Numerical

- A step index fiber has n_1=1.44 and n_2=1.40. Find

a) Numerical Aperture

b) Relative refractive index

c) Acceptance angle

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$$NA = \sqrt{n_1^2 - n_2^2} = 0.337$$

$$\Delta = \frac{n_1 - n_2}{n_1} = 0.0277$$

$$\theta_a = \sin^{-1}(NA) = 19.69^0$$

Numerical

- The refractive index of the core of the step index fiber is 1.46 and the relative refractive index is 2%. Find

a) Numerical Aperture

b) Critical angle

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a) Numerical Aperture

b) Critical angle

$$NA = n_1\sqrt{2\Delta} = 0.292$$

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

$$n_2 = 1.4308$$

$$\phi_c = \sin^{-1}\left(\frac{n_2}{n_1}\right) = 78.52^0$$

Numerical

- A silica fiber with a core diameter is large enough to be considered for ray theory analysis has a core refractive index of 1.5 and cladding refractive index of 1.47. Find

a) Numerical Aperture

b) Critical and acceptance angle

Numerical

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a) Numerical Aperture

b) Critical and acceptance angle

$$NA = \sqrt{n_1^2 - n_2^2} = 0.3$$

$$\theta_a = \sin^{-1}(NA) = 17.4^0$$

$$\phi_c = \sin^{-1}\left(\frac{n_2}{n_1}\right) = 78.5^0$$

Numerical

- A typical relative refractive index difference for an optical fiber is 1%. Estimate the NA and solid acceptance angle in air when the core index is 1.46. Further calculate the critical angle at the core cladding interface within the fiber.

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$$NA = n_1\sqrt{2\Delta} = 0.21$$

$$\theta_a = \sin^{-1}(NA) = 12.2^0$$

$$\phi_c = \sin^{-1}\left(\frac{n_2}{n_1}\right) = 81.9^0$$

Numerical

- A graded index fiber has a core with parabolic index profile which has a diameter of 50 μm. The fiber has a numerical aperture of 0.2. Estimate the total number of guided modes in fiber at 1 μm wavelength.

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$$V = \frac{2\pi a}{\lambda}\sqrt{n_1^2 - n_2^2} = 31.4$$

$$M \approx \left(\frac{\alpha}{\alpha+2}\right)\frac{V^2}{2} \approx \frac{V^2}{4} \approx 246.49$$

Numerical

- A step index fiber in air has a numerical aperture of 0.16, a core refractive index of 1.45 and core diameter of 60 μm. Determine the normalized frequency of the fiber when input light transmitted at the wavelength of 0.82 μm. Estimate the number of guided modes.

Numerical

- A step index fiber in air has a numerical aperture of 0.16, a core refractive index of 1.45 and core diameter of 60 μm. Determine the normalized frequency of the fiber when input light transmitted at the wavelength of 0.82 μm. Estimate the number of guided modes.

$$V = \frac{2\pi a}{\lambda}\sqrt{n_1^2 - n_2^2} = 36.76$$

$$M \approx \frac{V^2}{2} \approx 376$$

Numerical

- A step index fiber has a normalized frequency of $V=26.6$ at 1300 nm wavelength. If the core radius is 25 μm, what is the numerical aperture?

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- A step index fiber has a normalized frequency of V=26.6 at 1300 nm wavelength. If the core radius is 25 μm, what is the numerical aperture?

$$NA = V\frac{\lambda}{2\pi a} = 0.22$$

Numerical

- A multimode step-index fiber with a core diameter of 80 μm and a relative index difference of 1.5 % is operating at a wavelength of 0.85 μm. If the core refractive index is 1.48, estimate (a) the normalized frequency for the fiber; (b) the number of guided modes.

Numerical

- A multimode step-index fiber with a core diameter of 80 μm and a relative index difference of 1.5 % is operating at a wavelength of 0.85 μm. If the core refractive index is 1.48, estimate (a) the normalized frequency for the fiber; (b) the number of guided modes.

$$V = \frac{2\pi a}{\lambda} n_1 \sqrt{2\Delta} = 75.8$$

$$M \approx \frac{V^2}{2} \approx 2873$$

Numerical

- Determine the cutoff wavelength for a step-index fiber to exhibit single-mode operation when the core refractive index is 1.46 and the core radius is 4.5 μm, with the relative index difference of 0.25 %.

Numerical

- Determine the cutoff wavelength for a step-index fiber to exhibit single-mode operation when the core refractive index is 1.46 and the core radius is 4.5 μm, with the relative index difference of 0.25 %.

$$\lambda_c = \frac{2\pi a}{V} n_1 \sqrt{2\Delta} = 1214 nm$$

Numerical

- A step index multi mode fiber with a numerical aperture of 0.2 supports approximately 1000 modes at an 850 nm wavelength.

(a). Calculate the fiber core diameter

(b). How many modes does the fiber support at 1320 nm?

(c). How many modes does the fiber support at 1550 nm?

Numerical

- A step index multi mode fiber with a numerical aperture of 0.2 supports approximately 1000 modes at an 850 nm wavelength.

(a). Calculate the fiber core diameter

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$$M \approx \frac{2\pi^2 a^2}{\lambda^2}\left(n_1^2 - n_2^2\right) = \frac{2\pi^2 a^2}{\lambda^2}(NA)^2$$

$$a = \left(\frac{M}{2\pi}\right)^{1/2} \frac{\lambda}{NA} = \left(\frac{1000}{2}\right)^{1/2} \frac{0.85\mu m}{0.2\pi} = 30.25\mu m$$

Therefore, $D = 2a = 60.5\ \mu m$

(b) $M = \dfrac{2\pi^2 (30.25\mu m)^2}{(1.32\mu m)^2}(0.2)^2 = 414$

(c) At 1550 nm, M = 300

Numerical

- Find the core radius necessary for the single mode operation at 1320 nm of the step index fiber with n_1=1480 and n_2=1.478. Also, determine the NA and the maximum acceptance angle of the fiber.

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- Find the core radius necessary for the single mode operation at 1320 nm of the step index fiber with n_1=1480 and n_2=1.478. Also, determine the NA and the maximum acceptance angle of the fiber.

$$a = \frac{V\lambda}{2\pi}\left(n_1^2 - n_2^2\right)^{-1/2} = \frac{2.40(1.32\mu m)}{2\pi\left[(1.480)^2 - (1.478)^2\right]^{1/2}} = 6.55\ \mu m$$

$$NA = \sqrt{n_1^2 - n_2^2} = 0.077$$

$$\theta_a = \sin^{-1}(NA) = 4.4^0$$