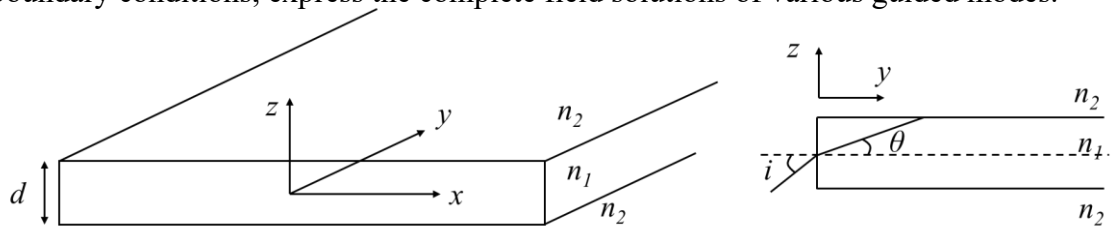


1. (1.1) A 100 km long step index fiber is to be chosen for optical communication purpose and hence tests with white/broadband light are being carried out. Write five most important reasons/observations which will help you choose the right one for the best of the purpose, i.e., fastest communication.
- (1.2) If n_1 and n_2 are refractive indices of the core and clad, and the operating mean wavelength is λ_0 , under optimal conditions, derive an expression for the best speed of communication possible in the above fiber.
- (1.3) For the above step index fiber, LP_{lm} are the possible guided transverse modes. Draw the radial field profiles and total field patterns in separate graphs for the fundamental, LP_{04} , LP_{12} and LP_{32} modes.

2. (2.1) A planar waveguide of width d and refractive indices n_1 (core) and n_2 (clad) is shown below (left schematic) for guiding light along y -direction. By describing the appropriate boundary conditions, express the complete field solutions of various guided modes.



- (2.2) Monochromatic light of wavelength λ_0 is launched from air ($n_0 = 1$) into the above waveguide (right schematic) at an incident angle i such that it makes angle θ from the axis (y -direction) of the waveguide. In the single mode operation, the light is launched at $i = 5$ degrees. Find the propagation constant of the guided mode.
3. (3.1) Show that lasing cannot be achieved with a just two-level system, whatever be the pumping and other conditions.
 - (3.2) An Nd:YAG laser delivers energy either in continuous wave (CW) mode or pulsed mode for the second harmonic. In the pulsed mode operation, the full width at half maximum duration is 2 ns and pulses are extracted at a rate of 500 pulses per second. However, in both the CW and pulsed modes, a constant average power of 10 W over beam diameter of 5 mm is measured. What is the laser energy delivered per second in the two modes? Also, find the maximum value of the electric field associated with the laser light in the two cases.
4. (4.1) An optical resonator is constructed using either two plane mirrors or two spherical mirrors (same radius of curvature R). Which of the two cases gives stable laser operation and why?
 - (4.2) Taking α as the gain medium loss parameter, derive an expression for the passive life-time of the above resonator for the end mirrors having intensity reflectivity as R_1 and R_2 , respectively.
 - (4.3) For a He-Ne laser, the length of the cavity is $L = 50$ cm, reflectivity of the two end mirrors is $R_1 = 100\%$ and $R_2 = 90\%$, respectively, and the medium loss parameter is 0.01 cm^{-1} . Calculate the passive cavity life-time and explain its relevance.
 - (4.4) For the above laser, draw the complete field modal profiles for the fundamental, first-order and second order transverse modes.
 - (4.5) What should be done to optimize the resonator for operating it in just the second-order transverse mode. Explain with proper reasoning.