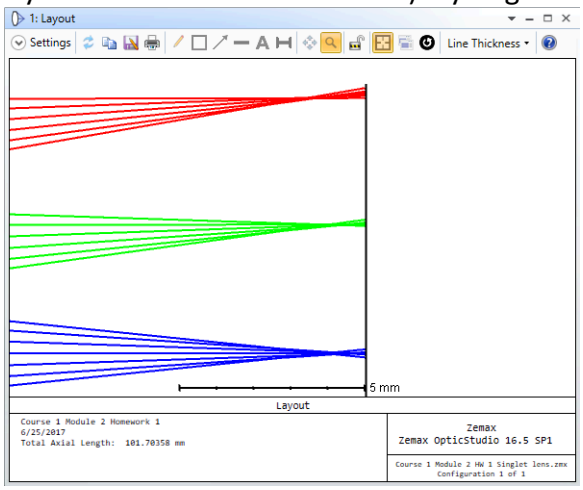
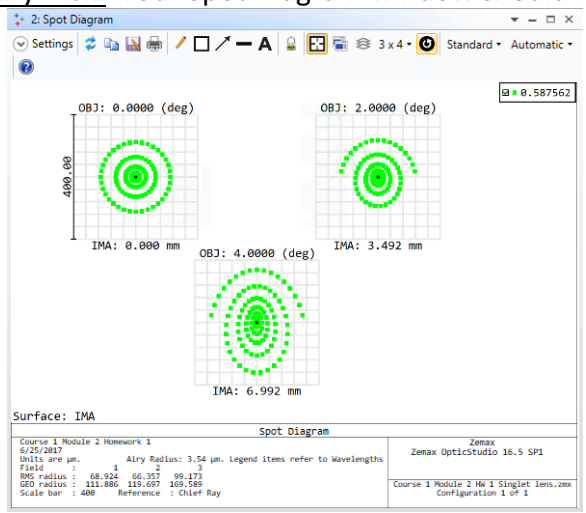
Now you will analyze the performance of this lens by finding how tightly the rays are focused for various objects.

1. Zoom the layout window by clicking and dragging around on the focal region. Use the reset zoom button (curly white arrow in a black circle) if you get lost. You should see



   You can see from this layout that the rays are not focusing perfectly and that the imperfection, called *aberration* in optics, depends on the field angle.

2. To measure the size of these spots, bring up the Analyze / Rays & Spots / Standard Spot Diagram window. This shows how a bundle of rays launched from each object field angle converges at the image plane for each wavelength. Note that color in this window is used to indicate wavelength, while in the Layout window, you are currently using color to represent field angle. Use the Settings menu of the Spot Diagram window and change Wavelength from All to 2. The second wavelength is 588 nm, or sodium D. Also check the box Show Airy Disk. Your Spot Diagram window should now look like:



   There is quite a bit of information here. The IMA coordinates are the centroid locations of the image spots and should be near to your calculation from the previous question. The tiny black circles at the center of each spot show the theoretical *diffraction limited* performance of this lens, from which we conclude that this lens is operating far from the best possible performance. Note that the spots are not symmetrical for the off-axis field

angles. Also note that not all rays from the object reach the image for the off-axis field angles – this is why the bottom of the outermost arc is missing for 2 and 4 degree field angles. This is called *vignetting*. Look up the Wikipedia article by this name to see how this loss of light off axis impacts an image transmitted by the optical system.

3. Switch to the Text version of the Spot Diagram window using the tab at the bottom and find the spot radius for each field angle, defined as the root mean square of the ray deviations from a central reference point (typically the centroid of the rays).