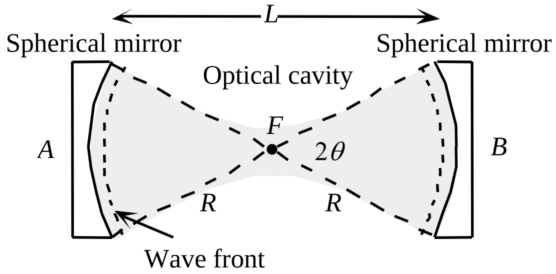
جامعة الملك سعود
كلية العلوم
قسم الفيزياء والفلك
الأسم .... الرقم الجامعي

الاختبار النهائي لمقرر ٥٣١ فيز (الفصل الدراسي الثاني ١٤٢٧/١٤٢٨ هـ)

Question one

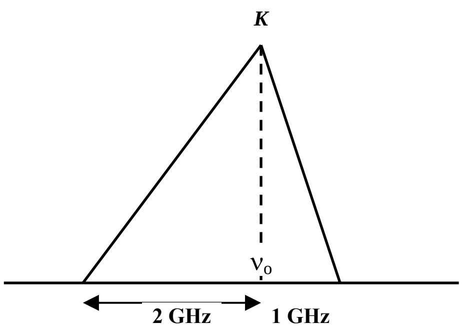
(a) In the confocal cavity shown, the light beam in the cavity is a Gaussian beam. If *R* =25 cm, and the mirrors are of diameter 2.5 cm, estimate the divergence of the beam and its spot size (minimum waist) for light of wavelength 500 nm.



(b) For inhomogeneous line shape function shown of the laser with;

$\lambda = 8\times10^{-5}$ cm , $A_{21} = 2.5\times10^{6}\ s^{-1}$, n = 2.75

Calculate the stimulated emission cross section.



Question Two

Consider a two-level system, non-degenerate, homogeneously broadened system of atoms with line-shape function g(ν) and energy levels E_1 and E_2. This system is pumped in a steady-state by monochromatic radiation with intensity I_ν and frequency $\nu = (E_2-E_1)/h$.

(a) give stimulated transtion rate W_{21} in terms of the pump intensity I_ν and other atomic parameters.

(b) Derive a steady-state expression for $(N_1-N_2)/(N_1+N_2)$ of this system in terms of W_{12}, W_{21} and A_{21}. N_1 and N_2 are the population density for the lower and upper state respectively; A_{21} is the spontaneous emmision rate.

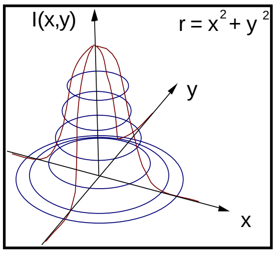
Question Three

The electric field of a TEM_{00} Gaussian beam may be expressed as follows;

$$E(x,y,z) = E_0 \times \frac{w_0}{w(z)} \exp[-\frac{r^2}{w^2(z)}] \times \exp\{-i[kz - \eta(z) + \frac{kr^2}{2R(z)}]$$

$$where \quad w(z) = w_0 \sqrt{1 + (\frac{z}{z_0})^2} \;,\; k = \frac{2\pi n}{\lambda_0} \;,\; R(z) = z[1 + (\frac{z_0}{z})^2]$$

$$z_0 = \frac{\pi n w_0^2}{\lambda_0} \;,\; \eta(z) = \tan^{-1}(\frac{z}{z_0})$$



Describe briefly the physical and consequences of the parameters, w_0 , z_0, $w(z)$, $\eta(z)$ and $R(z)$, which make a Gaussian beam different from plane wave field $E_0 \exp[i\omega t - ikz]$.

