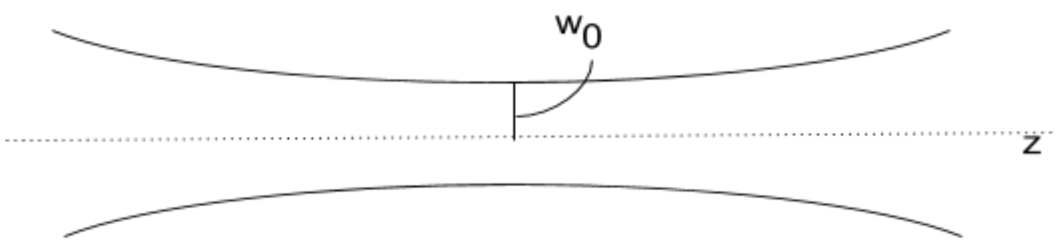
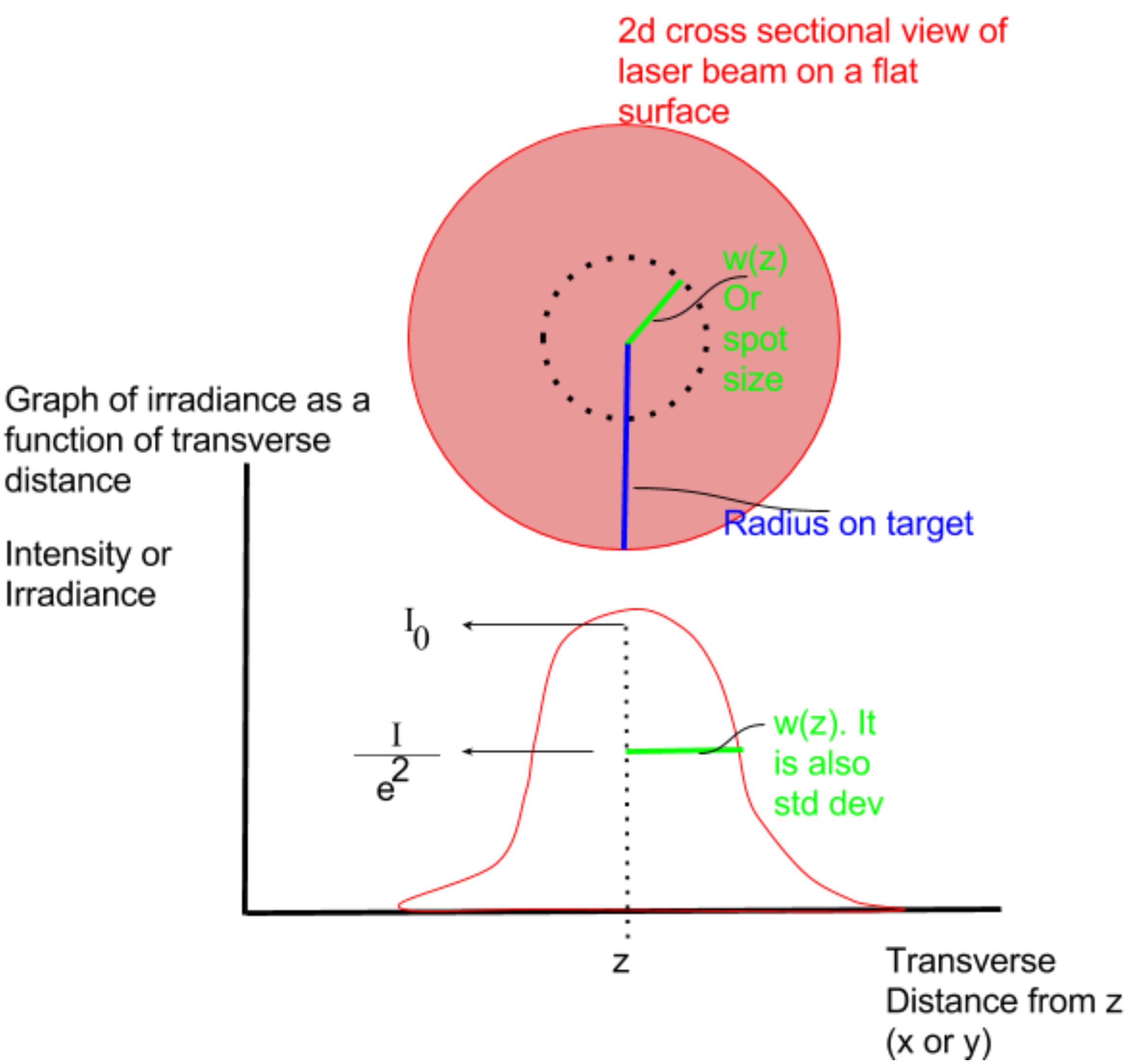
This document uses information from Chapter 27 section 4.



