UNIVERSITY OF ESWATINI

FACULTY OF SCIENCE & ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

MAIN EXAMINATION NOVEMBER 2019

TITLE OF PAPER:	**ELECTROMAGNETIC FIELDS II**
COURSE CODE:	**EEE441**
TIME ALLOWED:	**THREE** HOURS

INSTRUCTIONS:

1. Answer all five (5) questions
2. Each question carries 20 marks.
3. Marks for different sections are shown in the right-hand margin.

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QUESTION 1

a) A coil consisting of 200 turns of wire wrapped around a square frame of sides 0.25 m. The coil is centered at the origin with each of its sides parallel to the y-z-axis. If the magnetic field is given by $\mathbf{B} = (\hat{x} + \hat{y}\,3)\sin(\pi 10^6 t)$ (T), find the magnetic flux density linking a single turn of the coil. (6 marks)

b) For a loop moving at $\boldsymbol{u} = \hat{y}5$ (m/s) in a static magnetic $\mathbf{B} = \hat{z}0.9x$ (T), find the electric field. (8 marks)

c) the induced current in the circuit (assume the wire resistance is 10 Ω).

d) An inductor formed by 100 turns of a thin conducting wire with circular loops of radius 0.01 m is in the x-y plane with its center at the origin. In the presence of a magnetic field $\mathbf{B} = \hat{z}5\sin(\pi 10^3 t)$ (T) find V_{emf}. (6 marks)

QUESTION 2

The electric field of a 3-MHz plane wave travelling in the +z-direction in air points along the y-direction. If this field reaches a peak value 4 (mV/m) at $t = 0$ and 40 m, obtain the following:

a) The wavelength. (2 marks)
b) The wave number. (2 marks)
c) The expression for **E**(z,t). (11 marks)
d) The expression for **H**(z,t). (5 marks)

QUESTION 3

The magnetic field of a wave propagating through a certain nonmagnetic material is given by

$$\mathbf{H} = (\hat{z}100 + \hat{y}10)100\cos(10^8 t - 0.8x)\ \text{(mA/m)}.$$

Find the following:

a) The relative permittivity. (2 marks)
b) The intrinsic impedance. (2 marks)
c) The phase velocity. (2 marks)
d) The electric field phasor. (6 marks)
e) The average power density. (6 marks)

QUESTION 4

The electric field of an elliptically polarized plane wave is given by

$$\mathbf{E}(z,t) = \hat{\mathbf{x}}\, 18\sin(\omega t - kz + 60^0) + \hat{\mathbf{y}}\, 20\cos(\omega t - kz + 48^0)\ (\text{V/m})$$

Determine the following:

a) The auxiliary angle ψ_0
b) The angles (γ, χ).
c) The polarization state of the wave.

QUESTION 5

a) A 2-km-long optical fiber (in air) is made of a fiber core with an index of refraction of 1.55 and a cladding with an index of refraction of 1.44.

Determine:

i. The acceptance angle (5 marks)
ii. The maximum usable data rate of signals that can be transmitted through the fiber. (5 marks)

b) A TM wave propagating in a dielectric-filled waveguide of unknown permittivity has a magnetic field with y-component given by

$$H_y = 12\cos(50\pi\, x)\sin(100\pi y)\cos(10^8 t - 0.8x) \times$$

$$\times \sin(1.6\pi \times 10^{10} t - 100\pi z)\quad (\text{mA/m}).$$

If the wave impedance in the guide is 90 Ω, obtain an expression for the electric field. (4 marks)

c) A coaxial capacitor of 10cm uses an insulating dielectric material with $\varepsilon_r = 16$. The radii of the cylindrical conductor is 0.5 cm and 1 cm. If the voltage applied across the capacitor is $60\cos(100\pi t)$ (V), find the displacement current. (6 marks)