Tutorial Sheet-5

[Laser Technology and Applications, 16B1NPH533, Odd Semester 2020]

1. [CO 4] Determine the axial mode number at the extreme ends of the visible region (400-700nm) for a resonator cavity of length 0.35 m and refractive index 1.3.

2. [CO 4] Determine wavelength in the following cases of Laser resonators (assuming mirrors are attached at the ends of active medium).
   (a) Ruby Laser with crystal refractive index of 1.6, number of modes is 10^6 and length of ruby rod is 21.7 cm.
   (b) He-Ne Laser with medium refractive index 1.055, number of modes 4×10^6 and length of cavity is 1.2 m.

3. [CO 4] (a) Starting from dispersion relation $\omega = v \cdot k$, Show that the oscillation frequency (ν_{mnq}) of various modes in three dimensional closed cavity (with sides a,b,d) is given by $\upsilon_{mnq} = \frac{c}{2n_0}\left(\frac{m^2}{a^2}+\frac{n^2}{b^2}+\frac{q^2}{d^2}\right)^{\frac{1}{2}}$, where m,n,q are modes, n_0 is refractive index, c is speed of light in vacuum, ω is angular frequency, v is speed of light in medium and k is propagation constant.
   (b) Further obtain 'ν_q' and '$\Delta\nu_q$' for m,n<<q or a,b>> d for open cavity.
   (c) Also show that the separation between two adjacent transverse modes '$\Delta\nu_m$' is given by $\Delta\nu_m = \Delta\nu_q \frac{\lambda d}{2a^2}\left(m+\frac{1}{2}\right)$ and much smaller than $\Delta\nu_q$.
   (d) If d=50 cm, a=2 cm, n0=1 and λ =500nm. Determine $\nu_{q=5}$, $\Delta\nu_q$ and $\Delta\nu_{m=1}$.