the angle of acceptance and numerical aperture of given optical fiber having diameter of the spot **2.6 cm** and the distance between screen and optical fiber **3 cm**. (CSE Stream JUNE /JULY - 2023)

Experiment: Optical Fiber

Given: D = 2.6 cm & l = 3 cm.

Angle of acceptance is given by $\tan\theta_o = \frac{D}{2l}$

$$\therefore \theta_o = \tan^{-1}\left(\frac{D}{2l}\right) = \tan^{-1}\left(\frac{2.6}{2\times 3}\right) = \tan^{-1}(0.433) = \mathbf{23.4^o}$$

Numerical aperture NA = $\sin\theta_o$

NA = $\sin(23.4^o)$ = **0.40**

3. In an optical fiber experiment, the laser light propagating through optical fiber cable of length **1.5 m**, made spot diameter of **8 mm** on the screen. The distance between the end of the optical fiber and the screen is **3.4 cm.** Calculate the angle of acceptance and numerical aperture. (CSE Stream JAN/FEB - 2023)

Given: D = 8 mm= 0.8 cm & l = 3.4 cm.

Angle of acceptance is given by $\tan\theta_o = \frac{D}{2l}$

$$\therefore \theta_o = \tan^{-1}\left(\frac{D}{2l}\right) = \tan^{-1}\left(\frac{0.8}{2\times 3.4}\right) = \tan^{-1}(0.118) = \mathbf{6.71^o}$$

Numerical aperture NA = $\sin\theta_o$

NA = $\sin(6.71^o)$ = **0.117**

4. A circular coil of wire consisting of **100 turns**, each of radius **8 cm** carries a current of **0.4 A**. What is the magnitude of magnetic field on its axis, at a distance of **20 cm** from the center of the coil? (EEE Stream JAN/FEB - 2023)

Experiment: Magnetic Field

Given: $n = 100$, $I = 0.4$ A, $a = 8$ cm $= 0.08$ m & $x = 20$ cm $= 0.2$ m

Magnetic flux density $B = \dfrac{\mu_o n I a^2}{2\left(a^2 + x^2\right)^{3/2}}$ tesla

where $\mu_o = 4\pi\times10^{-7}$ Hm^{-1}

$$\therefore B = \frac{4\times3.142\times10^{-7}\times100\times0.4\times0.08^2}{2\left(0.08^2+0.2^2\right)^{3/2}}$$

Or $B =$ **1.61×10^{-5}** T

5. A circular coil with **100 turns** and radius **0.12 m,** carries a current of **0.1 A**. What is the magnetic flux density at the center of the coil?

Experiment: Magnetic Field

Given: $n = 100$, $I = 0.4\text{A}$, $a = 0.12\text{m}$ & $x = 0$ m

Magnetic flux density $B = \dfrac{\mu_o n I a^2}{2\left(a^2 + x^2\right)^{3/2}}$ tesla

where $\mu_o = 4\pi\times10^{-7}$ Hm^{-1}

At the center of the coil, $x = 0$.

$$\therefore B = \frac{\mu_o n I}{2a}$$

$$B = \frac{4\times3.142\times10^{-7}\times100\times0.1}{2\times0.12}$$

B = **5.24×10^{-5}** T

6. In a magnetic field experiment, an average deflection of **52 degree** is observed in the compass box kept at a point on the axis of the coil carrying current. If the horizontal component of earth's magnetic field is **3.8×10^{-5} tesla**, find the magnetic field due to the coil at the given point.

Given: $\theta = 52^o$ & $B_H = 3.8\times10^{-5}$T

Magnetic field $B = B_H \tan\theta$

$B = 3.8\times10^{-5} \times \tan 52^o$

B = **4.48×10^{-5}** T

7. In a Planck's constant experiment, the knee voltage of a given red LED emitting light of wavelength **650 nm** is **1.908 V**, calculate Planck's constant.

(EEE Stream JAN/FEB - 2023)

Given: $\lambda = 650$ nm $= 650\times10^{-9}$ m & $V = 1.908$volt.

Here, Planck's constant is given by the condition $\frac{hc}{\lambda} = eV$

where $e = 1.6\times10^{-19}$ C & $c = 3\times10^{8}$ ms^{-1}.

$$\therefore h = \frac{eV\lambda}{c}$$

i.e., $$h = \frac{1.6\times10^{-19}\times1.908\times650\times10^{-9}}{3\times10^{8}}$$

Or

$h =$ **6.61×10^{-34}** Js.

8. Find the wavelength of the semiconductor laser in the diffraction grating experiment when angle of diffraction is **$1.5^{\mathbf{o}}$** for the **second order** maximum. Given grating constant = **4.7×10^{-5} m**. (EEE Stream JUNE/JULY - 2023)

Experiment: Diffraction Grating

Given: $m = 2$, $d = 4.7\times10^{-5}$ m & $\theta = 1.5$ degree

Wavelength $\lambda = \frac{d\sin\theta}{m}$

$$\therefore \lambda = \frac{4.7\times10^{-5}\times\sin 1.5^{o}}{2}$$

$$\lambda = \frac{4.7\times0.026\times10^{-5}}{2} = 0.0615\times10^{-5} = 615\times10^{-9}\,m$$

i.e., $\lambda =$ **615** nm

9. If the distance between screen and grating is **20 cm** and the average distance of the 2^{nd} **order** spot is **2.7 cm**, calculate the wavelength of the laser light. Grating constant = $\mathbf{1\times10^{-5}}$ **m**. (CSE Stream JUNE/JULY - 2023)

Experiment: Diffraction Grating

Given: $m = 2$, $d = 1\times10^{-5}$ m, $f = 20$ cm & $x = 2.7$ cm.

