Phys 532/822 Assignment 2 Due February 11

1. **Gaussian Beam Waists** Suppose a Gaussian laser beam with wavelength λ and total power P is focused in the plane $z = 0$ with a waist W_0. The beam is directed at a target a distance d away.
   (a) Find the value of W_0 such that the peak intensity on the target is maximized.
   (b) Evaluate this W_0 if $\lambda = 532$ nm and for $d = 1$ cm, 1 m, and 100 m.

2. **Gaussian Beam Identification** (Saleh and Teich Problem 3.1-2) A Gaussian beam of wavelength $\lambda = 10.6$ μm (emitted by a CO_2 laser) has widths $W_1 = 1.699$ mm and $W_2 = 3.38$ mm at two points separated by a distance $d = 10$ cm. Determine the possible locations of the waist and the waist radius.

3. **Imaging a Gaussian Beam** Suppose a Gaussian laser beam with wavelength $\lambda =$ 532 nm is collimated with a beam waist of 50 μm at the point $z = 0$. If a thin lens with focal length 25 mm is placed at $z = 35$ mm, find the position and beam waist for the resulting focus. Compare the focal position with that predicted by geometrical optics for (*i*) a collimated input beam and (*ii*) input light diverging from a focus at $z = 0$

4. **Retro-reflection of a Gaussian Beam** A Gaussian laser beam with wavelength $\lambda =$ 670 nm is focused with a beam waist of 200 μm, and then reflects off a mirror located 10 cm away. What radius of curvature for the mirror is required to have the reflected beam refocus to the same point? Compare your result to the radius of curvature of the beam itself at the location of the mirror.

822 students only

5. **Gaussian Beams and Ray Matrices** Suppose that when a Gaussian laser beam passes through an optical system, its complex beam radius q is modified according to

$$q_{out} = \frac{A_1 q_{in} + B_1}{C_1 q_{in} + D_1}, \tag{1}$$

while a second system modified q as

$$q_{out} = \frac{A_2 q_{in} + B_2}{C_2 q_{in} + D_2}, \tag{2}$$

Show that a beam passing consecutively through the two systems will have

$$q_{out} = \frac{A_3 q_{in} + B_3}{C_3 q_{in} + D_3}, \tag{3}$$

with

$$\begin{bmatrix} A_3 & B_3 \\ C_3 & D_3 \end{bmatrix} = \begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix} \begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} \tag{4}$$

This establishes the correspondence between ray matrices and Gaussian beam propagation.