Tutorial Sheet-9
[Laser Technology and Applications, 16B1NPH533, Odd Semester 2020]

1. [CO4] The output wavelength of CO_2 laser is 10.6 μm. If it produces an output of 1kW, how many photons are emitted in one minute?

2. [CO4] A gaseous laser is operated by 2A current and 230 V. If it produces an output of 10mW, what is the efficiency of the laser?

3. [CO4] Differentiate between direct and indirect band gab semiconductor and give two examples of each. Draw E vs k plot for direct and indirect band gab semiconductor. Which one will you select for making LEDs or diode lasers and why?

4. [CO4] If refractive index of Galium Arsenide (GaAs) material is 3.6 then determine reflectance 'R' for the GaAs-Air interface.

5. [CO4] The threshold current density for semiconductor laser is given by $J_{th}=\Delta n.e.d/\tau$ where Δn is the excess carrier density, e is electronic charge, d is thickness of the gain region and τ is time taken in spontaneous recombination. If $\Delta n=2.02x10^{18}cm^{-3}$, $e=1.6x10^{-19}C$ and $\tau=4ns$ then determine $J_{th}(A/cm^2)$ in each case;
   (a) GaAs homojunction laser with d=0.1mm,
   (b) GaAs heterostructure laser with d=0.1μm and
   (c) GaAs quantum well laser with d=10 nm.

6. [CO4] For Indium Phasphide (InP) laser diode, the wavelength of light emission is 1.55μm. What is its bandgap in eV?

7. [CO4] Bandgap of $Al_xGa_{1-x}As$ is given by $E_g=(1.424+1.266x)eV$. Determine the effective bandgaps and corresponding wavelengths in each case; (i) x=0.1, (ii) x=0.2. Also determine the emission wavelength of AlAs and GaAs.

8. [CO4] For GaAs material, effective mass of electron in conduction band $m_c=0.067m_0$, effective mass of hole in valence band $m_v=0.46m_0$ and $(E_g)_{Bulk}$ = 1.424eV where $m_0 = 9.1x10^{-31}kg$ is free electron mass. Determine Effective bandgap and emission wavelength for Quantum well laser of width (i) L=1μm, (ii) L=10nm, (iii) L=1nm. Explain the qualitative effect of quantum mechanics in case (ii) and (iii)?