POSTAL Book Package 2021

Instrumentation Engineering

Objective Practice Sets

Optical Instrumentation

Contents

MADE EASY Publications

2 CHAPTER

Fiber Optics

Q.1 One of the combinations of materials used for optical fibers is
(a) Copper core and glass cladding
(b) Glass core and aluminum cladding
(c) Glass core and plastic cladding
(d) Plastic core and glass cladding

Q.2 A step index fiber has its core diameter and refractive index as 30 μm and 1.62 respectively and has a fractional index difference of 0.0007. It is operated at wavelength of 1.5 μm. The V-number of the optical fiber is
(a) 2.40 (b) 3.80
(c) 2.80 (d) 4.20

Q.3 In an optical fibre, the core material has refractive index of 1.43 and refractive index of clad material is 1.40. The maximum angle by which a light ray can have relative to the axis of fiber and propagate down the fiber is _____ degree.

Q.4 An optical fiber is characterised by
(a) $\mu_{core} < \mu_{cladding}$ (b) TIR
(c) $\mu_{core} > \mu_{cladding}$ (d) both (b) and (c)

Q.5 An LED is emitting light of wavelength 1 μm and is but coupled with an optical fiber of length 1000 m due to which the signal retrieved at its output is reduces to one fifth of its input power. The attenuation is found to be _____ dB/km.

Q.6 The critical angle at the core cladding interface of a silica optical fiber having a refractive index of 1.50 and a cladding refractive index of 1.47 is _____ degree.

Q.7 A multimode graded index optical fiber is used for transmitting signal from one point to the other. The diameter of the core of the fibre is 60 μm and the index difference is 3.6% The fiber is operated at an optical wavelength of 0.86 μm. If the refractive index of the core is 1.58. Then the number of modes that can be propagated through the fiber, are _____.

Q.8 An optical fiber having a numerical aperture of 0.45 is used to transmit an optical signal. The light coming out of the exit end of the fiber is made to fall on a wall perpendicular to the axis of the optical fiber. The diameter of the optical spot made by the light on the wall located at a distance 70 mm from the exit end of the fiber is _____ mm.

Q.9 The loss in an optical fiber when an optical signal after traversing a distance of 500 meters in fiber has remain with 70% of its input power is
(a) 5.41 dB/km (b) 3.09 dB/km
(c) 4.46 dB/km (d) 2 dB/km

Q.10 Optical signal of wavelength 0.75 mm is transmitted with the help of an optical fiber having a numerical aperture of 0.61. The signal is coupled to another optical fiber having the refractive index of core and cladding as 1.5 and 1.25 respectively. The coupling loss in the transmission of signal is_____dB/km.

Q.11 *V*-number of an optical fiber is given by

(a) $V = \frac{2\pi r}{\lambda}\sqrt{n_1^2 - n_2^2}$

(b) $V = \frac{2\pi d}{\lambda}\sqrt{n_1^2 - n_2^2}$

(c) $V = \frac{2\pi r}{\lambda\sqrt{n_1^2 - n_2^2}}$

(d) $V = \frac{2\pi d}{\lambda\sqrt{n_1^2 - n_2^2}}$

Q.12 An optical fiber having the core diameter of 80 μm has a core and cladding index difference as 0.02, the refractive index of the cladding is 1.5. The acceptance angle of the fiber if it is immersed in water is

(a) 17.81° (b) 13.30°
(c) 15.62° (d) 21.23°

Q.13 A multimode graded index fiber was used for transmiting signal from one point to the other. The diameter of core of the fiber is 70 μm and the index difference is 1.6%. The fiber was operated at an optical wavelength of 0.85 μm. If the *RI* of core is 1.48. Find how many modes can propagate through the fiber.

(a) 1171 (b) 1760
(c) 1820 (d) 1980

Q.14 A step index fiber having the core of refractive index 1.52 and the index difference of 0.01 is used to transfer the information. The transfer rate of the information through the fiber of length 1 km is

(a) 100 Mbps (b) 25 Mbps
(c) 22.17 Mbps (d) 19.73 Mbps

Q.15 A step index fiber has its core diameter and refractive index as 35 μm and 1.51 respectively and has a fractional index difference index of 0.0008. It is operated at wavelength of 1.5 μm. The V-number of the optical fiber is _____.

Q.16 An optical fibre is characterized by

(a) total internal reflection
(b) a core material of refractive index lower than that of cladding
(c) scattering loss
(d) diffraction

Q.17 An optical fibre has a refractive index of 1.641 for the core and 1.422 for the cladding. The critical angle above which a ray will be totally internally reflected is

(a) 37° (b) 41°
(c) 45° (d) 60°

Q.18 The refractive indices of the core and cladding of an optical fibre are 1.46 and 1.455 respectively. The diameter of the core is 4 μm. When operated at a wavelength of 1.31 μm, the fibre functions as a

(a) single-mode fibre with a numerical aperture of 0.1.
(b) multimode fibre with a numerical aperture of 0.15.
(c) single-mode fibre with a numerical aperture of 0.12.
(d) ten-mode fibre with a numerical aperture of 0.12.

