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UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE & ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

MAIN EXAMINATION DECEMBER 2017

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

INSTRUCTIONS:

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

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QUESTION 1

a) A light source in the visible part of the electromagnetic spectrum is place in a swimming pool at a depth of 1.2 meters below the water surface. The water, in this swimming pool, has a refraction index equal to 1.40.

I. What is the critical angle for the light waves generated by the light source?(4 marks)

II. How large a circle would the isotropic beam from the light source be when observed from the water surface (find circle's diameter)? (4 marks)

b) A generator with series impedance $Z_g = 50\ \Omega$ and voltage source given by

$$v_g(t) = 20\cos(2\pi \times 10^9 t + 45^0) \quad (V)$$

is connected to a load $Z_L = (50 + j100)\ \Omega$ through a 50-Ω, 41.35-cm long lossless transmission line. The phase velocity u_p of the transmission line is 0.8c, where $c = 3 \times 10^8$ which is the velocity of light in a vacuum.

Determine

I. The wavelength λ, (2 marks)

II. The phase constant β, (3 marks)

III. The reflection coefficient Γ, and (4 marks)

IV. The input impedance Z_{in}, (8 marks)

QUESTION 2

In a medium with $\varepsilon = 25\varepsilon_0$ and $\mu = \mu_0$ the magnetic field is given by

$$H(z,t) = \hat{x}\cos(2\pi \times 10^9 t - kz) \quad (mA/m)$$

determine

a) Wavenumber k, and (4 marks)

b) The electric field E. (21 marks)

QUESTION 3

a) A TM wave propagating in a dielectric-filled waveguide of dimensions a=2b=8cm, and of unknown permittivity has a magnetic field with y-component given by

$$H_y = 5\cos(25\pi x)\sin(100\pi y)\times\sin(3\pi\times10^{10}-150\pi z)\ (\text{mA/m}).$$

Determine

I. The mode numbers, and (5 marks)
II. The phase velocity. (4 marks)

[Hint: $\widehat{H}_y = \frac{j\omega\varepsilon}{K_c^2}\left(\frac{m\pi}{a}\right)E_0\cos\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-j\beta z}$]

b) The electric field of a plane wave is given by $E(z,t) = \hat{x}3\cos(\omega t - kz) + \hat{y}5.196\cos(\omega t - kz)$.

Determine

I. The polarization state (3 marks)
II. The modulus of E (4 marks)
III. The auxiliary angle (4 marks)

c) In case of single-stub matching network, What are the two degrees of freedom? (2 marks)

d) According to Faraday's law, under what three conditions can an emf be generated in a closed conducting loop. (3 marks)

QUESTION 4

Suppose a 1.2m long transmission line with a characteristic impedance of 75 Ω is terminated by a 125 Ω load, and excited by a rectangular pulse of duration 2 ns that start at time t = 0. The pulse is supplied by a generator with 50 Ω impedance. Given that the pulse amplitude is 5 V and the phase velocity is 3×10^8 m/s. Generate a bounce diagram and use it to plot the voltage waveform at the load. (25 marks)