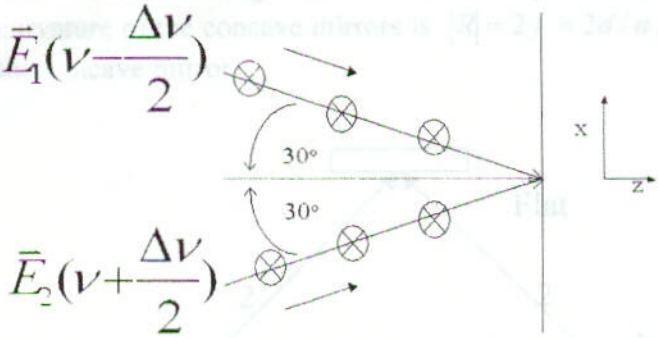
國立清華大學命題紙

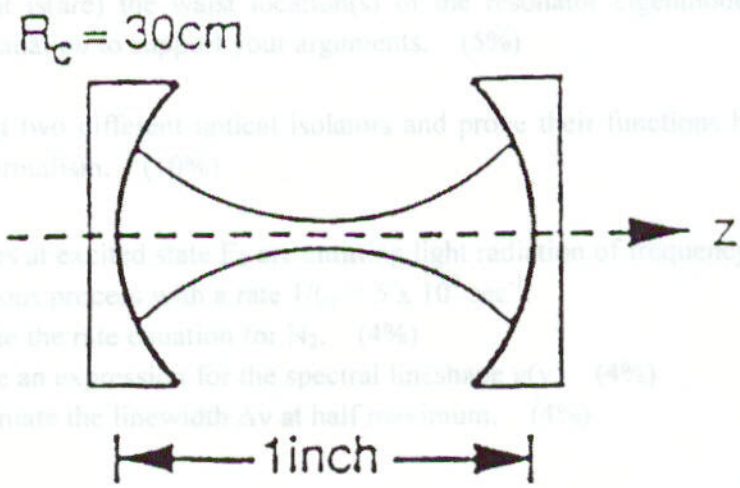
九十二 學年度第一學期 光電工程研究所 博士班研究生資格考試

科目 光電子學 科號 共 3 頁第 1 頁 ＊請在試卷(答案卷)內作答

1. Two uniform plane waves with propagation directions on x-z plan interfere on the screen as shown below. Assuming the magnitude of E_1 and E_2 are 1 and 2, respectively,
   (a) please write down the mathematical expressions of these two E fields (including the polarization directions) (5%),
   (b) assuming that $\nu = 5 \times 10^{14}$ Hz $>> \Delta\nu = 1 \times 10^{5}$ Hz, please derive the expression of the interference pattern and describe the behavior of this pattern (period, color, moving direction and speed) (15%)
   (c) defining the visibility V as $(I_{max}-I_{min})/(I_{max}+I_{min})$ where I is the intensity of the E field, please calculate V in this case. (5%)



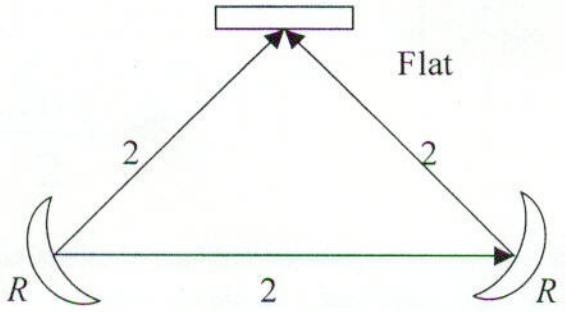
2. The Fabry-Perot optical spectrum analyzer consists of two spherical mirrors of radii of curvature Rc = 30 cm each that are placed 1 inch apart. The optical alignment of the mirrors is as shown.
   (a) For a Gaussian-beam mode of this device, where do you expect the beam waist to be? (4%)
   (b) Calculate the intensity radius at the waist for $\lambda = 600$ nm. (3%)
   (c) What is the intensity radius at each mirror? (3%)
   (d) What is the half-angle of divergence of the light beam that comes out? (3%)



3. (a) 1 W of optical power is focused uniformly on a flat round target with a radius of 0.2 mm placed in free space. Determine the peak value of the electric field E_0 (V/m). Assume that the optical wave is approximated as a TEM plane wave within the area of the target. (6%)

   (b) Determine the electric field at the center of a Gaussian beam (a point on the beam axis at the beam waist) if the beam power is 2 W and the beam waist radius $W_0 = 0.05$ mm. (6%)

4. A laser ring resonator consists of two concave mirrors of radius of curvature R and one flat mirror, as shown below. The minimum distance between any of the two mirrors is $2d$. Assume no astigmatism due to the angles in the bending plane. The radius of curvature of the concave mirrors is $|R| = 2f = 2d/a$, where f is the focal length of the concave mirror.



   (a) For a ring cavity like this, is it possible to choose any value of a so that the radius of curvature of the resonator eigenmode at the concave mirror is the same as the mirror's radius of curvature? Prove your statement. (5%)

   (b) To form a stable resonator, what is the (numerical) constraints on a. (5%)

   (c) What is(are) the waist location(s) of the resonator eigenmodes? Give your explanation to support your arguments. (5%)

5. Construct two different optical isolators and prove their functions by using Jones matrix formalism. (10%)

6. The atoms at excited state E_2 are emitting light radiation of frequency ν_0 through spontaneous process with a rate $1/t_{sp} = 5 \times 10^9$ sec^{-1}.

   (1) Write the rate equation for N_2. (4%)

   (2) Give an expression for the spectral lineshape $g(\nu)$ (4%)

   (3) Estimate the linewidth $\Delta\nu$ at half maximum. (4%)

7. For two particular emission lines at ν_1 and $\nu_2=4\nu_1$ of a gas sample, the linewidths $\Delta\nu_1$ and $\Delta\nu_2$ were found to be function of temperature T due to Doppler broadening.
   (1) Write the expression of lineshape $g(\nu)$. (5%)
   (2) What is the ratio $\Delta\nu_1/\Delta\nu_2$ you may expect? (4%)
   (3) How would the linewidth $\Delta\nu_1$ become when the temperature was increased by 5 folds? (4%)