HW #7 due 4/3/18 5PM

no later than 4/4/18 5PM

1. Consider a Fabry-Perot (FP) etalon with $R_1 = R_2 = R = 0.9$. This etalon will be used for a filter operating around the wavelength of $1.5\mu m$. If the etalon has thickness of 1.5mm and refraction index of 1.46, find a) free spectral range Δf_{FSR}, b) Finesse, c) $\Delta\lambda$, d) the integer order m that is closest to the intended operation wavelength and e) use answer from d) to find the actual operation wavelength.

2. Consider a 16-channel WDM system where the interchannel spacing is 100GHz and each channel has bandwidth of 2GHz. We will consider FP filter that is made of glass with n=1.5. i) What is the minimum free spectral range to include all the channels? How thick should be the FP filter? ii) What is the required finesse? iii) What should be the power reflectivity of the partial mirrors?

3. a) Consider the Mach-Zehnder filter in Fig. 3.21 (page 142 of 3rd Ed. and page 136 of 2nd Ed. of the text book). Assume that a signal enters into input 2. Show that $2\pi f_2 \Delta Ln/c = (2m+1)\pi$ and $2\pi f_1 \Delta Ln/c = 2m\pi$ for constructive interference at output ports using the fact that $\pi/2$ phase shift incurs when signal goes across ports but no phase shift when signal passes straight through. Notice that f_1 is the frequency at output port 1 and f_2 is the frequency at output port 2. (read description on page 137)

b) Consider the Mach-Zehnder filter in Fig. 3.21 being used as a demultiplexer for 2 WDM channels at a frequency separation of 25 GHz. Assuming that the refractive index of the filter is 1.45, find the path difference.

4. Consider a single mode communication link using a $Al_x In_{1-x} As$ LED as a transmitter and a single mode fiber with $D_{intra} = 25 ps/km-nm$ (a unusual combination). Assume that the formula $0.36 + 2.012x + 0.698x^2$ gives the bandgap energy of $Al_x In_{1-x} As$ and the bandgap energy is independent on temperature.

a) Find the bandgap energy for $Al_{0.4} In_{0.6} As$.

b) Find the wavelength of the LED at 273K and 323K.

c) Find the linewidth of the LED at 273K and 323K.

d) If the data rate is 1Gb/s, what is the maximum transmission distance at 273K and 323K.

Extra-credit for undergraduate (regular for graduate)

5. We discussed the 1×8 Mach-Zehnder filter in lecture has 3 stages and 7 1×2 filters. Generalize this concept to design a 1×32 Mach-Zehnder filter or demultiplexer. The distribution of frequencies follows the relationship $f_i = f_o + i\Delta f$ where $i = 1, \ldots, 32$ is the channel number.

a) How many stages and how many 1×2 filters will be required?

b) Draw a diagram show the distribution of channel frequencies at each stage.

c) If $\Delta f = 30GHz$ and the refractive index of each filter is 1.5, find the path difference for each 1×2 filter.

Extra-Credit

6. For the etalon in problem 1, plot its power transmissivity versus wavelength around the center wavelength region under the following conditions (note: make sure you show about 3-4 resonant peaks in plots and all plots use the same range. Please submit your program for these plots)

a) $R_1 = R_2 = 60\%$

b) $R_1 = R_2 = 99\%$

c) $R_1 = 98\%$, $R_2 = 20\%$

d) $R_1 = 98\%$, $R_2 = 60\%$

e) $R_1 = 50\%$, $R_2 = 20\%$

Preferably, you can put a) and b) in the same plot and c), d) & e) in another plot. The formula for power transmissivity is: $(1-R_1)(1-R_2)/[(1-h)^2 + 4h\sin^2(\phi/2)]$ where $h = \sqrt{R_1 R_2}$ since there is no gain or loss in this problem and $\phi = 2kd$.