UNVERSITY OF SWAZILAND

MAIN EXAMINATION SEMESTER 1, NOV/DEC 2010

FACULTY OF SCIENCE

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

TITLE OF THE PAPER: ANTENNAS AND WAVE PROPAGATION

COURSE CODE: ECO 510

TIME ALLOWED: 3 HOURS

INSTRUCTIONS:

1. **THERE ARE SIX QUESTIONS IN THIS PAPER. ANWSER ANY FIVE OF THEM. EACH QUESTION CARRIES 20 MARKS**
2. **IF YOU THINK NOT ENOUGH DATA HAS BEEN GIVEN IN THE QUESTION YOU MAY ASSUME ANY REASONABLE VALUES.**
3. **Intrinsic impedance of free space, $\eta_o = 377\ \Omega$**

THIS PAPER SHOULD NOT BE OPENED UNTIL PERMISSION HAS BEEN GIVEN BY THE INVIGILATOR

THIS PAPER CONTAINS FOUR PAGES INCLUDING THIS PAGE.

Q 1

A) What is the function of antennas? List the different types of antennas.
6 Marks

B) Calculate the exact directivity, and beam area of a unidirectional antenna if the normalized power pattern is given by: (i) $P_n = \cos\theta$ (ii) $P_n = \cos^2\theta$, (iii) $P_n = \cos^3\theta$, and (iv) $P_n = \cos^n\theta$. In all cases these patterns are unidirectional with P_n having a value only for zenith angles $0^0 \leq \theta \leq 90^0$ and $P_n = 0$ for $90^0 \leq \theta \leq 180^0$. The patterns are independent of azimuth angle Φ.
8 marks

C) An antenna in free space has a magnetic field strength H = 0.1 A/m, at a distance of 100 m for zenith angles 30^0 and 60^0 and azimuth angle between 0^0 and 90^0 with E = 0 elsewhere. The antenna current is 3 A. Find its directivity, effective aperture, and radiation resistance.
6 marks

Q 2

A) A weather radar operates at 5 GHz;

i) Find the minimum pulse repetition frequency (PRF) which may be used to measure the wind velocity in a tornado with a wind speed of 400 km/hr?

ii) At this PRF, how many pulses must be sampled to resolve, in frequency, two portions of the tornado with a differential velocity of 1 km/hr **8** marks

B) A radar system is capable of transmitting 120 kW at a frequency of 3 GHz. If the antenna gain is 20 dB, the maximum range of the radar is 10 km, the minimum detectable signal power is 2 pW and the target is moving with a speed of 800 km/hour, determine the cross sectional area of the target and the frequency of the received signal from the target. **8** marks

C) By means of a neat sketch, explain briefly a duplex Radar system. **4** marks

Q 3

A) Why are linear antenna arrays needed?

Derive an equation for the electric field strength E_θ and magnetic field strength H_Φ for a linear array of antennas of the same type and obtain the normalized field pattern.

10 marks

B) The amplitude of the electric field intensity broad side to a half-wave dipole antenna at a distance of 25 km is 0.1 V/m in free space. If the operating frequency is 100 MHz, determine the length of the antenna, the amplitude of the magnetic field intensity, the radiation resistance of the half wave dipole antenna, the total radiated power and the average power density.

10 marks

Q 4

A) The magnetic field intensity of a uniform plane wave in free space is given by $\boldsymbol{H} = 0.3\cos(300 \bullet 10^6 \boldsymbol{t} - 10\boldsymbol{z})\overline{\boldsymbol{a}_y}$ A/m. Determine the velocity of propagation, the wave frequency, the wave length, electric filed intensity, and the average power density in the medium. ***6*** marks

B) With the aid of suitable diagrams, explain briefly the propagation of radio waves in free space. **9** marks

C) What are the factors to be considered while transmitting an electromagnetic wave from one medium to another? Define each of these factors. ***5*** marks

Q 5

A) A copper wire antenna has efficiency η_e of 97% and radiation resistance R_{rad} of 1.974 Ω. The antenna is radiating power in free space at a frequency of 1 GHz, and the conductivity of copper, $\sigma = 5.8 \times 10^7$ S/m. Determine the resistance of the antenna, length of the antenna and skin depth. ***6*** marks

B) A half wave dipole antenna radiates 15 kW at frequency of 150 MHz. A short dipole antenna situated at a distance of 25 km is used as a receiving antenna. If both antennas are symmetrically placed in the xy plane with $\theta = 90^0$ and the medium is free space, determine the effective area of the each antenna and the power absorbed by the receiving antenna. ***6*** marks

C) The current in a small circular loop of radius 15 cm is $100\cos(\omega t - 30^0)$ A, where ω is 300×10^6 rad/s. If the medium is free space, write the expressions for the far field in the time domain. Compute the power radiated by the loop and its radiation resistance. ***8*** marks

Q 6

A) What do you understand by Poynting vector? Starting from Maxwell's equations derive an expression for the Poynting vector. ***10*** marks

B) The electric field intensity of a uniform plane wave propagating in the z-direction in a dielectric medium ($\mu = \mu_0, \varepsilon = \varepsilon_r \varepsilon_0$) is given by

$\vec{E} = 380\cos(10^9 t - 5z)\vec{a_x}$ V/m.

Determine the dielectric constant, the velocity of propagation, the intrinsic impedance, the wave length, the magnetic field intensity and average power density. ***10*** marks