PAPER 1

TECHNICAL UNIVERSITY OF MOMBASA

School of Engineering and Technology

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

UNIVERSITY EXAMINATION FOR:

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING

EEE 4412 ANTENNA & PROPAGATION

END OF SEMESTER EXAMINATION

SERIES: APRIL 2025

TIME: 2 HOURS

DATE: April 2025

Instructions to Candidates

You should have the following for this examination

Answer Booklet, examination pass and student ID

This paper consists of **FIVE** questions. Attempt **Question ONE and ANY other TWO questions.**

Do not write on the question paper.

Question ONE

(a) Define the following antenna parameters using sketches where appropriate:

(i) Radiation pattern (ii) Beamwidth

(iii) Radiation resistance (iv) Radiation efficiency (8 marks)

(b) The input current at the terminals of a half-wave dipole operated at a frequency of $300\,MHz$ in the broadside plane, $\theta = 90^0$ is $100 \angle 0^0\ mA$. Given that $\hat{E}_\theta = J\eta_o \frac{\hat{I}_m e^{\frac{-j2\pi r}{\lambda_0}}}{2\pi r} F(\theta)$ and radiation resistance ($R_{rad} = 73\,\Omega$), determine at a distance of $100\,m$:

(i) The magnitude of the electric and magnetic fields (ii) The total power radiated (iii) The power density in the wave

(6 marks)

(c) (i) Explain how an antenna array achieves better gain and directional characteristics compared to a single dipole.

(ii) Suppose the separation of two antennas in an array is one-quarter wavelength, $d = \lambda_0/4$ and the currents

are 90^0 out of phase, $\alpha = \pi/2$ and that $F(\phi) = \cos(\frac{\pi d}{\lambda_0} cos\phi + \frac{\alpha}{2})$, sketch the pattern of the array. (Hint: use the physical observation of how waves either reinforce or cancel each other in 90^0 angle of separation through to 360^0 (7 marks)

(d) Discuss the factors influencing beyond-the-horizon transmission at VHF and UHF frequencies, indicating typical power and transmission ranges for the following:

(i) Tropospheric scatter (ii) Ionospheric scatter (6 marks)

(e) A telemetry transmitter placed on the moon is to transmit data to earth. The transmitter power is $100\,mW$ and the gain of the transmitting antenna in the direction of transmission is $12\,dB$.Determine the minimum gain of the receiving antenna in order to to receive $1\,nw$. The distance to the moon is 238,857 miles and the transmitter frequency is $100\,MHz$. (3 marks)

Question TWO

(a) Define the following antenna parameters: (i) Aperture antenna (ii) Aperture efficiency Illustrate your answers with appropriate examples. (6marks)

(b) (i) Show that the total average power radiated by the Hertzian dipole antenna is given by the expression $80\pi^2\left(\frac{dl}{\lambda_0}\right)^2 \frac{|\hat{I}|^2}{2} W$. Motivate your answer with appropriate sketches, justifying any assumptions made.

(ii) A Hertzian dipole is of length $1\,cm$ and carries a current of $100\,mA$ at a frequency of $10\,MHz$. Determine the radiated power.

(14 marks)

Question THREE

(a) Explain the following antenna performance parameters:

(i) Antenna matching (ii) Antenna bandwidth (4 marks)

(b) With an appropriate sketch describe key performance characteristics of the log-periodic antenna (6 marks)

(c) (i) Show that the electric field at the receiving antenna is given by:

$$[\hat{E}] = \frac{\sqrt{60 P_T G_T(\theta,\phi)}}{d}$$

P_T - Power radiated by transmitting antenna

G_T - Gain of transmitting antenna

d - Distance to the receiving antenna

(ii) A microwave coomunication link is designed to transmit $3\,GHz$ signals over a distance of $3000\,m$. The

antennae are parabolic having main beam gains of $20\,dB$. The received power must be at least $1\,\mu W$ for proper operation. Determine the required transmitter power and the electric field intensity at the receiving antenna. (10 marks)

Question FOUR

(a) (i) With the aid of an appropriate sketch describe the essential nature of radio waves indicating how polarization is achieved.

(ii) Describe the essential performance characteristics of the following types of radio waves:

I Ground wave II Space wave III Sky wave (10 marks)

(b) (i) Explaining any assumptions made derive the expression for the refractive index of the ionosphere: $n=\sqrt{1-\frac{81\,N}{f^2}}$

(ii) A plane electromagnetic wave is propagated at a frequency of $30\,MHz$ into an ionized but otherwise field-free medium. The electron density increases in the direction of propagation. The positive ions may be regarded as effectively immobile. Taking the electronic mass to be $9\times10^{-31}\,Kg$, electronic charge to be $1.6\times10^{-19}\,C$ and the permittivity of free space to be $8.85\times10^{-12}\,F/m$, determine the electron density at which the phase velocity of the wave tends to infinity and explain what happens physically at this point. (10 marks)

Question FIVE

(a) (i) State the Friis equation and explain its practical significance

(ii) A geosynchronous satellite orbiting $36{,}900\,km$ above earth has a transmit power of $2\,W$, a transmit antenna gain of $37\,dB$, and operates at $20\,GHz$. If the receiving station on earth has an antenna gain of 45.8, find the received power. (6 marks)

(b) Explain how the following propagation effects affect the quality of a transmitted signal:

(i) Reflection (ii) Diffraction (4 marks)

(c) With the aid of appropriate sketches distinguish between a single line-of-sight (point-to-point link) propagation path and a multiple propagation path scenario. In each case indicate with reasons if the Friis formula can be used to determine path loss. (10 marks)