- This is a side view of a beam travelling along the z axis. The black solid lines above represent the distance from the z axis where the beam's electric field irradiance is equal to $\frac{1}{e^2}$ of the value on the axis (called I_0) (that is to say equal to $\frac{I_0}{e^2}$). The black lines are not the physical edges of the beam.
- W(z) or spot size is the transverse distance (a radial measurement) at which the irradiance is reduced from I_0 by a factor of $\frac{1}{e^2}$. The minimum spot size is called w_0.
- w_0 is called beam waist.



- W(z) is not center to edge of beam on a target. Also w(z) is a radius measurement, not a diameter measurement.
- As you can see from the distribution, w(z) is like a standard deviation of the irradiance.
- Also, a beam with a small beam waist spreads more rapidly than beam with larger beam waist
- It is know that Irradiance (I) as a function of transverse distance z (which for us will be measured from laser source) follows :
- 1) $I(x, y, w(z)) = I_0 e^{-\frac{2x^2}{w(z)_x{}^2} - \frac{2y^2}{w(z)_y{}^2}}$
- x and y are transverse distances from axis and w(z) is the spot size at various distances, z, from the beam source...the z axis is usually defined as the axis along which the beam propagates. I0 is maximum intensity
- Equation 1 will allow us to find spot size.
- We also know the relationship between w and z should follow the equation:
- 2) $w(z) = w_0 \sqrt{1 + \frac{(z-z_0)^2}{z_r{}^2}}$
- w_0 is the minimum waist size and z_0 is the location of the minimum waist size. z_r is the Rayleigh range.
- 3) $z_r = \frac{\pi w_0{}^2}{\lambda}$
- The Rayleigh range (also called the Rayleigh length) is the distance one must go from w_0 to increase waist size by a factor of $\sqrt{2}$. It is a helpful length in that the waist of the beam does not increase much inside the Rayleigh length, but does increase fast outside the length.
- Knowing w(z)'s allows us to find w_0 *and* z_0 which allow us to mode-match the beam to the cavity.
- Talk about what mode-matching is
- We are going to be taking images using the Thorlabs camera, so Thorcam software needs to be setup on your computer. It only works on windows computers (sorry mac users!). If you have a mac, Geneseo offers (via "on the hub") a windows os download/product key that will allow you to install windows on your mac with boot camp (search for "boot camp assistant" on your mac).
- Don't get to caught up on any one step for the following things. If you get stuck move on to the Mathematica file linked at the top and bottom of the webpage.
- Designing a program to find spot size.
    - To do this we fit an image's data to equation 1
    - The conceptual steps to take is to create something that does a pixel by pixel level analysis of a single image.

    - We ultimately need to take multiple images at different z values and fit each image to equation 1.
    - We should have multiple (different) resulting w(z) values.
- Designing the program to determine beam waist (w_0 aka minimum spot size)
    - We need to fit all of the w(z) vs z data to equation 2:
- Open the Mathematica file linked at the top and bottom of this webpage to actually determine spot size of an image you will take of the laser beam.