PROBLEM SET 2
(Due Tuesday, Sept. 25, 2001)

Mini-Project
Do either (1) or (2)

1. Carry out a numerical study to explore the ranges of validity of both the Fresnel and Fraunhofer approximations. Take the example of diffraction by a rectangular slit so as to simplify the problem to one dimension. Use 500 nm wavelength light, and a slit width of 0.1 mm. Calculate the diffraction pattern at various distances using the full Huygens-Fresnel integral, as well as the Fresnel and Fraunhofer integrals. Let’s establish, as a criterion for validity, that the intensity calculated anywhere in the pattern departs from the exact calculation by no more than 1%. Using this criterion, what are the minimum distances at which each of the two approximations may be safely used. Compare the computational efficiencies of each of the three calculations. If you have time and interest, determine how these minimum distances scale with the slit width.

Caution: Be sure that your discretizations in both the input and output planes are sufficiently fine that your numerical calculations of the integrals are not limiting your accuracy. You may also need to use double precision to get enough accuracy.

2. Examine the same issue using a purely analytical approach.

It’s possible (quite probable, I would think) that a study of this question (either numerical or analytical) has already been published somewhere. If you prefer to look into that possibility, by all means, do so. If you find something that is at least pretty close, turn in a summary of what was published, and be sure to fully cite the references you found.