HERIOT-WATT UNIVERSITY
DEPARTMENT COMPUTING AND ELECTRICAL ENGINEERING

Electromagnetics

Tutorial 3

1. Starting with Maxwell's equations in differential form derive the wave equation

$$\nabla^2 \underline{H} = \mu_o \varepsilon \frac{\partial^2 \underline{H}}{\partial t^2}$$

2. Determine the relative permittivity of a medium having an intrinsic impedance of 60 $\pi\Omega$ assuming that the medium is non-magnetic. What will be the velocity of a TEM wave in such a medium? If the instantaneous maximum power transmitted by the wave is 25 watts through an area 10 metres square, determine the magnitude of $\underline{E}$ in Vm^{-1}.

[$\varepsilon_r = 4, u = 1.5 \times 10^8 ms^{-1}, 21.7 Vm^{-1}$]

3. A plane e-m wave travels in a lossless medium with a velocity $u = \frac{1}{\sqrt{\mu_o \varepsilon}}$. By considering the rate of flow of energy per unit area show that

$$\underline{S} = \underline{E} \times \underline{H}$$

is a valid measure of the instantaneous power flow.

4.

A coaxial cable has a steady current I flowing in it and the conductors are assumed to have zero resistance. By taking the following steps

(i) Ampere's Law to find magnetic field

(ii) Gauss's Law to find E

(iii) $V = \int E \cdot dr$ to find V

(iv) application of Poynting's theorem

(v) integration of the Poynting vector over the coaxial line cross-section

show that the total power flow is W = VI. Consider the implication that the power flow is through the dielectric space and not through the conductors.

5. A sinusoidal plane electromagnetic wave is transmitted through a medium whose breakdown strength is 30 kVm^{-1} and whose relative permittivity is 4. Determine the maximum possible r.m.s. power flow density, and the peak value of the associated magnetising force.

[2,390 kWm^{-2}, 159 Am^{-1}]

6. Consider a cylindrical resistor of radius a and length L carrying a d.c. current I due to the applied voltage V. By considering the magnetic and electric fields associated with I and V show that the evaluation of the Poynting vector produces the well known result that the power dissipated P = VI.

