2017

MADE EASY

WORKBOOK

Detailed Explanations of Try Yourself *Questions*

Instrumentation Engineering

Optical Instrumentation

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1 Basic Optics

Detailed Explanation of Try Yourself Questions

T1 : Solution

$$\mu g = \frac{4}{3}$$

We know, $n_1 \sin\theta_i = n_2 \sin\theta_r$

$$1 \times \sin 30° = \frac{4}{3} \times \sin\theta$$

$$\theta_r = \sin^{-1}\frac{0.5}{1.33}$$

$$\theta_r = 20.08°$$

T2 : Solution

The maximum number of lines required are

$$\frac{\text{Mean}\,(\lambda_1, \lambda_2)}{\lambda_1 - \lambda_2} = \frac{\frac{589.6 + 589}{2}}{(589.6 - 589)}$$

$$= \frac{589.3}{0.6} = 982.16 \simeq 982$$

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2 Fiber Optics

Detailed Explanation of Try Yourself Questions

T1 : Solution

$$NA = \sqrt{n_1^2 - n_2^2}$$

$$= \sqrt{(1.5)^2 - (1.45)^2} = 0.384$$

T2 : Solution

$$P = 2\ \text{mW}$$

$$\text{Attenuation} = 10 \times \frac{10}{1000} = 0.1\ \text{dB}$$

$$R = 0.55\ \text{A/w}$$

$$\text{Detector current} = 0.55 \times \frac{2}{10^3}\ \text{Amp.}$$

$$= 1.1\ \text{mA}$$

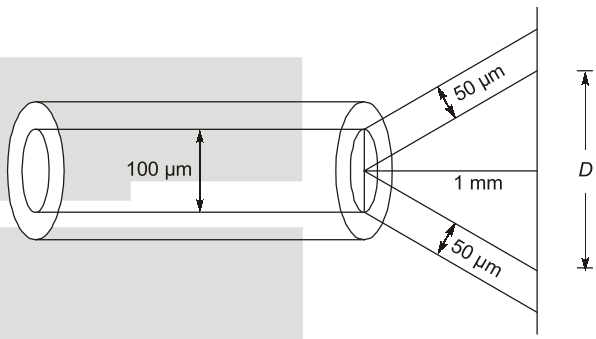
T3 : Solution

$$\Delta t = \frac{n_1 L}{C}\left[\frac{n_1}{n_2} - 1\right]$$

$$= \frac{1.46 \times 1000}{3 \times 108}\left[\frac{1.46}{1.45} - 1\right]$$

$$= 33.56\ \text{ns.}$$

T4 : Solution



$\because$ Spot diameter $= 2r\theta_a$

here $\theta_a = \sin^{-1} Na$

$$= \sin^{-1}\sqrt{1.5^2 - 1.485^2}$$

$$= 12.216°$$

$$= 0.213\ \text{rad}$$

$$D = 2 \times 1000 \times 0.213 = 427\ \mu\text{m}$$

Total length of photo-detector array

$427 + 50 + 50\ \mu\text{m} = 527\ \mu\text{m}$

Diameter of one photodetector = 5 µm

So, total number of photo detector in array

$$= \frac{527}{5} \simeq 106$$

T5 : Solution

$$\theta_c = \sin^{-1}\left[\frac{1}{\mu}\right] = \sin^{-1}\left[\frac{1}{1.45}\right] = 43.6°$$