Q.19 The refractive index of the core of an optical fibre is n_1 and that of the cladding is n_2. If $(n_1 - n_2) = \Delta n$, then the fibre can be made single mode with numerical aperture unchanged by

(a) reducing core diameter and increasing Δn
(b) reducing both core diameter and Δn
(c) reducing core diameter alone
(d) reducing Δn alone

Q.20 A step index fibre has a core refractive index of 1.46 and a cladding refractive index of 1.45. The pulse dispersion in ns/km due to the effect of numerical aperture alone is

(a) 33.3 (b) 31.5
(c) 29.5 (d) 25.2

Q.21 The maximum solid angle of acceptance of light coupled into a step index fibre having core and cladding refractive indices of 1.48 and 1.45 respectively, is

(a) 0.28 steradians (b) 0.30 steradians
(c) 0.32 steradians (d) 0.34 steradians

Q.22 In a step-index optical fiber, the refractive indices of the core and the cladding are equal to 1.501 and 1.499, respectively, at the wavelength of 850 nm. The fiber is surrounded by air.
The numerical aperture of the optical fibre is

(a) 0.077 (b) 0.501
(c) 1.499 (d) 1.501

Q.23 The numerical aperture of a step index fiber (refractive index = 1), is 0.39. The diameter of the core is 200 μm.

The angle of acceptance when the fiber is used in water (refractive index = 1.33) is closest to
(a) 15° (b) 16°
(c) 17° (d) 18°

Q.24 The core/cladding index difference of a single-mode optical fiber cable is 0.01. The refractive index of the material of the core is 1.5. The maximum angle of acceptance of the fiber is approximately equal to
(a) 17.5° (b) 12.1°
(c) 8.6° (d) 2.0°

Q.25 A double convex lens is used to couple a laser beam of diameter 5 mm into an optical fiber with a numercial aperture of 0.5. The minimum focal length of the lens that should be used in order to focus the entire beam into the fiber is
(a) 1.44 mm (b) 2.50 mm
(c) 4.33 mm (d) 5.00 mm

Q.26 Monochromatic light from a step index ($n_1 = 1.500$; $n_2 = 1.485$), multimode optical fiber of core diameter 100 μm is incident through air (n = 1.000) onto a linear photo-detector array placed at 1 mm distance from the tip of the fiber. The tip of the fiber is polished and its exit plane is perpendicular to the axis of the fiber. The detector array is oriented parallel to the exit plane of the tip. The array consists of photo-detector elements each of 5 μm diameter. The distance between the edges of two adjacent elements can be assumed to be zero. The number of elements illuminated by the light coming out of the fiber is _____.

Q.27 A beam of monochromatic light passes through two glass slabs of the same geometrical thickness at normal incidence. The refractive index of the first slab is 1.5 and that of the second, 2.0. The ratio of the time of passage of the beam through the first to the second slab is _____.

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Answers Fiber Optics

1. (c)	2. (b)	4. (d)	9. (b)	11. (a)	12. (b)	13. (a)	14. (d)	16. (a)
17. (d)	18. (c)	19. (c)	20. (a)	21. (a)	22. (a)	23. (c)	24. (b)	25. (c)

Explanations Fiber Optics

1. (c)
In optical fiber for the purpose of total internal reflection refractive index of the core must be greater than the refractive index of the cladding. So, from the given option only in option (c) this condition is true.

2. (b)
For step index fiber V number is given by

$$V = \frac{\pi d}{\lambda} \times (NA) = \frac{\pi d}{\lambda} \times n_1\sqrt{2\Delta}$$

$$\therefore \quad V = \frac{\pi \times 30 \times 10^{-6}}{1.5 \times 10^{-6}} \times 1.62 \times \sqrt{2 \times 0.0007}$$
$$= 3.80$$

3. (16.94)
Since, this angle is known as acceptance angle

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

$$\theta_a = \sin^{-1}\sqrt{1.43^2 - 1.40^2}$$
$$= 16.94°$$

5. (6.9)

$$\because \text{ Attenuation, } \alpha = \frac{10}{L}\log\frac{P_i}{P_0}$$

Here, $P_0 = \frac{1}{5}P_i$

$L = 1$ km

$$\therefore \quad a = \frac{10}{1}\log\frac{P_i}{1/5P_i}$$

$$= 6.9 \text{ dB/km}$$

6. (78.52)

$$\phi_c = \sin^{-1}\frac{n_2}{n_1} = \sin^{-1}\left(\frac{1.47}{1.50}\right) = 78.52°$$

7. (2156)

