1. (a) What are the boundary conditions for electrostatic fields at an interface between a conductor and a dielectric with permittivity $\varepsilon$. (5 points)

(b) What is the resistance of a lossy material with conductivity $\sigma$ and dimensions of $a \times b \times c$. (5 points)

(c) What is a magnetic dipole? Define magnetic dipole moment. (5 points)

2. A point charge $Q$ is located at a distance $d$ from two grounded perpendicular conducting half-planes as shown in the figure. Determine the surface charge density $\rho_\sigma$ on the horizontal conducting plane of $x \geq 0$. (15 points)

3. Consider a coaxial cable with an inner conductor of radius $a$ and an outer conductor whose inner radius is $b$. The space between the conductor is filled with a dielectric whose permittivity varies linearly from $\varepsilon_1$ at $r = a$ to $\varepsilon_2$ at $r = b$. Find the capacitance and inductance per unit length of the cable. (20 points)

$$\text{Hint: } \int \frac{dx}{x^2 + kx} = \frac{1}{k} \ln \left( \frac{x}{x + k} \right)$$

4. The electric and magnetic fields of a general TEM wave traveling in the $+z$ direction along a transmission line may have both $x$- and $y$-components, and both components may be functions of the transverse dimensions.

(a) Find the relations among $E_x(x,y), E_y(x,y), H_x(x,y), H_y(x,y)$ (5 points)

(b) Verify that all the four fields components in part (a) satisfy the two-dimensional Laplace’s equation for static fields. (5 points)
5. A right-hand circularly polarized plane wave represented by the phasor

\[ E(z) = E_0 (a_e - ja_o) e^{-j\omega t} \]

impinges normally on a perfectly conducting wall at \( z = 0 \)
(a) Determine the polarization of the reflected wave. (5 points)
(b) Find the induced current on the conducting wall. (5 points)
(c) Obtain the instantaneous expression of the total electric intensity based on the cosine time reference. (5 points)

6. A d-c voltage \( V_0 \) is applied at \( t = 0 \) directly to the input terminal of an open-circuited lossless transmission line of length \( L \) as shown in the following figure. Sketch the transient voltage and current waves on the line for the following time intervals:
(a) \( 0 < t < T (= L/u) \) (note: \( u \) is the propagation velocity of the wave on the line) (5%)
(b) \( T < t < 2T \) (5 points)
(c) \( 2T < t < 3T \) (5 points)
(d) \( 3T < t < 4T \) (5 points)
(e) What happens after \( t = 4T \)? (5 points)