**OPTICS, 114210 - Homework Exercises**
**J. Image Formation: 1. Resolution.**

1.1. The refractive index of a thin plate of glass (thickness d) can be determined as follows. The plate is put in contact with a plane object with some fine markings on it. A microscope is focused on the markings as seen through the plate (microscope position $z_1$). The plate is removed, and the microscope refocused ($z_2$). The vertical movement ($z_1$-$z_2$) between the two positions is noted. Relate ($z_1$-$z_2$) and d to the refractive index of the plate. Taking into account the working distance and depth of focus of a simple microscope lens, estimate the accuracy that can be obtained with this method?

1.2. An astronomical telescope observing in visible light is used in conjunction with a CCD imaging camera. The telescope has diameter 0.5m and focal length 6m. The CCD has pixels with dimension 10μm.. How much extra magnification can be included usefully between the primary focus and the CCD? (Ignore atmospheric disturbance).

1.3. Two points are illuminated coherently in antiphase, so that they are resolved by a microscope however close they may be. What is the apparent distance between them as a function of their real distance and the wavelength? Assume a microscope with NA=1.

1.4. An object consists of two white points situated on a black background. Their separation is 3λ. What image is observed with:
(a) axial coherent illumination, NA=0.5
(b) axial coherent illumination, NA=0.2
(c) incoherent illumination, NA=0.2?

1.5 Heisenberg's γ-ray microscope. A microscope with numerical aperture sin α observes a point object which emits one photon with momentum $p_0=hc/\lambda$. The photon is received within the resolution region δx of the microscope. Show that, since the photon had to enter the lens somewhere in order to be observed, the relationship $\delta p_x\, \delta x \geq h$ is obtained.