Practice Problems

1. Show that optical intensity I and energy density u are related by the relation

$$I = uv$$

Where v is the group speed of light.
(Hint: Consider a cube of volume $A\Delta z$ where A is the area perpendicular to the light flow. The optical energy crossing the left facet of the cube over a time Δt would be present over the length $\Delta z = v\Delta t$. Make use of the fact that intensity is power per unit area and energy density is energy per unit volume.)

2.Show that wavelength λ in microns emitted by a semiconductor laser is related to the band gap energy E_g in electron volts by the relation
$\lambda(microns) = 1.24 / E_g\,(eV)$

3. A double heterojunction InGaAsP LED emitting at a peak wavelength of 1310 nm has radiative and non-radiative recombination times of 25 and 90 ns, respectively. The drive current is 35 mA.
(a) Find the internal quantum efficiency and the internal power level.
(b) If the refractive index of the medium is 3.5, find the power emitted from the device.
(Ans. (a) 0.7826 and 25.9 mW (b) 0.366 mW)

4. (a)A GaAlAs laser diode has a 500 micron cavity length which has an effective absorption coefficient of 10 cm^{-1} . For uncoated facets the reflectivities are0.32 at each end. What is the optical gain at the lasing threshold? (Ans. 32.78 cm^{-1})
(b) If one end of the lasers is coated with a dielectric reflector so that its reflectivity is now 90%, what is the optical gain at the lasing threshold? (Ans: 22.44 cm^{-1} . Notice that required gain to overcome the loss can be reduced by coating on one side of the cavity and take the useful output on the otherside)

5. A GaAs laser operating at 800 nm has a 400 micron cavity length with a refractive index of 3.6. If the gain exceeds the total loss in the region 750 nm $< \lambda <$ 850 nm and the loss dominates the gain for wavelengths that are out of the above range, how many modes will exist in the laser?
(Ans: 451 modes)

6. Find the grating period of a DFB laser required to operate at 1550 nm. Assume the refractive index = 3.5 and choose the grating period such that operating wavelength corresponds to first order Bragg diffraction.
(Ans: 221.42 nm)

7. A 1300nm InGaAs laser diode has the following parameters:

Active area width w 3 microns

Active area thickness d 0.3 microns

Length L 500 microns

Confinement factor Γ 0.3

Time constant τ_{r} 1 ns

Gain cross-section σ_{g} $2.5\times10^{-20}\,\mathrm{m}^2$

Threshold density n_{th} $0.8\times10^{24}\,m^{-3}$

Absorption coefficient α $0.46\,\mathrm{c}m^{-1}$

Refractive index $= 3.5$

Reflectivities $R_1 = R_2 = 0.6$

Under steady state conditions, calculate (a) threshold current
(b) the bias current required to generate a power of 10 mW.
(Ans: (a)57.7mA (b)63.3mA)