



TECHNICAL UNIVERSITY OF MOMBASA
School of Engineering and Technology

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

UNIVERSITY EXAMINATION FOR:

BACHELOR OF TECHNOLOGY IN ELECTRICAL AND ELECTRONIC ENGINEERING

TEE 4425 ANTENNA & PROPAGATION

END OF SEMESTER EXAMINATION

SERIES: AUGUST 2024
TIME: 2 HOURS
DATE: August 2024
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,

 $\theta = 90^\circ$ is $100 \angle 0^\circ \text{ mA}$. Given that $\hat{E}_\theta = j\eta_0 \frac{\hat{I}_m e^{\frac{-j2\pi r}{\lambda_0}}}{2\pi r} F(\theta)$ 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° out of phase, $\alpha = \pi/2$ and that $F(\phi) = \cos\left(\frac{\pi d}{\lambda_0} \cos\phi + \frac{\alpha}{2}\right)$, sketch the pattern of the array. (Hint: use the physical observation of how waves either reinforce or cancel each other in 90° angle of separation through to 360°) (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 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. (6 marks)
- (b) (i) Show that the total average power radiated by the Hertzian dipole antenna is given by the expression $80\pi^2 \left(\frac{dl}{\lambda_0}\right)^2 \frac{|\hat{I}|^2}{2} \text{ W}$. 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 communication link is designed to transmit 3 GHz signals over a distance of 3000 m . The

(10 marks)

- (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:

(10 marks)

$$n = \sqrt{1 - \frac{81 N}{f^2}}$$

(10 marks)

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

(ii) A geosynchronous satellite orbiting $36,900\text{ km}$ 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)

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

(10 marks)