171.603 **Midterm Exam** **November 7, 2001**

This is a closed book exam. However, feel free to use your own notes. You will not need a calculator, since there are no numerical estimates to be performed. In fairness to your classmates, if you have a symbolic calculator, please, do not use it: others may not have one. Please, be sure to show all essential steps of your work.

Good luck!

1. A very long and thin wire carries a static charge density.

   Assuming that the linear charge density is λ, determine the potential around the wire.

   (Normalize the potential to zero at some arbitrary distance from the wire.)

2. A charged particle is moving along a prescribed trajectory, given by $\mathbf{y}(t)$. Its charge and current distributions are given by:

$$\rho(\mathbf{x}) = f(\mathbf{x} - \mathbf{y}(t)), \qquad \mathbf{j}(\mathbf{x}) = \mathbf{v} f(\mathbf{x} - \mathbf{y}(t)),$$

   where $\mathbf{v} = d\mathbf{y}/dt$.

   Do this charge density and current density satisfy the equation of continuity?

3. Consider the line integral of a vector potential (generated by some prescribed current) over a *closed* path, C:

$$\Psi = \int_C \mathbf{A} \cdot \mathbf{dx}$$

   Is Ψ an observable quantity? Explain your answer.

4. Consider a TV downlead of two parallel wires. The distance betwen the wires is d. (Assume that the downlead is infinitely long, *i.e.* it is much longer than the wave length in vacuum of the TV signal. You may neglect the thickness of the wires.)

   Can a TEM mode propagate along this pair of wires? Explain your answer (yes/no). Calculate the the electric field between the wires.