HW #2
1. a) A point source of light is located 1m below water-air interface. Find the radius of the light circle seen by an observer positioned over the source (outside of the water). The refractive index of water is 1.333.
b) A laser is 1m below the water0air interface. Draw a diagram and indicate in the diagram the polarization of the laser and the angle at which all the laser light will be transmitted.
c) If the laser beam is normal to the water-air interface, Find the percentage of transmitted power.

2. A laser beam has beam radius (waist) of 100 µm and wavelength of 630nm.
Find the beam radius (waist) at a) 1 m and b) 1 cm from the laser.
c) Find the divergence angle of the beam and distance range at which the divergence angle is invalid.

3. An elliptic beam as shown in the following diagram originating from a laser pointer with wavelength of 638 nm, apply the Gaussian beam formula to estimate the beam shape and size of the beam 5m from the laser pointer. Sketch your answer.
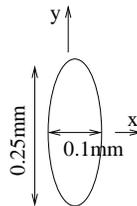
(Notice that you need to apply the Gaussian beam formula separately to x and to y.)

4. Find the constructive interference conditions for Mach-Zehnder and Michelson interferometers shown in the following diagram. All beams are propagating in air with n=1 unless indicated otherwise in diagrams.

Mach–Zehnder   Michelson
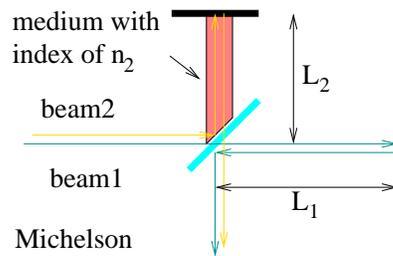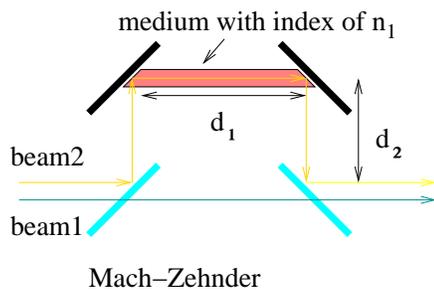
Extra-Credit for undergraduate (regular for graduate)
5. Use information from the Jan. 25 lecture summary on the web to show that
$$\Gamma_p = \frac{-n_2 \cos\theta_1 + n_1 \cos\theta_2}{n_2 \cos\theta_1 + n_1 \cos\theta_2} \text{ and } \Gamma_s = \frac{-n_2 \cos\theta_2 + n_1 \cos\theta_1}{n_2 \cos\theta_2 + n_1 \cos\theta_1}.$$

Extra-Credit
6. a) Show that $\Gamma_s = -\sin(\theta_1 - \theta_2)/\sin(\theta_1 + \theta_2)$ and $\Gamma_p = -\tan(\theta_1 - \theta_2)/\tan(\theta_1 + \theta_2)$ starting with the expressions in problem 5.

b) Make use of the formulas for Γ_p, Γ_s problem 5 as well as formulas for τ_p and τ_s on Jan. 25 summary. Plot $|\tau_p|^2 = \tau_p \cdot \tau_p^*$ and $|\tau_s|^2 = \tau_s \cdot \tau_s^*$ versus incidence angle θ_1 (ranging from 0° to 90° for $n_1 = 3.6$ and $n_2 = 1$. (You can use any program, e.g. Excel or Matlab to plot. You may consider gnuplot if you want a free plotting program: http://www.gnuplot.info/
Notice that θ_2 is determined by θ_1 through Snell's law and the plot can stop at the critical angle)