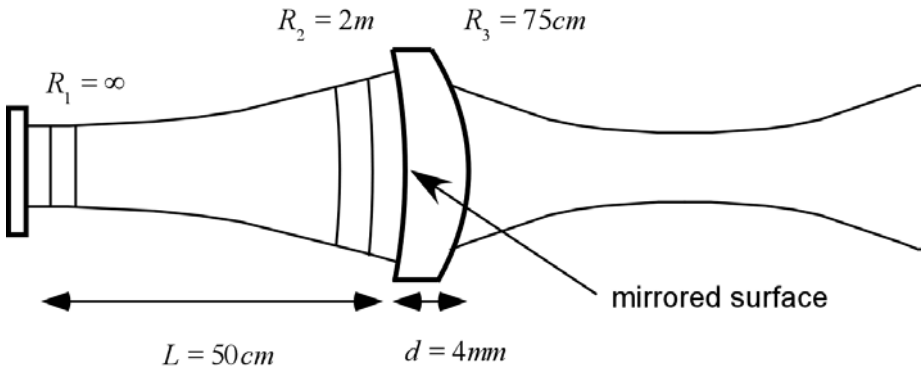
3C43 LASERS & MODERN OPTICS

Problem sheet 3 – Gaussian Beams

Question 1.

A helium-neon laser cavity consists, as shown in the figure, of a completely reflecting plane mirror placed a distance 50cm from the output mirror. The output mirror consists of a positive lens of thickness 4mm, made of glass of refractive index 1.5 with its inner surface coated to give a high reflectivity. The inner (reflecting) surface of the lens has radius of curvature 2m and outer surface a radius of curvature 75cm (both concave with respect to the laser beam propagation direction).



a) Find the spot-size of the laser beam at the plane mirror [4]

b) Find the ray-transfer matrix for the output coupler-lens [4]

c) Show, by calculating the ray transfer matrix neglecting the term describing propagation through the lens, that the output coupler is to a good approximation a *thin lens* and hence determine its focal length. [4]

d) Find the location of the beam waist outside the laser cavity. [4]

e) State the criterion generally used to determine the distance over which a laser beam is *collimated* and determine the distance over which the beam is collimated in this case. [4]

Question 2.

a) State the ABCD-law of Gaussian beams. [2]

b) If the ray transfer matrix representing a complete round-trip of a laser cavity is $\begin{pmatrix} A & B \\ C & D \end{pmatrix}$, show that the condition for the cavity to be a stable one is $|A + D| < 2$. [4]

c) Hence show that the stability condition for a cavity composed of two concave mirrors of radii of curvature R_1 and R_2 separated by a distance L is equivalent to

$$0 < \left(1 - \frac{L}{R_1}\right)\left(1 - \frac{L}{R_2}\right) < 1$$

[6]

d) A laser cavity of length L is composed of a plane-mirror and a concave mirror of radius of curvature R. If the spot-size on the plane-mirror, w_0, satifies $w_0^2 = 2L\lambda/\pi$, with λ the wavelength, find

i) the value of the ratio R/L [4]

ii) the value of the ratio w_L/w_0 where w_L is the spot-size on the curved mirror. [4]