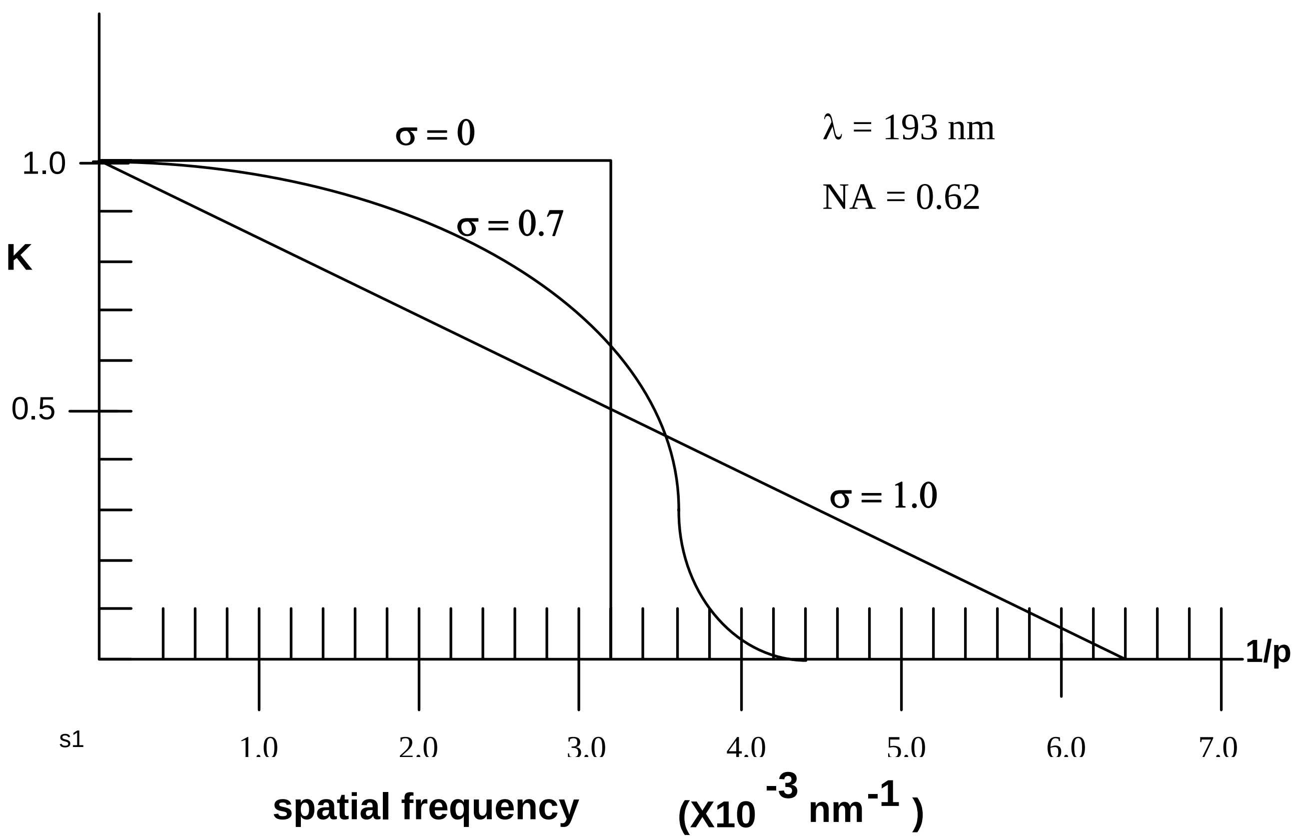
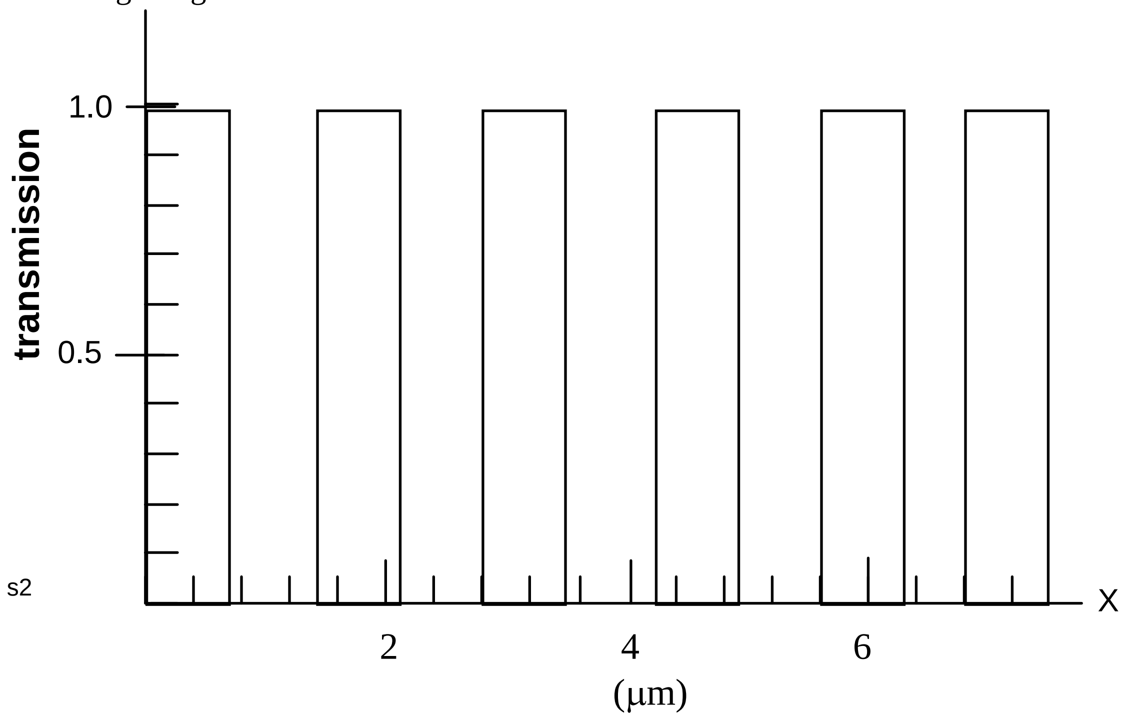
6.781
Submicrometer and Nanometer Technology
Homework Set #12

