1. Consider an infinitely long, coaxial, cylindrical capacitor, in which the radius of the inner and outer cylinders are R_a and R_b, respectively, and the potentials in the inner and outer cylinders are V_a and V_b, respectively. The permittivity of the material ε filled in the region between the coaxial cylindrical conductors is isotropic and uniform.
   (a) Find the potential in the region between the coaxial cylindrical conductors. (8%)
   (b) Find the electric field in the region between the coaxial cylindrical conductors. (5%)
   (c) Find the capacitance per unit length. (7%)

2. Medium 1, consisting of the region $x > d$, is free space. Medium 2, consisting of the region $0 < x < d$, is a perfect dielectric of $\varepsilon = 3\varepsilon_0$ and $\mu=\mu_0$. Medium 3, consisting of the region $x <0$, is a perfect conductor. The electric and magnetic fields in medium 2 are given at a particular instant of time by

$$\vec{E} = E_1 \cos \pi x \sin 2\pi z \vec{a}_x + E_2 \sin \pi x \cos 2\pi z \vec{a}_z$$
$$\vec{H} = H_1 \cos \pi x \sin 2\pi z \vec{a}_y$$

   (a) Find the surface charge and the surface current on the surface $x = 0$ at that instant of time. (10%)
   (b) Find the electric and magnetic fields in medium 1 and immediately adjacent to the surface $x = d$ at that instant of time. (10%)

3. Three forces experienced by a test charge q at a pointing in a region of electric and magnetic fields for three different velocities of the test charge are given by

$$\vec{F}_1 = qE_0(\vec{a}_x - \vec{a}_y + \vec{a}_z) \quad \text{for} \quad \vec{v}_1 = v_0\vec{a}_x$$
$$\vec{F}_2 = qE_0(\vec{a}_x - \vec{a}_y - \vec{a}_z) \quad \text{for} \quad \vec{v}_2 = v_0\vec{a}_y$$
$$\vec{F}_3 = 0 \quad \text{for} \quad \vec{v}_3 = v_0\vec{a}_z$$

   where v_0 and E_0 are constants. Find the electric and magnetic fields at that point. (20%)

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4. Current I flows along a straight wire from a point charge $Q_1(t)$ located at the origin to a point charge $Q_2(t)$ located at (0, 0, 2). Find the line integral of $\bar{H}$ along the square closed path having the vertices at (2, 2, 0), (-2, 2, 0), (-2, -2, 0), and (2, -2, 0). (20%)

5. A uniform plane electromagnetic wave $\bar{E}_i$ is incident from free space onto a dielectric medium, in which the interface between free surface and the dielectric medium is located at x=0 and the dielectric medium has $\varepsilon=1.5\varepsilon_0$ and $\mu=\mu_0$. The electric field of the incident plane wave is

$$\bar{E}_i = E_0(\frac{\sqrt{3}}{2}\bar{a}_x - \frac{1}{2}\bar{a}_z)\cos[6\pi\times10^8 t - 10\pi(x+\sqrt{3}z)]$$

Find the electric fields of the reflected and transmitted waves. (20%)

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