Angle of diffraction is given by $\tan\theta = \dfrac{x}{f}$

$$\therefore \theta = \tan^{-1}\left(\frac{x}{f}\right) = \tan^{-1}\left(\frac{2.7}{20}\right) = \tan^{-1}(0.135) = 7.69^{o}$$

Wavelength $\lambda = \dfrac{d\sin\theta}{m}$

$$\therefore \lambda = \frac{1\times10^{-5}\times\sin(7.69^{o})}{2}$$

$$\lambda = \frac{0.133\times10^{-5}}{2}$$

$\lambda = 0.0669\times10^{-5}$ m

$\lambda = 669\times10^{-9}$ m

$\lambda =$ **669** nm

10. In a diffraction grating experiment, the laser light undergoes **second order** diffraction for diffraction angle **1.48^{o}**. The grating constant is **5.08×10^{-5} m** and the distance between the grating and the source is **80 cm**. Find the wavelength of the laser light. (CSE Stream JAN/FEB - 2023)

Given: m =2, d = 5.08×10^{-5} m, f = 80cm & θ = 1.48^{o}.

Wavelength $\lambda = \dfrac{d\sin\theta}{m}$

$$\therefore \lambda = \frac{5.08\times 10^{-5}\times \sin(1.48^{o})}{2}$$

$$\lambda = \frac{5.08\times 0.026\times 10^{-5}}{2}$$

λ = 0.0656×10^{-5} m

λ = 656×10^{-9} m

λ = **656** nm

11. Find grating constant *d* and determine the wavelength of laser for **2^{nd} order** diffraction. Given: Angle of diffraction **$\theta = 7.575^o$** & Number of lines per inch on grating ***N* = 2500**. (CV Stream JAN/FEB - 2023)

Given: $N = 2500$LPI, $m = 2$ & $\theta = 7.575^o$.

$$N = \frac{2500 \times 100}{2.54} = 98425 \text{ lines per metre}$$

$$\text{Grating constant } d = \frac{1}{N} = \frac{1}{98425} = 1.016 \times 10^{-5} m^{-1}$$

$$\text{Wavelength } \lambda = \frac{d \sin\theta}{m}$$

$$\therefore \lambda = \frac{1.016 \times 10^{-5} \times \sin(7.575^o)}{2}$$

$$\lambda = \frac{1.016 \times 0.132 \times 10^{-5}}{2} = 0.0670 \times 10^{-5} = 670 \times 10^{-9} m$$

$\lambda = 0.0670 \times 10^{-5}$ m

$\lambda = 670 \times 10^{-9}$ m

λ = **670** nm

12. Find the resonance frequency of an LCR series circuit with inductance = **0.5 H**, capacitance = **0.45 µF** and resistance = **400 Ω**. (EEE Stream JUNE/JULY - 2023)

Experiment: LCR Resonance Circuit

Given: $L = 0.5$ H, $C = 0.45$ µF= 0.45×10^{-6} F & $R = 400\ \Omega$.

Resonance frequency $f_r = \dfrac{1}{2\pi\sqrt{LC}}\, Hz$

$$f_r = \frac{1}{2\pi\sqrt{0.5\times0.45\times10^{-6}}}$$

Hence f_r = **336** Hz

13. In an LCR series resonance experiment, a **50 µF** capacitor when connected in series with a coil having resistance of **40 Ω**, resonates at **1000 Hz**. Calculate the inductance of the coil for the resonant circuit. (ME Stream JUNE/JULY - 2023)

Given: $C = 50$ µF = 50×10^{-6} F, $R = 40\ \Omega$ & $f_r = 1000$ Hz.

Resonance frequency $f_r = \dfrac{1}{2\pi\sqrt{LC}}\, Hz$

$$\therefore L = \frac{1}{4\pi^2 f_r^2 C}\, henry$$

$$L = \frac{1}{4\times3.142^2\times1000^2\times50\times10^{-6}}$$

$L = 0.51\times10^{-3}$ H or

$L =$ **0.51** mH

14. In the experiment of charging & discharging of a capacitor, the time taken for the voltage to increase or decrease to the 50% of its maximum value is **7.5 second**. If the value of the resistance used is **100 kΩ**, calculate the capacitance of the capacitor.

Given: $T = 7.5$ s & $R = 100\times10^3\,\Omega$

Capacitance $C = \dfrac{1.44T}{R}$ *farad* Or $C = \dfrac{T_{1/2}}{0.693R}$ *farad*

$$C = \frac{1.44\times7.5}{100\times10^3}$$

$C = 108\times10^{-6}$ F

or C = **108** μF

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