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(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY EXAMINATIONS 2022/2023 ACADEMIC YEAR

FIFTH YEAR FIRST SEMESTER EXAMINATIONS

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

COURSE CODE: ECE 514E

COURSE TITLE: RADAR & SATELLITE ENGINEERING

DATE: 14TH DECEMBER, 2022 TIME: 8: 00 AM – 10:00 AM

INSTRUCTIONS TO CANDIDATES

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

TIME: 2 Hours

MMUST observes ZERO tolerance to examination cheating

QUESTION ONE (30 MARKS)

(a)(i) Explain the Kepler's laws of planetary motion and how they relate to artificial satellites.

(ii) The earth has an orbital period of 365 days and its mean distance from the Sun is 1.495×10^8 km. The planet Pluto's mean distance from the Sun is 5.896×10^9 km. Using Kepler's third law, calculate Pluto's orbital period in Earth days.

(ii) Discuss three factors that make practical satellite motion to deviate from predictions based on Kepler's laws.

(7 marks)

(b) A radar has a pulse width of 1 microsecond and a pulse repetition frequency of 1800 Hz. Calculate the following.

(i) Maximum unambiguous range
(ii) Range resolution.

(4 marks)

(c)(i) What is a sidereal day? How long is it?

(ii) What velocity is needed to launch a satellite into a circular orbit at an altitude of 800 km above the surface of the Earth? Assume the radius of the earth is 6370km and the gravitational coefficient, g_o = $398600.5 km^3/s^2$.

(4 marks)

(d) Two satellites, A and B, are moving in an elliptical eccentric orbit but with different apogee distances. Satellite A is rotating with an orbital period of 5 hours and semimajor axis of 2,000Kms. Satellite B has an orbital period of 2 hours 50 minutes. Determine the length of the semimajor axis of satellite B.

(6 marks)

(e)(i) Derive the free-space radar range equation for a monostatic radar system.

(i) Define a weather radar scan angle.

(iii) Describe THREE moments of a weather radar image.

(9 marks)

QUESTION TWO (20 MARKS)

(a)(i) List the advantages and disadvantage of using the C-band in satellite communication.

(ii) Name and describe THREE broad categories of services provided by Global Positioning System (GPS).

(7 marks)

(b) (i) Discuss the various features of a runaway that can make a pilot fail to land a plane successfully?

(ii) With the aid of drawings, name and describe the various components of an instrument landing system (ILS).

(iii) Name and discuss the radar systems which performs the functions of ILS at large international airports.

(8 marks)

(c) Calculate the power received from a satellite located 35,800km from the surface of the earth which is operating at a frequency of 12GHz with Effective (Equivalent) Isotropic Radiated Power (EIRP) of 21dBW. Assume the gain of the receive antenna gain is 50.5 dB.

(5 marks)

QUESTION 3 (20 MARKS)

(a)(i) With the aid of a diagram, describe operation of a pulse radar system for remote sensing.

(ii) Define the following terms which are used in remote sensing radar systems:

(I) Synthetic Aperture Radar (SAR)

(II) Depression angle

(7 marks)

(b)(i) With the aid of block diagrams, name and discuss four satellite subsystems.

(ii) With the aid of a block diagram, describe the key elements in a Ku-band satellite transponder.

(8 marks)

(c) A satellite orbit has an apogee of 28,300 kms and eccentricity of 0.3. Assuming that the geocentric gravitational constant is $\mu = 39.8 \times 10^{13}\ Nm^2/Kg$, determine the following.

(i) the perigee distance;

(ii) The orbital period of the satellite.

(5 marks)

QUESTION FOUR (20 MARKS)

4(a) Suppose you are to design a satellite with apogee radius of 30,000 km occurring directly above the North pole. Answer the following questions assuming G = 6.672×10^{-11} Nm^2/kg^2 and the mass of the earth is M = 5.974×10^{24} kg

(i) Given that the orbit must clear the earth's radius plus 500 km at the perigee, what is the shortest possible period for the satellite?

(ii) Given the conditions in part (i), what is the maximum eccentricity for this orbit?

(iii) When the satellite is at apogee, what is the lowest possible latitude an earth station could have and still theoretically receive a radio transmission?

(6 marks)

(b)(i) What is a tracking radar? Briefly describe its functions.

(ii) Derive the expression for the error signal in a conical tracking radar system.

(iii) With the aid of a block diagram, describe ` operation of the conical tracking radar system.

(8 marks)

(c) Assume a Low Earth Orbit satellite is at 1,000 km from the sub-satellite point on the earth. The satellite is supposed to scan from 20° south-east to 40° northeast. If the gravitational coefficient is $g_o = 3.986 \times 10^5\ km^2/s^2$, determine

(i) The angular velocity

(ii) The orbital period

(iii) The number of satellites required to maintain coverage for 24 hours.

(6 marks)