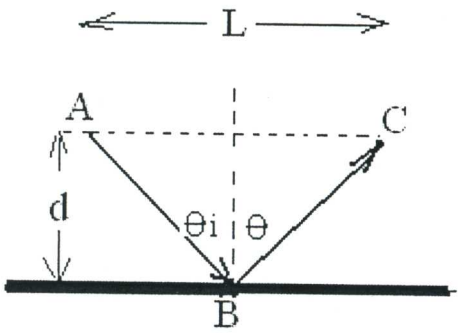
光電所光電子學博士班資格考 2007 年 10 月 15 日總共十一題 100 分 (96K)

1. Fermat's principle states that optical rays follow a path such that the time of travel is an extremum (usually a minimum). Show how to use this theory to prove that the angle of incidence is equal to the angle of reflection for an optical wave incident upon a mirror, by following the following steps.

(a) Refer to the following figure, and express the path AB+BC in terms of d, Θi and Θ. (2 %)

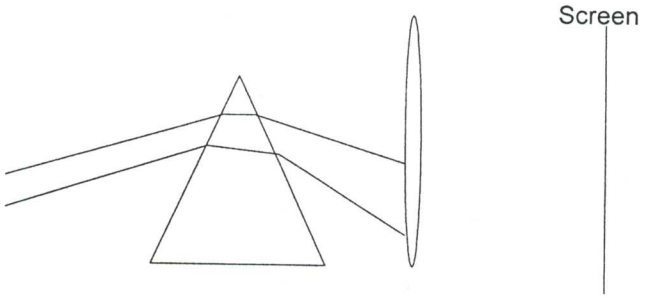
(b) Minimize the path AB+BC with respect to the angle Θ. Note that d and the distance L between points A and C are both fixed, and Θi is related to Θ through the equation $d \tan \Theta i + d \tan \Theta = L$. (8 %)

(You may differentiate the equation above with respect to Θ to obtain the term $\frac{\partial \theta i}{\partial \theta}$. When you do this, use the formula $d(\tan x)/dx = 1/\cos^2 x$.)



2. What are Mach-Zehnder interferometer, Michelson interferometer and Sagnac interferometer? Explain how they work. (5%)

3. (15%) A transparent prism is illuminated with roughly collimated white light as shown below. To get a clear image, where should we locate the lens and the screen? Plot the order of the output color. Explain it with a dispersion diagram.



transmitted Poynting vector when light is incident on the interface between air and an uniaxial crystal with arbitrary crystal orientation with respect to the incident light.(10%).

8. (10%) The ***mutual intensity*** of an optical wave at points on the x axis is given by

$$G(x_1, x_2) = I_0 \exp[-\frac{(x_1^2 + x_2^2)}{W_0^2}]\exp[-\frac{(x_1 - x_2)^2}{\rho_c^2}],$$

where I_0, W_0, and ρ_C are constants. Derive an expression for the normalized mutual intensity $g(x_1, x_2)$ (5%) and sketch it as a function of $x_1 - x_2$ (2%). What is the physical meaning of the parameters I_0, W_0, and ρ_C (3%)?

9. (8%) (a) Please find the expressions of the transmittance T and reflectance R of the resonator cavity below, where the cavity length is d, reflection coefficients of mirror 1 (M_1) and mirror 2 (M_2) are Γ_1 and Γ_2, and the single-pass power gain is G_0.

(2%) (b) Does T + R = 1? Why?

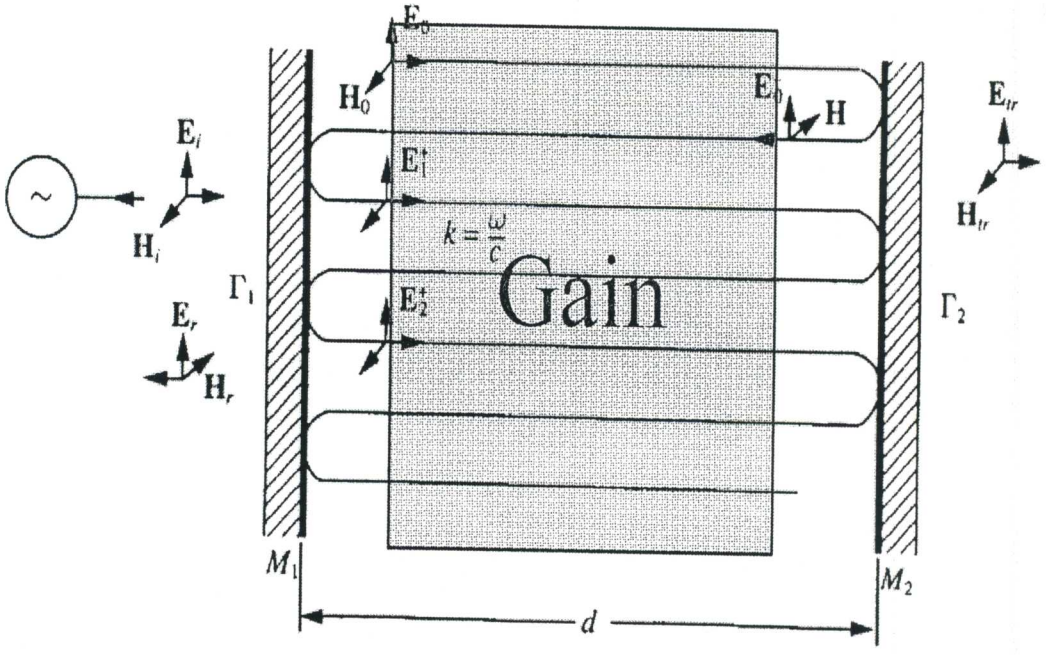


FIGURE 6.1. Optical cavity.

10. (10%) For the spherical-mirror resonator below, please show that the resonance frequencies can be expressed as $\upsilon_{l,m,q} = \frac{c}{2d}\left[q + \frac{1+l+m}{\pi}\cos^{-1}(g_1 g_2)^{1/2}\right]$, where d is the cavity length, g_1 and g_2 are the g parameters for mirror 1 and mirror 2, q is the longitudinal mode index, and l and m are the Hermite-Gaussian mode