1. A point charge q is brought to a position a distance d away from an infinite plane conductor held a zero potential.

(a) Find the total charge induced on the conducting plane. (5%)

(b) Determine the force on q caused by the induced charge. (5%)

(c) Find the energy required to move the charge q to a distance $2d$ away from the infinite plane conductor. (5%)

2. Consider a very long coaxial cable. The inner conductor has a radius of a_1 at potential V_1 and the outer conductor has an inner radius of a_2 and is grounded. Assume the dielectric material between the two conductors has a permittivity of ε_k.

(a) What is the purpose of the ground outher conductor? (5%)

(b) Determine the potential distribution in the space between the two conductors. (5%)

(c) Find the capacitance per unit length of this coaxial cable. (10%)

3. Let us consider a waveguide and a resonator.

(a) An air-filled coaxial line has thick walls made by copper. Its attenuation constant is $\alpha_c = 0.03 Np/m$ at 900 Mhz. (Note that Neper is a dimensionless quantity. If $\alpha_c = 1(Np/m)$, then a unit wave amplitude decreases to a magnitude e^{-1} while travels a distance of 1 m.) What is α_c at 1.8 GHz? (5%)

(b) Will the Q factor of a circular cylindrical cavity resonator be higher or lower by increasing its length? Explaining by physical reasoning. NO credit will be given without explanation with physical reasoning. (5%)

4. The time-harmonic electric field of a uniform plane wave propagating in free space is given in phasor form as

$$\mathbf{E} = (4\mathbf{a}_x + j8\mathbf{a}_y + j6\mathbf{a}_z) \cdot e^{j(1.2\pi y - 1.6\pi z)}.$$

(a) What is the direction of the propagation? (5%)

(b) Determine the frequency of the wave. (5%)

(c) Find the corresponding time-harmonic magnetic field in phasor form. (5%)

(d) What is the polarization of this wave? (5%)

(e) Find the time-averages power flow per unit area normal to the direction of propagation. (5%)

5. Let us consider two kinds of media. The first is a microstrip line and the second is the cylindrical step-index fiber.

(a) Please explain (or prove) whether modes of transverse electric (TE) and (TM) transverse magnetic waves are allowed in each of the waveguide or not. (10%)

(b) Please draw the schematic, cross-sectional electric field lines of the microstrip line. (3%)
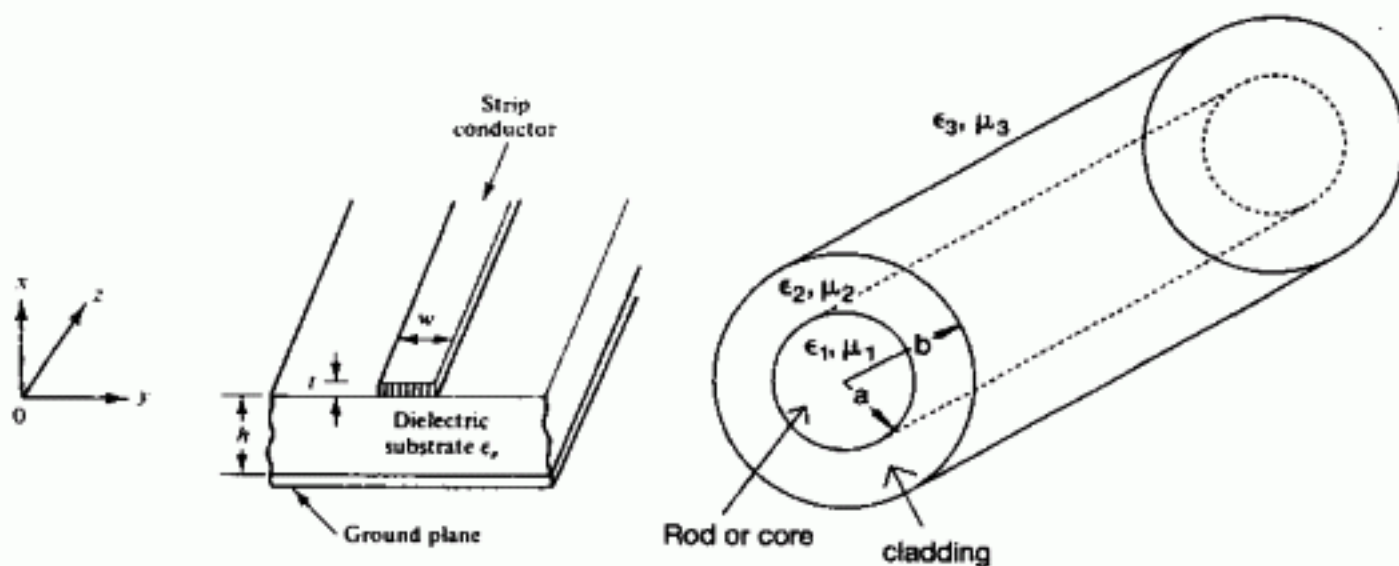
6. Consider a z-directed hollow rectangular metallic waveguide of a cross-sectional dimension of sides a and b in the x and y directions, respectively.

(a) We can derive E_z and H_z first, and then derive the remaining four components based on the former two components, i.e., the well-known E_z-H_z formulation. Please EXPLAIN whether we can derive the remaining four components starting with any other two components instead, i.e., using E_x and H_y, etc. (5%)

(b) Please derive E_z. (8%)

7. An antenna is a current-carry element. Can you estimate the radiation frequency from the antenna? In your answer sheet, please CLEARLY explain why you can make such an estimation while based on certain physical principles. (4%)