Question Four

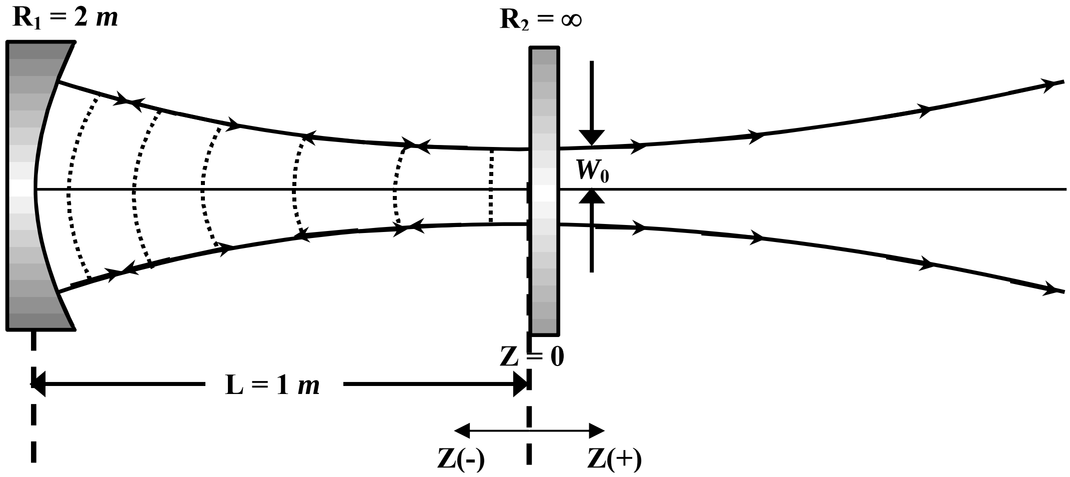
Consider a 4 mW, TEM_{00} He-Ne laser (λ =632.8 nm) with cavity dimensions given below. The left mirror (R_1 = 2 m) is 100% reflecting. The right mirror ($R_2 \to \infty$) is partially reflecting plain through which 4 mW output beam passes. The beam waist in the laser cavity (L = 1 m) occurs at the plane mirror, where the reference plane z = 0 was chosen.

(a) Determine the spot size w_0 at the beam waist.

(b) Determine the laser beam spot size on the rear laser mirror.

(c) Determine the complex radius of curvature $\tilde{q}(z)$ at z = -1 m and z = 0.

(d) What is the half angle beam divergence θ_{FF} for this laser in the far field?



Question five

(a) Laser intensities are quoted in units of W/cm^2, and electric fields are quoted in units of V/cm.

(i) Give the numerical value of the electric field in a laser focus of 100 W/cm^2 intensity (a relatively low power laser focused gently), in a focus of 10^{19} W/cm^2 intensity (ultra high power laser focus).

(ii) For a 780 nm wavelength laser focused to 10^{19} W/cm^2 intensity, what is the photon density (how many photons/s-cm^2 are passing through the focus)?

(b) The concept of oscillator strength *f* has been developed to provide a theoretical reference for the intensity of a spectroscopic transition. An absorption band in merocyanine dye has oscillator strength of 0.3 and an absorption maximum at 470 nm.

(I) Find the transition dipole moment.

(II) Find the Einstein B coefficient.

(III) Find the radiative lifetime.

مع تمنياتي لكم بالتوفيق والنجاح

PHYSICAL CONSTANTS

Rest mass of electron	m	$= 9.110 \times 10^{-31}$ kg
Charge of electron	*e*	$= 1.602 \times 10^{-19}$ C
Avogadro's constant	N_A	$= 6.022 \times 10^{23}$ mol^{-1}
Planck's constant	*h*	$= 6.626 \times 10^{-34}$ J s
Boltzmann's constant	*k*	$= 1.381 \times 10^{-23}$ J K^{-1}
Speed of light (vacuum)	c	$= 2.998 \times 10^{8}$ m s^{-1}
Stefan-Boltzmann constant	σ_{SB}	$= 5.670 \times 10^{-8}$ W m^{-1} K^{-4}