Paper 2

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

TEE 4412 ANTENNA & PROPAGATION

SPECIAL/SUPPLEMENTARY EXAMINATION

SERIES: NOVEMBER 2025

TIME: 2 HOURS

DATE: November 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) Near-field and far-field (ii) Radiation intensity

(iii) Antenna polarization (iv) Aperture efficiency (8marks)

(b) A lossless quarter-wave monopole antenna is situated above a perfectly conducting ground plane and is driven by a $100\,V$ $300\,MHz$ source that has a source impedance of $50\,\Omega$. Determine the:

(i) The total average power radiated

(ii) Magnitude of the electric field broadside to the antenna $\left(\theta = 90^0\right)$ at a distance of $100\,m$

(iii) Power density at a distance of $100\,m$

(iv) Direction of this electric field with respect to ground. (12 marks)

(c) (i) With the aid of appropriate sketches describe the essential nature of radio waves indicating how polarization is determined.

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

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

Question TWO

(a) Given that for a half-wave dipole $\hat{E}_\theta = J\eta_o \frac{\hat{I}_m e^{\frac{-j2\pi r}{\lambda_0}}}{2\pi r} F(\theta)$ and stating appropriate assumptions show that

(i) $\overline{S}_{avg} = \frac{4.7746|I_m|^2}{r^2} F^2(\theta) W/m^2$ (ii) $P_{avg} = 73|I_m|^2$ (10 marks)

(b) A $\lambda/10$ lossless monopole has an input impedance of $(4 - j180)\Omega$ and a source impedance of 50Ω. Determine the total power radiated.
(6 marks)

(c) By making appropriate assumptions, compare a monopole dipole to a half-wave dipole in terms of radiation resistance and power radiated. (4 marks)

Question THREE

(a) Consider two identical Hertzian dipole antennae separated by a distance d as illustrated in Fig.Qu.3(a). The antennae are placed along the x-axis at $x = -d/2$ and $x = d/2$ and are directed in the z-direction (perpendicular to the page)

Noting that for the two dipoles in Fig.Qu.3(a): $\hat{E}_1 = K\hat{I}_1 \frac{e^{-j\frac{2\pi r}{\lambda_0}}}{r_1}$; $\hat{E}_2 = K\hat{I}_2 \frac{e^{-j\frac{2\pi r}{\lambda_0}}}{r_2}$; $K = J\frac{f}{2}\mu_0 dl sin\theta$

Show that the array factor is given by $F(\phi) = \cos\left(\frac{\pi d}{\lambda_0} cos\phi + \frac{\alpha}{2}\right)$ (14 marks)

(b) Suppose the separation of the two antennae in the array is one-half wavelength, $d = \frac{\lambda_0}{2}$, the currents are 180^0 out of phase, and $\alpha = \pi$. Sketch the pattern of the array.

Question FOUR

(a) With reference to wave propagation and with appropriate sketches describe the following terms:
(i) Ducting (ii) Scattering (4 marks)

(b) Describe the essential characteristics of a horn antennae. Illustrate your answer with appropriate sketches and typical performance parameters. (6 marks)

(c) Describe the following terms with reference to the ionospheric layer:
(i) Virtual height (ii) Critical frequency (4 marks)

(d) Develop an expression for the critical frequency and calculate the electron density required to return a signal at $20\,MHz$ incident on the bottom of the layer at an angle of 26^0 to the normal given that:

$\varepsilon = 1 - N\frac{e^2}{\varepsilon_0 m\omega^2}$; Where N is the number of electrons¿ m^3; m is the electron mass $(9\times10^{-31}kg)$;

$\varepsilon_0 = 8.85\times10^{-12}F/m$ (6 marks)

Question FIVE

(a) With appropriate sketches explain the following terms as applied to antenna systems:

(i) End-fire array (ii) Broad-side array (iii) Parasitic elements (6 marks)

(b) 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)

(c) (i) Derive the approximate expression for the maximum distance of line-of-sight transmission for a radio system in terms of the heights of the transmitting and receiving antennae (assume the radius of the earth to be $6350\,km$).

(ii) If a transmitting antenna is located at the top of a tower $200\,m$ above the surface of the earth, determine the maximum distance at which an aircraft, flying at an altitude of $3000\,m$ will be able to receive signals from the transmitter (assume only line-of-sight propagation).

(iii) If the transmitting antenna has a power gain of $13\,dB$ in the direction of the aircraft and the power radiated is $400\,W$, determine the electric field strength of the signal at the aircraft. (8 marks)