Homework 6

Here are the parameters of semiconductor laser:
Active layer thickness $d_a=100$ Angstrom
Width $W=2\mu m$
Length $L=300\mu m$
Reflectivity $R=32\%$
Refractive index $n=3.35$;
Confinement factor $\Gamma=0.04$
Modal loss $\alpha=20cm^{-1}$
Wavelength $\lambda=1550nm$

Gain dependence on carrier concentration $\gamma = \gamma_0 \ln \left( \frac{N_e + N_{e,\text{sat}}}{N_{\text{tr}} + N_{e,\text{sat}}} \right)$

Where transparency density is $N_{e,\text{tr}}=1.8\times10^{18} cm^{-1}$, saturation density is $N_{e,\text{sat}}=-0.4\times10^{18} cm^{-3}$ (negative sign is OK) and $\gamma_0=1800 cm^{-1}$
The recombination rate is $\tau_r^{-1}=A + BN_e + CN_e^2$ where $A=10^7 s^{-1}$ $B=0.8\times10^{-10} cm^3/s$ and $C=3.5\times10^{-30} cm^6/s$
Assume 100% injection efficiency (no leakage)

1. Plot gain vs carrier density curve
2. Plot differential gain vs carrier density curve
3. Plot gain vs current density curve.
4. Determine photon lifetime $\tau_p$, threshold modal gain, and threshold material gain $\gamma_{\text{th}}$ Determine threshold carrier density $N_{e,\text{th}}$, threshold current density $J_{\text{th}}$ and threshold current $I_{\text{th}}$
5. Determine threshold differential gain $a_{\text{th}}$ and recombination rate at threshold.
6. Plot output power versus input current curve.
7. Determine the current at which output power is equal to 1mW.
8. Determine the resonant frequency at this power level.
9. Determine the linewidth at this power level ($\alpha=4$)