Project 2: Photon Transport in Vegetables
Math 5740, Spring 2003

Disclaimer: I couldn't come up with a plausible story to go along with this project. The real reason for this project is that there is a huge interest in photon transport in human tissue for the purposes of imaging and diagnostics. I want you all to go through the excercise of modeling a similar phenomenon, *without* the benefit (or burden) of a large scientific literature to draw from. Anyway, here's the scenario:

Many companies produce optical and machine-vision inspection systems for fruit and vegetable processing and packaging plants. Typically the systems are able to sort vegetables and identify *externally* visible problems.

One company wants to investigate the feasibility of an optical inspection system which provides information about *internal* structure, by measuring light which has propagated through the fruit. The company would like to be able to identify the presence of pests, the presence of seeds in certain fruits, and possibly defects like bruising which may not be visible externally. Preferably such a system would work without cutting the fruit open, but the company would consider a method which imaged "slices" of random samples coming from the production line. For definiteness, the study will focus on apples and potatoes. Because research and development capital is very tight, the company is only willing to invest in (1) a flashlight, and (2) a digital camera, for this project.

As part of this feasibility study, the company would like to develop a model of light propagation in vegetables. They hope to be able to answer the following questions:

1. How thick of a sample can be imaged?
2. How small of a structural inclusion can be detected?
3. How much information about size and location of defects can be inferred from the measured data?
4. What other information can be obtained from the data (eg. nutritional content, presence of disease, ripeness, etc.).

Data provided to you will be in the form of digital photgraphs of fruit slices illuminated from behind by a flashlight, with or without inclusions.

You may request additional experimental data, and may experiment with your own vegetables, but you may **not** purchase any equipment for your experiments.

Your model should be able to predict the data (photograph) resulting from an inclusion in a specific fruit or vegetable slice, in a specified location. At the conclusion of the project, I will provide each group with the parameters for such an experiment, and we will compare the output of your model to an actual photograph of the experiment. Your goals for the project should be to produce a model which predicts the outcome of the experiment well, and which helps answer questions (1)–(4) above.