1. (a) Find the location and the value of a point charge that produces both fields: $\vec{E}_1 = (2\vec{a}_x + 2\vec{a}_y + \vec{a}_z)$ V/m at (1, 1, 1) and $\vec{E}_2 = (2\vec{a}_x + \vec{a}_y + 2\vec{a}_z)$ V/m at (1, 2, 0). (5%) (b) Find the orientation of an infinitely long filamentary wire and the current in it required to produce both fields: $\vec{B}_1 = (4/3)\times10^{-7}\vec{a}_y$ Wb/m^2 at (3, 0, 0) and $\vec{B}_2 = -10^{-7}\vec{a}_x$ Wb/m^2 at (0, 4, 0). (5%)

2. Consider a pair of coils attached to nails on a piece of wood, as shown in Fig. 1. Connect the output terminal A and B of an alternating current (AC) voltage source to the ends C_2 and D_2, respectively, so that a current flows in the Coil No. 2. Coil No. 1 is kept floating and terminated by a resistor R. Answer the following questions with reasonings. (a) R is set at ∞ Ω. Is a voltage induced in Coil No. 1? Does attraction or repulsion action occur between two coils? (5%) (b) R is set at 0 Ω. Is a voltage induced in Coil No. 1? Does attraction or repulsion action occur between two coils? (5%)

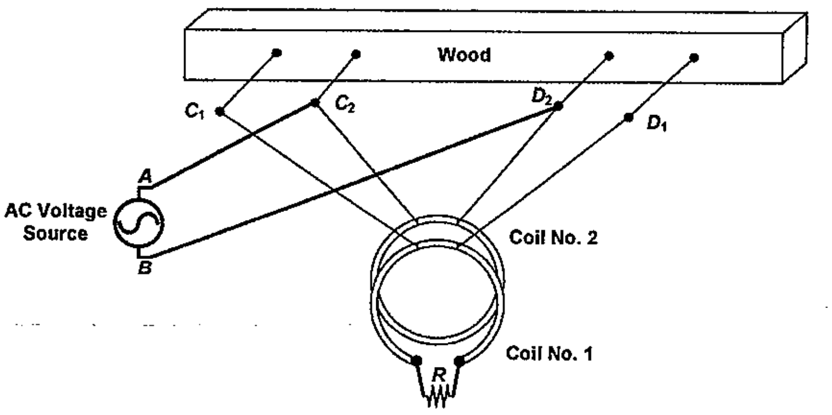

Fig. 1

3. As shown in Fig. 2, a current I flows along a straight wire from a point charge $Q_1(t)$ located at (0, 0, −2) to a point charge $Q_2(t)$ located at (0, 0, 0). Find the line integral of $\vec{H}$ along the square closed path C having the vertices at (2, 2, 0), (−2, 2, 0), (−2, −2, 0), and (2, −2, 0), that is, the magnetomotive force (*mmf*), and traversed in that order. (a) Please solve it by using Ampere's law in integral form and considering the plane surface S bounded by C except for a slight upward bulge at the origin to avoid $Q_2(t)$. (5%) (b) If $Q_1(t)$ is moved to negative infinity and $Q_2(t)$ is moved to positive infinity along the z-axis, find the *mmf* again. (5%)

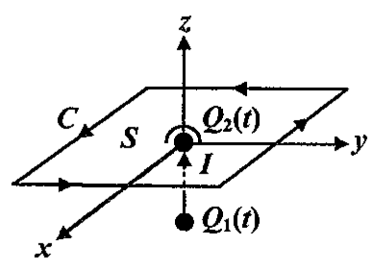

Fig. 2

4. Consider an infinite sheet lying in the xy-plane, as shown in Fig. 3, with a uniformly distributed current flowing in the negative x-direction, as given by $\vec{J}_S(t) = -J_S(t)\vec{a}_x$ for $z = 0$, where $J_S(t)$ is a given function of time. The medium on either side of the current sheet is free space. Find electromagnetic fields due to

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the time-varying current sheet: $\vec{E}(z, t)$ for $z > 0$ and $\vec{H}(z, t)$ for $z < 0$. (10%)

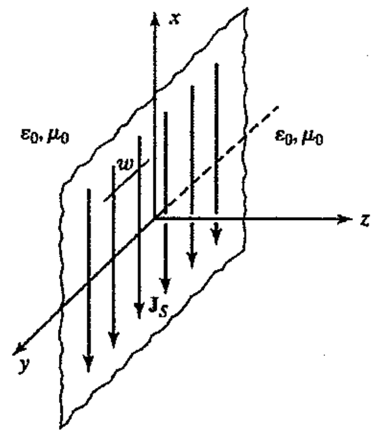

Fig. 3

5. Consider two infinite, plane, parallel, perfectly conducting plates occupying the planes $x = 0$ and $x = d$ and kept at potentials $V = 0$ and $V = V_0$, respectively, as shown by the cross-sectional view in Fig. 4. The region between the two plates is filled with imperfect dielectrics having conductivities σ_1 and σ_2 for $0 < x < t$ and $t < x < d$, respectively. Find the solutions for the potentials in the two regions. (10%)

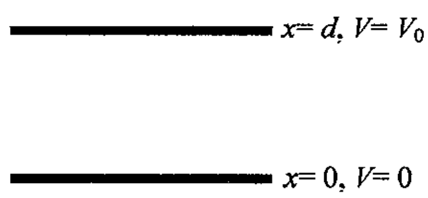

Fig. 4

6. A transmission line is open circuited at the load. (a) Illustrate the voltage and current distributions along the line. (5%) (b) Find out how the input impedance changes with the frequency. (5%)

7. Consider a dielectric-filled (the dielectric constant is 4) rectangular metallic cavity of size 2 cm × 2 cm × 1 cm. (a) Find out the three lowest frequencies of oscillation. (5%) (b) Specify the mode(s) of oscillation for each frequency and the coordinate system you used. (5%)

8. Answer the following questions about dipole antennas.
   (a) Why is the length typically a half wavelength for a dipole antenna? (4%)
   (b) Illustrate the current distribution of a half-wave dipole antenna. (4%)
   (c) Illustrate the radiation pattern of a half-wave dipole antenna. (4%) Label the polarization direction. (2%)
   (d) Illustrate the current distribution of a full-wave dipole antenna. (3%) Explain why it is rarely used. (3%)

9. Briefly explain the finite element method and how to apply it to electromagnetic simulations. (10%)

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