Homework #4

1. Book problem 3.4

2. The output power of a laser diode family is given by $P_{out} = A(I - I_{th})$ for I>I_{th} and zero otherwise. Let A=1mW/mA. If the bias current I is 70mA, find the output power if (a) I_{th}=30mA, and (b) I_{th}=100mA.

3. If the linewidth of an LED at 300K is 0.01 μm, find the operating temperature to reduce the spectrum width to 10GHz. For simplicity, assume the central wavelength is 0.9μm and stays the same when temperature changes.

4. If the gain profile of a laser diode of cavity length L=1000μm has λ_{min}=1.399μm and λ_{max}=1.400μm, find the mode separation and the total number of propagation modes. Assume the refractive index of the device is 3.0. If you want to have only one longitudinal mode, what is the maximum possible cavity length?

5. If a laser diode has length L=800μm and dielectric constant of 15, find the minimum distributed gain in dB/m. Assume the distributed loss is 1200dB/m.

6. Consider a FP laser made of InGaAsP with refractive index 3.5.
   a. If the device has a gain profile
   $$g(\lambda) = g_o\, e^{-(\lambda-\lambda_o)^2/\sigma^2}$$
   With g_o=1500m-1, σ=10nm, and distributed cavity loss of α=1000m^{-1}, find the lower limit of the cavity length for lasing.

   b. If the device has a longitudinal length L=2000μm and the same gain profile given in a, find the number of longitudinal modes. Let α=500m^{-1} and λ_o=1.5μm.

7. A cleave coupled cavity laser has two cavities of lengths 800 μm and 1000μm. Assume that the effective refractive index of the cavity is 3.0.
   a. Find the mode separation in GHz.
   b. Find the approximate mode separation in nm. Assume the central wavelength is λ=1.5μm.

8. If a DFB laser diode has a cavity length of 1000μm, find the period of the Bragg reflector structure so that the output wavelength is 1.50μm. Let the effective refractive index of the cavity be 3.0.

9. A vertical cavity surface emitting laser (VCSEL) is constructed with a center wavelength near λ_o=980nm. Assume that the effective index of refraction of the cavity is 3.5. What is the cavity length such that there is only single mode in the gain region 970nm < λ < 990nm? If the threshold gain is g=2000m^{-1} and the distributed loss is 300m^{-1}, what is the minimum reflectivity of the cavity, r? Assume that r_1=r_2=r.