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MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

MAIN 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: MONDAY, APRIL, 25TH, 2022 **TIME:** 8:00 - 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.

QUESTION ONE (30 MARKS)

1(a)(i) Determine the maximum unambiguous range and range resolution of a pulse radar having a pulse repetition frequency of 1000 Hz and a pulse width of 5 microseconds.

(ii) List the advantages and disadvantage of using the 6/4 GHz band in satellite communication.

(7 marks)

(b)(i) What is 'blind speed' and how can radars be designed to avoid it's effects?

(ii) Two MTI radar systems are operating at the same PRF but with different operating frequencies. If the 2^{nd} blind speed of one is equal to the 4^{th} blind speed of the other, find the ratio of their operating frequencies.

(6 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 is 398600.5km^3/s^2.

(4 marks)

(d) (i) What is a dawn-to-dusk satellite?

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

(iii) What are the problems associated with launching satellites in retrograde orbits?

(7 marks)

(e)(i) Derive the radar range equation for a bistatic radar system.

(ii) The maximum unambiguous range of a pulse Radar system is 500Km, if the wavelength is 1 decimeter, calculate the following.

(I) Pulse Repetition Frequency

(II) The maximum unambiguous velocity

(6 marks)

QUESTION TWO (20 MARKS)

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

(ii) Earth has an orbital period of 365 days and its mean distance from the Sun is 1.495x108 km. The planet Pluto's mean distance from the Sun is 5.896x109 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 Keplerian laws.

(9 marks)

(b) (i) Discuss the various features of a runaway that can make a pilot not land the plane successfully?

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

(8 marks)

(c) Below are the specifications for the digital downlink of a deep space probe. Assuming an ideal (Shannon limit) communication system, calculate the maximum distance from earth that this satellite is capable of maintaining communications.

Communications Link parameters	
Ku-band Downlink Frequency	14.0 GHz
RF Signal Bandwidth	200.0 kHz
Target Data Rate	100.0 kbps
Satellite Transmitter Hardware parameters	
Satellite Transmit Power (Amplifier Output)	800 W
Satellite Transmit Antenna Gain	40 dBi
Earth Station Receiver Hardware parameters	
Earth Station Receiver Antenna	55 dBi
Receiving Antenna Noise Temperature	30 K
Low-Noise Amplifier Device Noise Temperature	70 K

(3 marks)

QUESTION 3 (20 MARKS)

3(a) (i) With the aid of a block diagram, explain the working of a Frequency Modulated Continuous Wave (FMCW) radar.

(ii) A frequency modulated continuous wave radar sweeps from 400Hz to 800 Hz in 10 microseconds. What is the maximum unambiguous range that can be measured by this radar?

(7 marks)

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

(ii) A communication satellite located at 20,000km from an observation point on the earth's surface operates at a frequency of 11.8 GHz and EIRP of 20 dBW. If the gain of the receiving antenna is 50.5 dB, determine the power at the receiver mounted on the satellite.

(8 marks)

(c) Satellite A and Satellite B are moving in different elliptical orbits with the same perigee but different apogee distances. The semi-major axis of the two orbits are 18,000 and 22,000 kilometers respectively. Determine the orbital period of satellite B if the orbital period of Satellite A is 600 minutes.

(5 marks)

QUESTION FOUR (20 MARKS)

(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 $G = 6.672 \times 10^{-11}$ Nm^2/kg^2 and the mass of the earth is $M_E = 5.974 \times 10^{24}$ kg

(i) Given that the orbit must clear the earth's radius + 500 km at 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 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° North-East. If the gravitational coefficient $g_o = 3.986 \times 10^5$ km^2/s^2, determine the following:

(i) angular velocity

(ii) orbital period

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

(6 marks)