UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

MAIN EXAMINATION DECEMBER 2011

TITLE OF PAPER:	**ELECTROMAGNETIC FIELDS II**
COURSE CODE:	**EE441**
TIME ALLOWED:	**THREE** HOURS

INSTRUCTIONS:

1. Answer any **four (4) questions**
2. Each question carries 25 marks.
3. Marks for different sections are shown in the right-hand margin.

This paper has 4 pages including this page.

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Question 1

In a nonconducting medium with $\varepsilon = 36\varepsilon_0$ and $\mu=\mu_0$ the electric field intensity of an electromagnetic wave is $E(z,t) = -\hat{x}10\cos(10^7 t - kz)$ (V/m).

a) Determine the associated magnetic field intensity **H** and find the value of *k*. (17 marks)

b) What is a Smith chart and why is it useful in calculating transmission lines? (2 marks)

c) Use the Smith chart to determine the input impedance Z_{in} of the line of length 0.2λ connected to a load of 60 - j60 Ω. The characteristic impedance of the line is 50 Ω. (6 marks)

Question 2

A 9–m section of 50 Ω line is driven by a source with $v_g = 12\cos(4\pi \times 10^{7t} - 15^0)$ (V)

and Z_g =50 Ω, is terminated in a load Z_L =(50-j100) Ω, determine:

a) λ on the line. (2 marks)

b) The reflection coefficient at the load. (4 marks)

c) The voltage standing wave ratio. (2 marks)

d) The input impedance. (6 marks)

e) The input voltage $v_i(t)$. (7 marks)

f) The net average power flowing towards (and then absorbed by) the load P_{av}. (4 marks)

Question 3

a) If the radius of Earth's orbit around the sun, R_s, is approximately 1.5×10^8 km, and Earth's mean radius R_e is 6,380km and that the sun radiates isotropically with its illumination characterized by an eletromagnetic wave average power density of $1 kW/m^2$ on Earth's surface, then determine:

i) The total power radiated by the sun. (6 marks)

ii) The total power intercepted by Earth. (6 marks)

iii) The electric field of the power density incident upon Earth's surface. (6 marks)

Hints: 1) the area of a spherical surface is $4\pi R^2$.

2) the area of interception is πR^2.

3) the intrinsic impedance of free space is $\eta_0 = 120\pi$

b) What does the polarization of a uniform wave describe and what is polarization state. (3 marks)

c) Write the differential of Maxwell's equations and identify each equation with proper experimental law. (4 marks)

Question 4

Using the coordinate system of Figure 4 , a plane wave radiated by a distant antenna is incident in air upon a plane soil surface located at Z=0. The electric field of the incident wave is given by

$$E^i = \hat{y} 50 \cos(\omega t - \pi x - 1.5\pi z) \qquad \text{(V/m)}$$

and the medium 2 may be assumed to be a losselss dielectric with a relative permittivity of 4.

a) Determine k_1, k_2, and the incidence angle θ_i. (10 marks)

b) Determine the transmission angle θ_t . (3 marks)

c) Determine the transmission coefficient $\tau_\perp$. (4 marks)

d) Obtain the expression for the instantaneous electric field in medium 1. (8 marks)

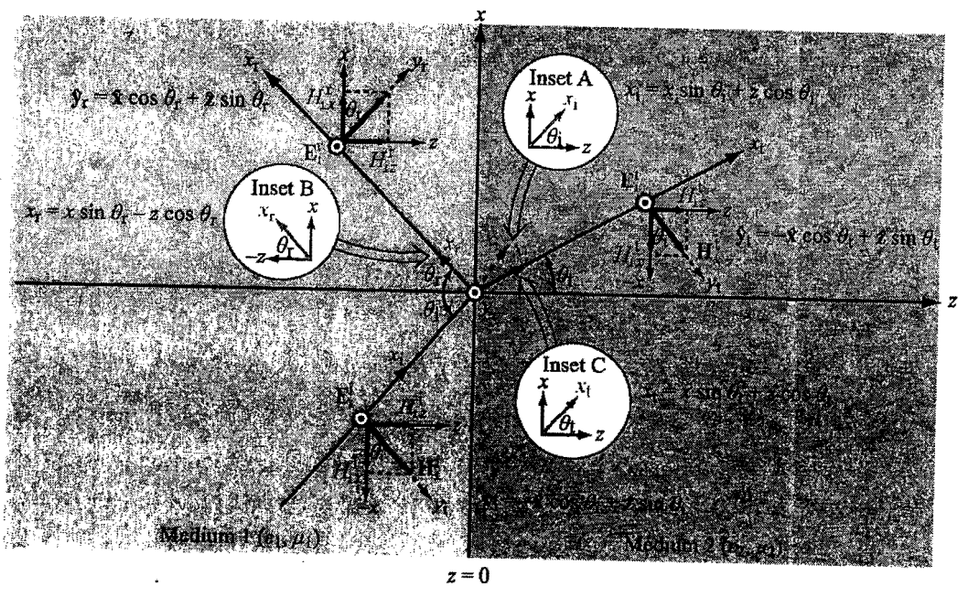

Figure 4

Question 5

A TM wave propagating in a dielectric-filled waveguide of unknown permittivity has a magnetic field with y-component given by $H_y = 6\cos(50\pi x)\sin(100\pi y) \times \sin(1.8\pi \times 10^{10} t - 100\pi z)$ (mA/m).

If the guide dimensions are a=2b=4cm, determine:

a) the mode numbers, (4 marks)

b) the relative permittivity of the material in the guide, (7 marks)

c) the phase velocity, (2 marks)

d) obtain an expression for E_x. (12 marks)