Do any THREE out of the four problems.

Problem 1: An infinitely long line carries charge per unit length $\lambda$. It is placed parallel to and at a distance $d$ from the center of an infinitely long grounded conducting cylinder of radius $a$, where $a < d$.

(a) Calculate the force per unit length on the line charge.

(b) Calculate the surface charge density on the cylinder as a function of position on the cylinder.

Problem 2: Consider the propagation of an electromagnetic wave in vacuum between two infinite parallel conducting plates spaced a distance $d$ apart, occupying the planes $z = 0$ and $z = d$. For the case in which the electric field is everywhere parallel to the plates, and the wave propagates in the $x$ direction:

(a) Give an expression for the electric and magnetic fields between the plates.

(b) Show that there is a minimum angular frequency $\omega_c$ below which waves will not propagate, and derive an expression for $\omega_c$.

Problem 3: A very long solenoid has $n$ turns of wire per unit length, and carries a slowly time-varying current $I(t)$. The radius of the solenoid is $a$, and the axis of symmetry is the $z$ axis.

(a) Find the magnetic field $\vec{B}$ inside the solenoid.

(b) Use Faraday’s Law in integral form to find the electric field $\vec{E}$ both inside and outside of the solenoid.

(c) Consider an imaginary cylinder, coaxial with the solenoid, and with length $d$ and radius $r$. Find the rate at which electromagnetic energy is flowing into this cylinder from the outside, for the two cases $r < a$ and $r > a$. 
Problem 4: A coaxial cable consists of two infinitely long coaxial perfectly conducting cylinders with radii $a$ and $b$, with $a < b$, and with the common axis being the $z$ axis. The inner conductor carries a current $I$ in the $+\hat{z}$ direction, and the outer conductor carries the current back in the opposite direction. The region between the conductors has magnetic permeability $\mu$ (different from the permeability $\mu_0$ of empty space).

(a) Find the magnetic fields $\vec{B}$ and $\vec{H}$ everywhere.

(b) Find the self-inductance per unit length of the cable.