Problem Set 3
Due: see website for due date

Chapter 23: Gauss' Law
Exercises & Problems: 2, 14, 26, 27, 39, 41, 49, 53

Question A
For a sphere, E falls off with $1/r^2$; for an infinite line charge, E falls off with $1/r$; for an infinite sheet of charge it's independent of r! However, according to Coulomb's Law, the electric fields fall off as $1/r^2$. So why don't the electric fields for the infinite line and infinite sheet of charge also fall off the same way?

Hint: As the Gaussian surface gets very far from the source charge, look at what its characteristics depend on.

Question B
(i) Explain physically how one can use Gauss's Law to find the electric field of a long (infinite) charged wire? (ii) Now do the same for a finite charged wire; explain why you can still use Gauss's Law but it is not useful to use in this case.

Question B
Some modern aircraft are made primarily of composite materials that do not conduct electricity. The U.S. Federal Aviation Administration (FAA) requires that such aircraft have conducting wires imbedded in their surfaces to provide protection when flying near thunder storms. Explain the physics behind this requirement.

Question C
Radio reception is poor, but not zero, when your car passes through a tunnel made of concrete, which has been reinforced with metal. Why?

Question D
A lightning rod is a pointed copper rod mounted on top of a building and welded to a heavy copper cable running down into the ground. Lightning rods are used to protect houses and barns from lightning; the lightning current runs through the copper rather than through the building. Why? Why should the end of the rod be pointed?

Question E
A sphere is placed in a uniform external electric field. Accurately draw the vector field lines for the situation when the sphere is a (i) conductor and (ii) then replaced with a uniformly polarizable dielectric. (iii) Briefly explain how your field lines correctly illustrate the nature of the field around the conducting plane. (iv) What is the field inside the sphere in both cases?