Number of modes through the graded index fiber

$$= \frac{V^2}{4}.$$

$$V = \frac{2\pi r}{\lambda}\sqrt{n_1^2 - n_2^2} = \frac{2\pi r}{\lambda} n_1\sqrt{2\Delta}$$

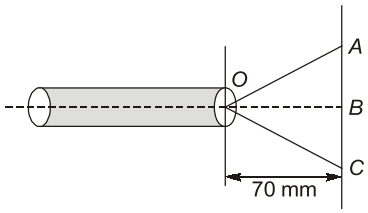
$$= \frac{2\times 3.14\times 30\times 10^{-6}}{0.86\times 10^{-6}} \times 1.58\sqrt{2\times 0.036}$$

$$= 92.876$$

Number of modes

$$= \frac{(92.87)^2}{4} = 2156.5 \cong 2156$$

8. (70.53)



$$NA = 0.45$$

$$\theta_a = \sin^{-1}(0.45) = 26.74°$$

$\angle AOB = 26.74°$,

$$\frac{AB}{OB} = \tan(26.74°) = 0.5038$$

$$\therefore \quad \frac{AB}{70} = 0.5038$$

$$AB = 70 \times 0.5038$$

$$= 35.27 \text{ mm}$$

$$\therefore \text{ Spot diameter} = AC = 2\,AB$$

$$= 70.53 \text{ mm}$$

9. (b)

$$\text{Loss} = \frac{10}{L}\log\frac{P_i}{P_0} = \frac{10}{0.5}\log\left(\frac{P_i}{0.7P_i}\right)$$

$$= 3.09 \text{ dB/km}$$

10. (2.67)

$$(NA)_{\text{Sending}} = 0.61$$

$$(NA)_{\text{Recieving}} = \sqrt{1.5^2 - 1.25^2} = 0.83$$

$$\because \text{ Coupling loss} = \frac{20}{L}\log\left(\frac{(NA)_{\text{Sending}}}{(NA)_{\text{Recieving}}}\right)$$

$$\text{Coupling loss} = \frac{20}{1}\log\frac{0.61}{0.83} = 2.67 \text{ dB/km}$$

12. (b)

$$\Delta = 0.02$$

$$\frac{n_1 - n_2}{n_1} = 0.02$$

$$\frac{n_1 - 1.5}{n_1} = 0.02$$

Solving, $n_1 = 1.53$

$$NA = n_1\sqrt{2\Delta}$$

$$= 1.53\sqrt{2\times 0.02} = 0.306$$

$$AA = \sin^{-1}\left(\frac{NA}{\mu}\right) = \sin^{-1}\left(\frac{0.306}{1.33}\right)$$

$$= 13.30°$$

13. (a)

Number of modes through graded index fiber $= \frac{V^2}{4}$

$$V = \frac{2\pi r}{\lambda}\sqrt{n_1^2 - n_2^2}$$

$$= \frac{2\pi r}{\lambda} n_1\sqrt{2\Delta}$$

$$= \frac{2\times 3.14\times 70\times 10^{-6}}{0.85\times 10^{-6}\times 2} \times 1.48\sqrt{2\times 0.016}$$

$$= 68.46$$

Number of modes

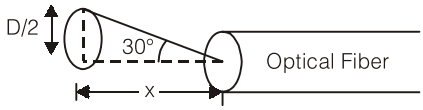
$$= \frac{(68.46)^2}{4} = \frac{4686.77}{4}$$

$$= 1171.6 \approx \text{modes}$$

14. (d)

$$n_1 = 1.52$$

$$\Delta = 0.01$$



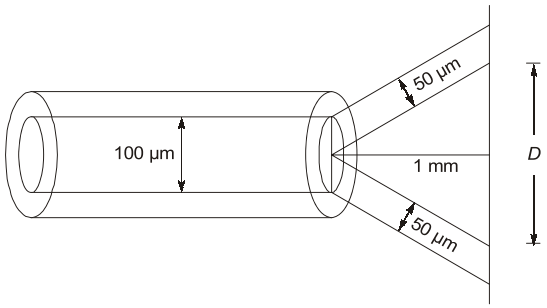
We have to find this distance 'X', as it is the focal of the lens

$$\tan 30° = \frac{D/2}{x}$$

$$\frac{1}{\sqrt{3}} = \frac{5}{2x}$$

$$x = \frac{5\sqrt{3}}{2} = 4.33\,\text{mm}$$

26. (106)



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

Here $\theta_a = \sin^{-1} \text{Na}$

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

$$= 12.216° = 0.213\,\text{rad}$$

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

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

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

27. (0.75)

$$v \propto \frac{1}{\mu}$$

But, $$v \propto \frac{1}{t}$$

$\therefore$ $$t \propto \mu$$

$\therefore$ $$\frac{t_1}{t_2} = \frac{1.5}{2} = 0.75$$

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