HW #7
Due Nov. 29 (Thursday) in class

1. A GaAs quantum well laser has the following parameters:

   Gain: $g(N,S) = \frac{g_0}{1+\varepsilon S}\ln\left(\frac{N}{N_{tr}}\right)$, where $g_0 = 2400 cm^{-1}$

   Transparency carrier concentration: $N_{tr} = 10^{18} cm^{-3}$

   Gain compression coefficient: $\varepsilon = 10^{-17} cm^3$

   Effective refractive index: $n_{eff} = 3$

   Carrier recombination lifetime: $\tau = 1ns$

   Cavity length: $L = 200\mu m$

   Laser width: $w = 1\mu m$

   Quantum well width: $L_z = 10nm$

   Confinement factor: $\Gamma = 3\%$

   Spontaneous emission factor: $\beta = 10^{-4}$

   Intrinsic optical loss: $\alpha_i = 10 cm^{-1}$

   Internal quantum efficiency: $\eta_i = 90\%$

   a. Find the threshold gain, threshold current, and the slope efficiency (in W/A) of the laser.
   b. If the laser is biased to have a total output power of 10 mW from both facets, what is the carrier concentration at this bias point? (Hint: assume the carrier concentration is clamped at threshold value).
   c. For the remaining problems, assume an output power of 10 mW unless stated otherwise. What is the photon density inside the cavity?
   d. Find the resonance frequency (relaxation oscillation frequency) of the laser. (Hint: please note that the differential gain here is a function of the photon density. You should use the photon density you found in Part c.)
   e. What are the K factor and the damping coefficient of the laser at this bias point?
   f. Plot the frequency response of the laser, $|H(\omega)|^2$, in log-log plot.
   g. If we increase the bias and hence the output power, the resonance and the 3-dB frequency will continue to increase until the damping becomes dominant. What is the maximum 3-dB frequency of the laser? What is the resonance frequency at that bias point?
   h. What is the photon density at which the maximum 3-dB frequency is attained? What is the bias current?