12-1

An optical projection system with a numerical aperture of 0.62, a demagnification factor of 4X, a field diameter of 20 mm, and an operating wavelength of 193 nm (ArF excimer laser) is characterized by the following dependence of contrast, K, on spatial frequency, 1/p, for 3 values of the aperture filling, σ.



A grating reticle with a transmission as sketched below is illuminated with $\sigma = 0.7$.



(a) What is the contrast, K, in the image of this reticle?

(b) What fraction of the zero-order diffraction cone falls within the entrance aperture?

(c) What fraction of the 1st order diffraction cone falls within the entrance aperture?

(d) What fraction of the 2nd order diffraction cone falls within the entrance aperture?

(e) What is the ratio I_{max}/I_{min} in the image?

(f) Plot the irradiance (intensity) distribution of the image.

(g) Calculate the approximate depth of focus.

Assume that the substrate is coated with a special resist, type MIT-1, whose development rate, R, is linearly proportional to the energy absorbed per unit volume, E.

$$R_{(nm/sec)} = a\, E_{(erg/cm^3)}$$

The energy absorbed per unit volume, E, is, of course, proportional to the product of the intensity (ergs/cm^2) and the exposure time, t.

$$E \propto It$$

Assume that you expose a l-μm-thick film for a sufficiently long time that the development rate at the point of maximum intensity is R = 100 nm/sec. Also assume that the energy absorbed is uniform with depth in the resist (an unrealistic assumption). Thus, development rate will vary as a function of x only.

$$R = R(x)$$

h) What development time should be used to achieve equal widths for the spaces and the lines.

i) Sketch the resist profile.