University of New South Wales – School of Physics

PHYS 3011 / PHYS 3230 – Electrodynamics
Mid-term Test – Thursday, 26 April 2012
Time: 50 minutes

Please PRINT your name and show all working.
There are **three** questions on this paper: answer **all** questions (total 50 marks)

Q 1 (10 marks)
Find the divergence of the Poynting vector in a medium of resistivity ρ, where the electric and magnetic fields are not varying with time. Show that the result is equal to the power lost through Joule heating of the medium.

Q.2 (20 marks)
A TV transmitter transmits at a frequency of 770 MHz and an effective power of 500 kW. (Effective power is the total power that would be radiated if it was uniform over the surface of a sphere.)

(a) What are the rms **E** and **B** field strengths of these transmissions received at 30 km from the transmitter? (You can assume a plane wave front at this distance.)

(b) If I use an indoor aerial, what is the maximum thickness the walls can be, to allow me still to receive a signal, assuming that my receiver will not work if the signal falls to $1/e$ of its original amplitude? (Take the bricks to be a conductor with conductivity, $\sigma = 0.1$ S/m.)

Q.3 (20 marks)
$E_x = E_0 \exp i(\omega t - kz)$ is a solution of the wave equation:

$$\frac{\partial^2 \mathbf{E}}{\partial z^2} - \mu_0 \sigma \frac{\partial \mathbf{E}}{\partial t} - \epsilon_0 \mu_0 \frac{\partial^2 \mathbf{E}}{\partial t^2} = 0$$

(a) Of the two time-dependent terms, which dominates in free space, and which dominates in a good conductor?
(b) Show that for a good conductor, the wave number k has equal (and opposite) real and imaginary components, each of magnitude $\sqrt{\frac{1}{2}\omega\mu_0\sigma}$.
(c) Hence calculate the skin depth and phase velocity of a 1 MHz wave in copper ($\sigma = 5.8 \times 10^7$ Sm^{-1}).

Note: $\sqrt{(\pm i)} = (1 \pm i)/\sqrt{2}$
