ENEE 381 Problem Set #2

9/19/02 - due 9/26/02

(1) Calculate the electric field and magnetic field amplitudes produced 1km from a radio transmitter whose output is 4W at 100MHz. The waves coming from the transmitter are spherical, but to a good approximation they are plane far enough away from the transmitter. Compare these field amplitudes with those produced by a laser beam whose intensity is 10GW/cm^2 at a wavelength of 1μm.

(2) Calculate the electric and magnetic field amplitudes produced 50mm from a cellular phone that is isotropically transmitting 1W at 850 MHz. Use a plane wave approximation to calculate the fields. If all this power is absorbed in a spherical region of radius 100mm whose specific heat is 1 calorie/gram, what is the rate of heating expected?

(3) (RWD 3.8c) Check to see which, if any, of the following could be phasor reprentations of fields consistent with Maxwell's equations, in a charge-free region:

(i) $\mathbf{E} = \hat{\mathbf{i}} C e^{-j\omega\sqrt{\mu\epsilon} z}$. Rectangular coordinates

(ii) $\mathbf{H} = \hat{\phi}(C/r) e^{-j\omega\sqrt{\mu\epsilon} z}$. Cylindrical coordinates

(iii) $\mathbf{E} = \hat{\theta}(C/r) e^{-j\omega\sqrt{\mu\epsilon} r \cos\theta}$. Spherical coordinates

(4) (RWD 3.13b) The field a large distance from a dipole radiator has the form, in spherical coordinates

$$E_\theta = \sqrt{\frac{\mu}{\epsilon}} H_\phi = \left(\frac{A}{r}\right) e^{-jkr} \sin\theta.$$

Find the average power radiated through a large sphere of radius r.

(5) (RWD 3.17b) Find the magnetic field $\mathbf{H}$ for any point z in a plane conductor in terms of J_0 (the current density at the surface of the conductor) by first finding the electric field, and then utilizing the appropriate one of Maxwell's equations to give $\mathbf{H}$. Show that the surface current density J_{sx} (A/m) is equal to H_y at the surface.

(6) (RWD 3.18b) A uniform plane wave of frequency 1GHZ has an intensity of 1MW/m^2. It can be shown that upon reflection from a good conductor, the magnetic field at the surface of the conductor is essentially double that in the incident wave. Estimate the power absorbed in the aluminum per unit area and note it as a fraction of the incident power. The conductivity of aluminum is 3.72×10^7 S/m.

(7) Calculate the time it would take for a light sail powered space craft to accelerate to $0.1\times$ the velocity of light. Use a sail area of 100km^2, a space craft mass of 10,000 kg, and a light intensity on the sail of 1W/m^2. Assume that the sail is perfectly reflecting.

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