Problem 1 (10 Points)
An infinite-long line charge in a free space is along the z axis and has a uniform density ρ_l. Find the electric potential in the whole space.

Problem 2 (10 Points)
A point charge Q is located at the origin of a rectangular coordinate system. Find the total flux pass through the triangular area defined by *(1, 0, 0)*, *(0, 2, 0)* and *(0, 0, 3)*.

Problem 3 (10 Points)
Given a region of free space in which the electrostatic field is everywhere directed parallel to the x-axis, prove that the field is independent of the y- and z-coordinates. If there is no charge in this region, prove that the field is also independent of x.

Problem 4 (20 Points)
A long straight conductor carries uniform current density J. It is in the form of a cylinder of radius a with an off-axis cylindrical hole of radius b. The distance between the axis of the cylinder and the axis of the hole is d. Prove that the magnetic field intensity at any point in the hole is given by $\vec{J} \times \vec{d} / 2$, where $\vec{d}$ is the position vector of the cavity axis with respect to the axis of the conductor.

Problem 5 (20 Points)
A section of an electromagnet with a plate below it carrying a load is shown in the figure. The electromagnet has a contact area of 200 cm^2 per pole with the middle pole having a winding of 1000 turns and current I. Calculate the required current to lift a mass of 50 kg. Assume that the reluctance of the electromagnet and plate is negligible.

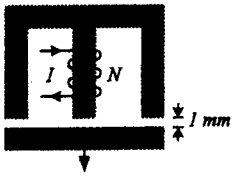

Figure for Problem 5

Figure for Problem 6

Problem 6 (10 Points)
Draw the electric fields, magnetic fields, and Poynting vectors around the simple circuit as shown in the figure.

Problem 7 (20 Points)
Write down the complete Maxwell's equations in differential form and all the boundary conditions.