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(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY EXAMINATIONS
2023/2024 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 20/12/2023 **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.

MMUST observes ZERO tolerance to examination cheating

QUESTION ONE (30 MARKS)

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

(ii) Name and describe FOUR broad categories of services provided by satellites in the C-band.

(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 2nd blind speed of one is equal to the 4th 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, go = $398600.5 km^3/s^2$.

(5 marks)

(d)(i) Name and discuss THREE types of multiple access schemes used in satellite communication. State their advantages and disadvantages.

(ii) Calculate the apogee and perigee heights for a satellite with eccentricity, $e = 0.00115$ and major axis, $a = 7192.3$ Km. Assume the mean radius of the earth is 6371Kms.

(6 Marks)

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

(6 marks)

QUESTION TWO (20 MARKS)

(a) (i) State and explain Kepler's laws of planetary motion.

(ii) 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 kms. Using Kepler's third law, calculate Pluto's orbital period in earth days.

(ii) Discuss THREE factors that make practical satellite motion deviate from predictions based on Keplerian laws.

(8 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 (ILS).

(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.

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

(4 marks)

QUESTION 3 (20 MARKS)

3(a) (i) What do you understand by the term 'Doppler effect'? How is it used in a Doppler radar?

(ii) A pulse Doppler radar has a carrier frequency of 9 GHz and a pulse repeating frequency of 400 Hz. Find its blind Doppler frequencies and the radial velocity of a target which would be undetected by the radar.

(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 $G = 6.672\times10^{-11}\ Nm^2/kg^2$ and the mass of the earth is $M_E = 5.974\times10^{24}$ kg

(i) If the lowest height from the surface of the earth is 500 kms, what is the shortest possible period for the satellite?

(ii) Given the conditions in part (i), what is the maximum eccentricity for the 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 a 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 degrees south-east to 40 degrees northeast. If the gravitational coefficient is $g_o = 3.986 \times 10^5$ km^2/s^2, determine the following.

(i) The angular velocity

(ii) The orbital period

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

(6 marks)