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3 Lasers

Detailed Explanation of Try Yourself Questions

T1 : Solution

$$\therefore \quad \Delta\theta = \frac{1.22\lambda}{d} = \frac{1.22 \times 729 \times 10^{-9}}{6 \times 10^{-3}}$$

$$= 1.48 \times 10^{-4} \text{ rad}$$

$$\text{Areal spread} = \pi (r\theta)^2$$

$$= 3.14 \times 54.76 \times 10^{8}$$

$$= 1.72 \times 10^{10}$$

$$\frac{\Delta\theta_1}{\Delta\theta_2} = \frac{\lambda_1}{\lambda_2} \times \frac{d_2}{d_1}$$

$$\frac{\Delta\theta}{\Delta\theta_2} = \frac{\lambda}{2\lambda} \times \frac{d}{2d}$$

$$\Delta\theta_2 = 4\,\Delta\theta$$

$$= 4 \text{ Times}$$

T2 : Solution

$$\therefore \quad \Delta\theta = \frac{1.22\,\lambda}{d}$$

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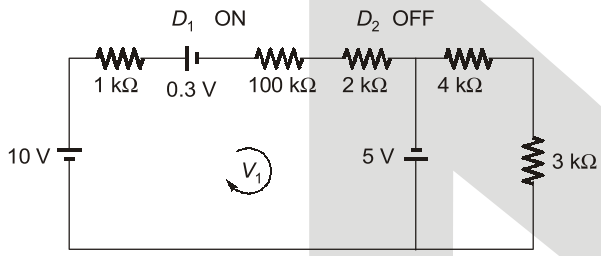
4 Light Emitting Diode (LED) Photodiode, Photo-Resistor

Detailed Explanation of Try Yourself Questions

T1 : Solution

D_1 and D_2 are in forward bias



$V_{2K} = ?$ $\quad V_{3K} = ?$

$$i_2 = \frac{-5\text{ V}}{4\text{ k}\Omega + 3\text{ k}\Omega} = \frac{-5}{7\text{ k}\Omega}$$

$$= -0.7214\text{ mA}$$

$$V_{3\text{k}\Omega} = i_2 \times 3\text{ k}\Omega = -2.14\text{ V}$$

From circuit

$$I_i = 1.41\text{ mA}$$

So, $V_{2\text{k}\Omega} = 1.41\text{ mA} \times 2\text{ k}\Omega = 2.8\text{ V}$

T2 : Solution

$$0.75 = \frac{I_p/q}{P/hV} \Rightarrow \frac{I_p}{q} \times \frac{hV}{P}$$

$$I_P = \frac{0.75 \times 65 \times 10^{-6} \times 1200 \times 10^{-9}}{6.625 \times 10^{-34} \times 3 \times 10^8}$$

$$I = 47.1\ \mu\text{A}$$

T3 : Solution

I = Sensitivity × Intensity × Area

$$I = 0.55 \times 10 \times 10^{-3} \times 10^{-2}$$

and output voltage

$$V_o = -IR_L$$

$$= -5.5 \times 10^{-5} \times 100 \times 10^3$$

$$= -5.5\text{ V}$$

T4 : Solution

$$\therefore \quad R = \frac{I_p}{Pi}$$

$$I_p = P_i \cdot R$$

$$= I \times A \times R$$

$$= \frac{10^{-3}W}{10^{-4}} \times 10 \times 10^{-6} \times 0.5\,\frac{A}{W}$$

$$= 0.5 \times 10^{-4}\text{ A}$$

$$V_L = IR$$

$$= 0.5 \times 10^{-4} \times 100\text{ k}\Omega$$

$$= 5\text{ V}$$

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5 Interference

Detailed Explanation of Try Yourself Questions

T1 : Solution

T1. Solution:

$\therefore \quad n\lambda = t(\mu - 1)$

$5 \times 589 \times 10^{-9} = 5 \times 10^{-6}(\mu - 1)$

$\mu = 1.589$

T2 : Solution

$\lambda = 589$ nM

$d = 2$ mm

$D = 4$ cm $= 40$ mm

$D >> d$

Location n of n^{th} bright fringe from the central position x_n is

$$x_n = \frac{D}{d} n\lambda$$

$$x_{10} = \frac{40}{2} \times 10 \times 589 \times 10^{-9}$$

$$= 117.8\ \mu m$$

Fringe width (β)

$$= \frac{D}{d}\lambda = \frac{40}{2} \times 589 \times 10^{-9}$$

$$= 11.78\ \mu m$$

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