(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

SUPPLIMENTARY/SPECIAL EXAMINATIONS 2021/2022 ACADEMIC YEAR

FIFTH YEAR FIRST SEMESTER EXAMINATIONS

FOR THE DEGREE
OF
BACHELOR OF SCIENCE IN ELECTRICAL AND COMMUNICATIONS ENGINEERING

COURSE CODE: ECE 514E

COURSE TITLE: RADAR & SATELLITE ENGINEERING

DATE: Wednesday, 5th October, 2022 **TIME:** 3-5pm

INSTRUCTIONS TO CANDIDATES

ANSWER QUESTION ONE AND ANY OTHER TWO QUESTIONS.
QUESTION ONE CARRIES 30 MARKS AND ALL OTHERS 20 MARKS EACH.

MMUST observes ZERO tolerance to examination cheating

QUESTION ONE (30 MARKS)

(a) (i) With the aid of a block diagram, describe the operation of a bistatic Frequency Modulated Continuous Wave radar system.

(ii) A frequency modulated radar sweeps from 500Hz to 1,000 Hz in 8μSec. What is the maximum unambiguous range that can be measured?

(iii) Discuss three applications of Frequency Modulated Continuous Wave radars.

(6 marks)

(b) A target is approaching a CW radar at a velocity of 200 Knots. If the radar transmitter operates at a wavelength of 2 cm, calculate the following:

(i) the Doppler frequency shift due to the target?

(ii) The Doppler shift when the target alters course by 45°?

(5 marks)

(c) (i) With the aid of a diagram, describe the operation of a Moving Target Indicator (MTI) radar which uses a power oscillator as a transmitter.

(ii) Describe the term 'blind speed' as applied to MTI radar and describe how it can be minimized.

(iii) A pulse Doppler radar operates at a Pulse Repetition Frequency of 500Hz with a carrier frequency of 2GHz. Calculate the lowest three blind Doppler frequencies and the lowest three radial velocities of targets which cannot be detected by the radar.

(6 marks)

(d) (i) With the aid of a block diagram, describe the various subsystems of a communication satellite.

(ii) What do you understand by the term satellite stabilization? Explain the importance of stabilization.

(5 marks)

(e) Determine the apogee, perigee and orbit eccentricity of a satellite having elliptical orbit given that the furthest and closest points from the earth's surface are 20,000 kms and 500 kms respectively.

(5 marks)

(f) (i) Explain the Kepler's laws of planetary motion and how they relate to a satellite motion in orbit.

(ii) Discuss three factors that make practical satellite motion to deviate from the predictions by Keplerian laws.

(5 marks)

QUESTION TWO (20 MARKS)

(a) (i) Determine the escape velocity of an object which is launched from the surface of the earth at a point where the distance from the centre of the earth is 6,360kms.

(ii) A satellite is launched in a circular orbit at a height of 200Kms above the surface of the earth. Determine the velocity and period of the satellite in the orbit. Assume that the radius of the earth is 6,360 Kms.

(10 marks)

(b)(i) Derive the general satellite link equation.

(ii) Explain the factors which affect satellite uplink and downlink design.

(iii) Determine the power received by a satellite located 35,000kms from the surface of the earth if the satellite is operating at a frequency of 11GHz with EIRP of 21dBW and the gain of the receiving antenna is 50.5dB.

(10 marks)

QUESTION THREE (20 MARKS)

(a) (i) Assume that two satellites (A and B) are moving in different orbits with the same perigee but different apogee distances. If the semimajor axis of the two orbits are 1600 Kms and 24000 Kms, determine the orbital period of satellite A if the orbital period of satellite B is 10 hrs.

(ii) List the various advantages of using the Ku band for direct broadcast services.

(7 marks)

(b)(i) Distinguish between pre-assigned and demand-assigned multiple access techniques and give the relative advantages and disadvantages of each when used in satellite communication.

(ii) What is meant by process gain and jam margin and what are their importance in satellite communication?

(6 marks)

(c (i) What is a down-to-dusk satellite?

(ii) Define the following terms as used in satellite systems: *ascending node, descending node, elevation angle and inclination angle.*

(ii) Why is it expensive to launch satellites in retrograde orbits?

(7 marks)

QUESTION FOUR (20 MARKS)

(a) With the aid of a block diagram, list and describe six basic components of a pulse radar system.

(5 marks)

(b) A radar has a maximum range of 300 Kms, Determine the maximum permissible pulse repetition frequency for unambiguous detection of targets. Explain your answer.

(3 marks)

(c) The following table lists the characteristics of a ground-based pulse radar system.

1. Frequency	4600 MHz
2. Pulse Width	1.3 Microseconds
3. Duty Cycle	8.3×10^{-4}
4. Antenna rotation rate	16 RPM
5. Vertical Beam Width	4^{o}
6. Effective Aperture, A_e	$0.9m^2$
7. Power Gain, G	3940
8. Number of Returns per sweep	9.9
9. Minimum Discernible Signal	-83dBm
10. Receiver sensitivity, S_{min}	-5.012×10^{-12}
11. Maximum Theoretical Range, R_{max}	50Kms
12. Radar Cross Section, σ	$5m^2$

Using the table, determine the following:

(i) Pulse Repetition Frequency, *PRF*

(ii) Peak Power, P_t

(iii) Average Power, P_{av}

(iv) Maximum unambiguous range, R_{unamb}

(v) Minimum range, R_{min}

(vi) Range resolution, R_{Res} *(8 marks)*

(c) With the aid of illustrations, discuss features of the following satellite orbits.

(i) Sun-synchronous orbit

(ii) Down – to – dusk orbit

(4 marks)