Part I: 50points, Please describe your answers as complete as possible

1. The Wollaston prism:

(a) (10%) Determine the angle of deviation between the two emerging beams of a Wollaston prism constructed of calcite and with wedge angle of 45°.

(b) (5%) Please sketch the entering and emerging beams and identify the state of polarization. ($n_{\perp}$ = 1.6584, $n_{\|}$ = 1.4864)

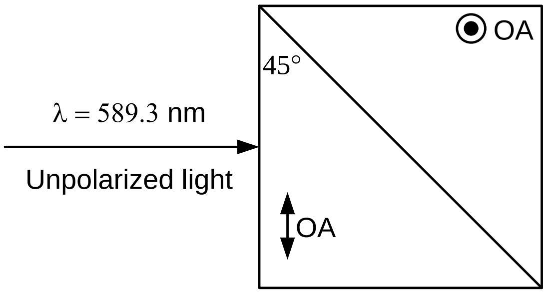

Fig. 1

2. Consider a light source consisting of two components with different wavelength λ_1 and λ_2. Let light from this source be incident on a scanning Fabry-Perot interferometer of nominal length d = 5 cm. Let the scaled transmittance through the Fabry-Perot as a function of the change in the cavity length be as shown in Fig. 2(a) and 2(b). Fig. 2(b) shows the first set of dual peaks of Fig. 2(a) over a smaller length scale in order to allow a closer examination of the structure of the overlapping peaks.

(a) (5%) What is the nominal wavelength of the light source?

(b) (5%) Estimate the difference λ_2 - λ_1 in wavelength of the two components presuming that the overlapping transmittance peaks have the same mode number, $m_2 = m_1 = m$.

(c) (5%) Estimate the difference λ_2 - λ_1 in wavelength of the two components presuming that the overlapping transmittance peaks have mode numbers that differ by 1, so that $m_2 = m_1 + 1$.

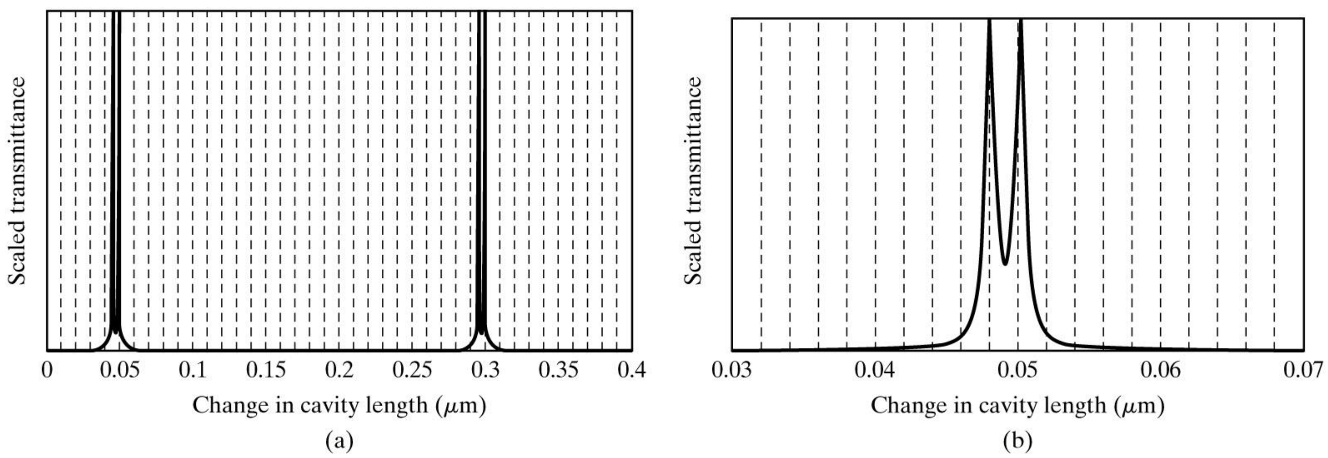

Fig. 2

3. The numerical aperture (NA) is a measure of the light-gathering capability of a fiber. It is defined as the sine of the maximum external angle of the entrance ray (measured with respect to the axis of the fiber) that s trapped in the core by total internal reflection.

(a) (5%) Show that $NA = n_1 \sin\theta_1 = (n_1^2 - n_2^2)^{1/2}$

(b) (5%) Show that the solid acceptance angle in air is $\Omega = n\pi(n_1^2 - n_2^2)^{1/2} = \pi(NA)^2$.

(c) (5%) Show that the solid angle (in air) for a single electromagnetic radiation mode leaving or entering the core aperture is $\Omega_{\text{mode}} = \dfrac{\lambda^2}{\pi a^2}$.

(d) (5%) Find the numerical aperture of a multimode fiber with n_1=1.52 and n_2=1.50.

Part II: 50points

1. (a) What's gain saturation phenomenon in laser media? (b) Calculate the gain saturation, $\gamma(\nu)$, in homogeneous and inhomogeneous media in terms of $I_0(\nu)$ and $I_s(\nu)$ which are the intensity of the optical field and the saturation intensity, respectively. (c) Compare the difference of the gain saturation between the homogeneous and inhomogeneous media. (15%)

2. Give an optical resonator

(← l = 30 cm →)

R_1 = -20 cm $\qquad\qquad$ R_2 = 15 cm

(a) Calculate the position of the waist of the mode at λ = 1 μm. (10%)

(b) Calculate the diameter of the waist. (10%)

3. The ability of an optical resonator to support low loss modes depends on the mirror's separation l and their radii of curvature R_1 and R_2. Calculate the stability condition for optical resonators. (15%)

Part II: 50points

1. Plot the energy band diagram, for (a) a homogeneous p-n junction and (b) a p-i-n junction at equilibrium and forward bias. (18 points)

2. Define the responsivity of a photodetector. What is its unit? Plot the responsitivity versus wavelength curve for an ideal and a typical commercial available Si photodiode. List the advantages of a p-i-n photodiode over a p-n diode. (14 points)

3. (a) Under weak injection, what is the relation between the luminescent rate as a function of photon energy? Plot the spectral intensity of the direct band-to-band injection-electroluminescence rate versus photon energy under weak injection. (b) Show that the spectral intensity of the emitted light attains its peak value at the frequency of (E_g + kT/2). (18 points)