Exam 1 Review Sheet (workout)

exam will also have T/F and conceptual questions

1. An electromagnetic wave travels in the $\mathbf{a}_x$ direction in a lossless (σ=0), nonmagnetic (μ_r=1) medium. The wavelength is 2m and the frequency is 75MHz. The electric vector, with a magnitude of 5V/m, points in the $\frac{\mathbf{a}_y + \mathbf{a}_z}{\sqrt{2}}$ direction.

   i) find the electric and magnetic vectors (time-domain and frequency-domain). *Take ϕ_e to be zero*.

   ii) find the instantaneous and time-averaged Poynting vectors.

Answers:

$$\tilde{\mathbf{E}} = \left(\frac{\mathbf{a}_y+\mathbf{a}_z}{\sqrt{2}}\right)5e^{-j\pi x}\ \frac{V}{m} \qquad \tilde{\mathbf{H}} = \left(\frac{-\mathbf{a}_y+\mathbf{a}_z}{\sqrt{2}}\right)\frac{5}{188.5}e^{-j\pi x}\ \frac{A}{m}$$

$$\mathbf{E} = \left(\frac{\mathbf{a}_y+\mathbf{a}_z}{\sqrt{2}}\right)5\cos\left[2\pi(75)10^6 t - \pi x\right]\ \frac{V}{m}$$

$$\mathbf{H} = \left(\frac{-\mathbf{a}_y+\mathbf{a}_z}{\sqrt{2}}\right)\frac{5}{188.5}\cos\left[2\pi(75)10^6 t - \pi x\right]\ \frac{A}{m}$$

$$\mathbf{S} = \mathbf{a}_x\frac{5^2}{188.5}\cos^2\left[2\pi(75)10^6 t - \pi x\right]\ \frac{W}{m^2} \qquad \langle\mathbf{S}\rangle = \mathbf{a}_x\frac{1}{2}\frac{5^2}{188.5}\ \frac{W}{m^2}$$

2. Two conductors, one coated with 0.1mm of zinc alloy ($\sigma=10^7/\Omega$m), the other coated with 0.05mm of copper [$\sigma=5.8(10^7)/\Omega$m], have a 100mA (RMS), 4GHz current through them. Both zinc and copper are non-magnetic (μ_r=1). The conductors, with round cross-sections, each have a radius of 1mm (including coating) and are each 20 mm in length. Find the RMS voltage dropped across them and the average power absorbed by each conductor.

   Answers: V_{Cu} = 5.3 mV, P_{Cu} = 0.53 mW, V_{Zn} = 12.6 mV, P_{Zn} = 1.26 mW

3. An electric vector, amplitude 20mV/m, f=1GHz, points in the $\mathbf{a}_x$ direction and travels in the $\mathbf{a}_z$ direction in a medium with material properties σ=0.005/Ωm, ε_r=10, and μ_r=1.

   i) is this material a good conductor, a good dielectric, or neither? Why?
   ii) What is the speed of propagation? The wavelength?
   iii) What would be the new wavelength if the conductivity were changed to σ=0.001/Ωm? Why?
   iv) find the time-averaged Poynting vector.

   Answers: i)good dielectric ($\sigma << \varepsilon\omega$), ii)$v_p = 9.49(10^7)$m/s, λ=9.49cm, iii)same (β,ω unchanged),

   iv) $\langle\mathbf{S}\rangle = \mathbf{a}_z\frac{0.02^2}{2(119.2)}e^{-2(0.298)z}\ \frac{W}{m^2}$