And those supported by graded index fiber can be calculated as :

$$M_G = \frac{\alpha}{\alpha+2}\left(\frac{V^2}{2}\right)$$

where alpha is index profile parameter

Problem statement :

a) Determine the normalized frequency at 850 nm for step index fiber having core radius of 25 um, core refractive index 1.48 and cladding refractive index 1.46. How many modes propagate through this fiber at 1300 nm and 1550 nm wavelength

→ Given

$\lambda = 850$ nm

$\cancel{\lambda_1 = 1300 \text{ nm}}$

$\cancel{\lambda_2 = 1550 \text{ nm}}$

$a = 25$ um

$n_1 = 1.48$

$n_2 = 1.46$

$$NA = (n_1^2 - n_2^2)^{1/2}$$
$$= ((1.48)^2 - (1.46)^2)^{1/2}$$
$$= 0.24$$

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

$$V = 44.35$$

Number of Modes at 1300nm and 1500nm
at 1300 nm

$$V_1 = \frac{2\pi}{1300 \times 10^{-9}} \cdot 25 \times 10^{-6} \cdot (0.24)$$

$$V_1 = 28.99$$

$$M_{31} = \frac{V_1^2}{2}$$

$$= \frac{(28.99)^2}{2}$$

$$= 420.21$$

$$V_2 = \frac{2\pi}{1550 \times 10^{-9}} \cdot 25 \times 10^{-6} \cdot (0.24)$$

$$= 24.32$$

$$M_{32} = \frac{V_2^2}{2}$$

$$= \frac{(24.32)^2}{2}$$

$$= 295.73$$

Q 2 A Multimode step index fiber has a relative refractive index difference of 1% and a core refractive index of 1.5. The number of modes propagating at a wavelength of 1.3 um is 1100. Estimate the diameter of the fiber core. Also determine maximum core diameter for single mode operation at same wavelength.

→ Given

$\Delta = 0.01$

$n_1 = 1.5$

$\lambda = 1.3\ \mu m$

$MS = 1100$

$MS = \frac{V^2}{2}$

$1100 = \frac{V^2}{2}$

$1100 \times 2 = V^2$

$2200 = V^2$

$V = 46.90$

$NA = n_1 (2\Delta)^{1/2}$

$= 1.5 (2 \times 0.01)^{1/2}$

$= 0.21$

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

$a = \frac{V\lambda}{2\pi\ NA} = \frac{46.90 \times 1.3 \times 10^{-6}}{2\pi \cdot 0.21} = 46.20 \times 10^{-6}$

$\cancel{d = 2a}$

$\cancel{d = 2(46.20 \times 10^{-6})}$

$\cancel{d = 92.4 \times 10^{-6}}$

$V \leq 2.405$

$\frac{2\pi}{\lambda}\ a\ NA \leq 2.405$

$a \leq \frac{2.405 \times \lambda}{2\pi (NA)}$

$$a_{max} = \frac{2.405 \times (1.3 \times 10^{-6})}{2\pi\ (0.21)}$$

$$= 2.36 \times 10^{-6}$$

$$d_{max} = 2\ a_{max}$$
$$= 2 \times (2.36 \times 10^{-6})$$
$$= 4.72 \times 10^{-6}$$

Q-3 A Graded index fiber with parabolic index profile supports the propagation of 742 guided modes. The fiber has a numerical aperture in air of 0.3 and core diameter of 70 um. Determine the wavelength of light propagating in fiber.

→ Given.

$M_a = 742$

$NA = 0.3$

$d = 70\ \mu m$

$$a = \frac{d}{2} = 70 \times 10^{-6}$$

$$a = 35 \times 10^{-6}$$

$$\cancel{M_a = \frac{\alpha}{\alpha+2}\left(\frac{V^2}{2}\right)}$$

$$M_a\ \frac{\alpha+2 \times 2}{\alpha} = V^2$$

$$\frac{742(2+2) \times 2}{2} = V^2$$

$$2968 = V^2$$

$$V = \sqrt{2968}$$

$$V = 54.47$$

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

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

$$= \frac{2\pi}{54.47} \cdot 35 \times 10^{-6} \cdot 0.3$$

$$\lambda = 1.21 \times 10^{-6}$$

Conclusion:

In this experiment we studied the v-number and no of modes supported by fiber.