Gaussian Beams

1) **Parameters of a Gaussian Laser Beam**

A 1 mW HeNe laser produces a Gaussian beam of wavelength $\lambda = 633$ nm and a spot size $2w_o = 0.1$ mm.

a) Determine the angular divergence of the beam and its depth of focus (this is twice the Rayleigh range z_o). Find the beam diameter at $z = 3.5 \times 10^5$ km (approximately the distance to the moon).

b) What is the radius of curvature of the wavefront at $z = 0$, $z = z_o$, and $z = 2z_o$?

c) What is the optical intensity (in W/cm^2) at the beam center ($z = 0$, $\rho = 0$) and on axis at the point $z = z_o$, $\rho = 0$? Compare this with the intensity at $z = z_o$ of a 100 W spherical wave produced by a small isotropically emitting light source located at $z = 0$. The intensity of an isotropically radiating point source is given by $I = P/(4\pi r^2)$ where P is the power and r is the distance from the source.

2) **Beam Identification by Two Widths**

A Gaussian beam of wavelength $\lambda = 10.6$ μm (emitted by a CO_2 laser) has widths $w_1 = 1.699$ mm at z_1, and $w_2 = 3.38$ mm at z_2 with $z_2 - z_1 = 10$ cm. Determine the location of the waist (find z_1 and z_2) and the waist radius w_0. You may assume that the measurements are in the far field, meaning that $z >> z_o$. Check this assumption by computing w_1 and w_2 once you have solved for w_o and z_1 and z_2.

3) **Beam Focusing**

An argon-ion laser produces a Gaussian beam of wavelength $\lambda = 488$ nm and waist radius $w_o = 0.5$ mm. Design a single-lens optical system for focusing the light to a spot of diameter 100 μm. Specify lens focal length and its position relative to the laser beam waist. What is the shortest focal-length lens that may be used?