LASER TUT SOLUTIONS

Q.1 $\lambda = 632.8\,nm$; $hc = 1240$

Power $P = 1\,mW$

Photon output per second $= \dfrac{\text{Power of laser}}{\text{Energy of 1 Photon}}$

$$= \frac{1\,mW}{\left(\frac{1240}{632.8}\right) eV} = 10^{16}$$

So there will be 10^{16} Photons/s for the given laser.

Q.2 Photon Output of He-Ne laser $= \dfrac{1\,mW}{\left(\frac{1240}{632.8}\right) eV} = 10^{16}/s$

Photon output of Nd-YAG laser ($\lambda = 1.06$)

$$= \frac{10^{12}\,W}{\left(\frac{1240}{1060}\right) eV} = 10^{32}/s$$

Given that thermal photon output from ordinary broadband thermal source $= 10^{9}$ photons/sec.

Photon output of He-Ne laser & Nd-Yag laser is at least 7 and 23 orders higher than that from the broadband thermal source.

Q.3

Spectral width of Laser = 0.01 nm

Coherence length $L_c = \frac{\lambda^2}{\Delta\lambda} = \frac{(543\,nm)^2}{0.01\,nm} \simeq 2.9\,cm$

Coherence time $t_c = \frac{L_c}{c} = \frac{2.9\,cm}{3\times10^8\,m/s} = 0.1\,ns$

Q.4

$c = \lambda\nu$

$\nu = \frac{c}{\lambda} \Rightarrow \Delta\nu = -\frac{c\,\Delta\lambda}{\lambda^2} \Rightarrow \Delta\lambda = \frac{-\lambda^2\Delta\nu}{c}$

$\therefore |\Delta\lambda| = \frac{\lambda^2\Delta\nu}{c}$

$|\Delta\lambda| = \frac{\lambda^2\Delta\nu}{c} = \frac{(546.1\,nm)^2(6\times10^8\,s^{-1})}{3\times10^8\,m/s} = 5.96\times10^{-4}\,nm$

Temporal Coherence Length

$L = \tau c = \frac{c}{\Delta\nu} = \frac{\lambda^2}{\Delta\lambda} = \frac{546.1\,nm}{5.96\times10^{-4}\,nm} = 0.50\,m$

or

$L_c = \frac{c}{\Delta\nu} = \frac{3\times10^8\,m/s}{6\times10^8\,s^{-1}} = 0.5\,m$

Q.5

For ordinary light $\Delta\nu = \frac{1}{0.1ns} = 10^{10} s^{-1}$

For laser $\Delta\nu = \frac{1}{10\mu s} = 10^{5} s^{-1}$

And the corresponding coherence length for

ordinary light $L_c = \frac{c}{\Delta\nu} = c\tau_c = \frac{c}{10^{10}} = 3cm$

For laser light

$L_c = \frac{c}{10^5 s^{-1}} = \frac{3\times10^8 m/s}{10^5/s} = 3km$

Q.6 Angular spread $\theta = \frac{1.27\lambda}{D}$

$\theta = \frac{1.27 \times 0.85\mu m}{0.27 cm} = 4\times10^{-4} rd$

Size of the spot = Angular spread x Distance

$\therefore$ Distance $= \frac{200km}{4\times10^{-4}} = 0.5\times10^{9}$ m