HW #8 due 4/11/18 5PM
no later than 4/12/18 in class

Notice a one page progress report will be due on 4/10/18.

1. Consider a semiconductor laser which has a FP resonator of length 400 $\mu m$. The peak radiation is at 1330nm and refractive index of the semiconductor is is 4. The laser has slope efficiency 0.3 W/A and threshold current of 35mA. Assume optical gain linewidth is 3nm and internal attenuation coefficient $\alpha$ is 10 $cm^{-1}$.

a) Find the current required to drive the laser to output 2mW.
b) Find the integer m (mode index) that is closest to the peak radiation.
c) Find the separation between modes (resonant freq) of the FP cavity.
d) How many modes are there within the gain linewidth?
e) What is the power reflectivity at the ends of the FP cavity?
f) Find the threshold gain coefficient to sustain oscillation.

2. Consider the fiber in HW4 question 4 operating at the same wavelength of 1300nm. The system data rate is 0.3Gb/s. Now we have 3 sets of transmitter and receiver. Check their feasibility and compute the maximum transmission distance for the case(s) that is (are) feasible a) modulation bandwidth for transmitter and receiver are the same, 2 GHz, b) modulation bandwidth for transmitter is 800 MHz and modulation bandwidth for receiver is 2GHz, d) modulation bandwidth for transmitter and receiver are the same, 500 MHz.

3. Consider a system that uses the fiber in HW4 problem 4 operating at 1300nm, OKI OL303A laser diode (see spec on the web) and Melles Griot 13DSH001 spec for photodiode (see spec on the web). A 1.8 $k\Omega$ load resistor is used in the photodiode. The system is required to operation at 40 Mb/s. (Notice: 13DSH001 is a silicon diode that will not work at $1.3\mu m$. Here, we assume to use a Germanium diode that has the same parameters as 13DSH001.)

a) Which modulation response time is larger (transit time or circuit time)? Find the effective rise time of the photodiode.
b) What is the maximum transmission distance?
c) Suggest one way to double the transmission distance by adjusting other device parameters. Show the new set of parameters for this system.

4. A PIN photodetector has responsivity 0.3 A/W and 2nA of dark current. The load resistance is 1000Ω and the system bandwidth is 60 MHz. The temperature is $15^{o}C$.

a) At what value of received optical power is the thermal noise equal to shot noise?
b) What is the signal to noise ratio at this power level?
c) What is the value of the shot-noise power at this value of the received optical power?

Extra-Credit for undergraduate (regular for graduate)

5. Consider the spec sheet for Melles Griot's 13 DSH series PIN photodiodes on the web,

a) Estimate the minimum output photo-currents when a laser beam at 830nm with uniform intensity of 200 $W/cm^2$ inputs to the three diodes (13DSH001, 13DSH003, 13DH005).
b) Estimate the minimum output photo-currents when a laser beam at 500nm with uniform intensity of 200 $W/cm^2$ inputs to the three diodes (13DSH001, 13DSH003, 13DH005).
c) Estimate the minimum quantum efficiency for 13DSH001 at 830nm and 500nm.
d) For diodes 13DSH001, 13DSH003 and 13DH005, estimate their maximum modulation bandwidths.
e) What should be the maximum load resistance for each diode to achieve the maximum modulation bandwidth calculated in d).

Extra-Credit

6. An analog system has a bandwidth of 10 MHz, a photodetector whose responsivity is 0.3A/W (it has no gain) and whose dark current is 1 nA and a SNR of 30dB when the input optical power is modulated as $P_{in} = P_o(1 + \cos\omega t)$ where $P_o$ is the amplitude of the AC portion of optical power. The receiver's temperature is $40^o C$ and the load resistance is 50Ω. How much optical power (average) must reach the receiver?