Ref. No. : Ex/IEE/PE/B/T/421A/2025

B.E. INSTRUMENTATION AND ELECTRONICS ENGINEERING FOURTH YEAR SECOND SEMESTER - 2025

Subject : INSTRUMENTATION IN SPACE TECHNOLOGY | Time : 3hr | Full Marks : 100

*Ensure that you clearly designate the questions you're answering by using the format: Q1.a), Q1.b), Q1.c), etc. for Question 1, Q2.a), Q2.b), etc. for Question 2, and so forth. This designation should be explicit and located directly beside each question you choose to address.*

*Conceptual Questions*

Q1 Any five

a) Define "Directivity of antenna" with its mathematical expression? How does antenna radiate? 5x5

b) How is stellar parallax used to measure the distance to nearby stars?

c). What is the purpose of Fractal Analysis? How could you explain the randomness of a time series data using Fractal Dimension?

c) What is transponder? Explain microwave frequency band for communication satellite.

d) What is the solar wind, and what impact does it have on the solar system?

e) How do weather satellites differ from other types of satellites in terms of their sensors and data collection methods?

f) What distinguishes navigation satellites from scientific research satellites in terms of their applications and payloads?

g) What instruments and methods are used to observe and measure solar flares, CMEs, and solar radio bursts?

*Critical Thinking Questions*
*( Answer based on knowledge and understanding)*

Q2 Any five

a) Explain the concept of half-wave dipole antenna. 5x5

b) How do scientists observe and study solar phenomena using space-based and ground-based instruments?

c) How the star's luminosity can be used to measure the interstellar distance?

d) How does spherical trigonometry help in the design and implementation of global positioning systems (GPS)?

e) What is the main difference between Simple Exponential Smoothing (SES) and Moving Average Smoothing?

f) How do particle instruments on spacecraft protect themselves from damage caused by high-energy particles?

[ Turn over

g) Explain how the feed horn of a parabolic dish antenna is positioned relative to the focal point of the reflector. What role does the feed horn play in the antenna's operation?

h) What is a solar radio burst, and what are the primary types of solar radio bursts observed?

i) How does mixing length theory impact the calculation of stellar evolution models?

*Analysis and Design Questions*

Q3 Any five

a) How do scintillator detectors contribute to the study of cosmic rays and high-energy particles in space? 5x5

b) How does a discrete electron multiplier compare to a photomultiplier tube in terms of performance? What are the advantages and limitations of using discrete electron multipliers in detecting charged particles?

c) Analyse the trade-offs involved in selecting specific orbital parameters for a satellite mission based on mission objectives, coverage requirements, and operational constraints

d) Describe the design and operation of Langmuir probes for measuring plasma parameters in space-based experiments.

e) How does the aperture size of a telescope affect its light-gathering power and resolving power? How is the angular resolution of a telescope calculated, and why is it important for astronomical observations?

f) Analyse how deviations from Kepler's laws, such as those observed in the orbits of comets or moons, have contributed to advancements in astronomical theory and observation.

g) How do space flight particle instruments calibrate their measurements to ensure accuracy in the data collected?

h) What types of particles are typically detected by Faraday cups in space missions? How does the design of a Faraday cup ensure accurate measurements of particle flux in the vacuum of space?

*Application and Problem-Solving Questions*

Q4 Any five

a) An aeroplane flies in a great circle course from a point A (lat 30oN; long 10oE) to a point B on the equator, the initial direction of departure being 20oE of S. Find the longitude of B, and the length of the journey, taking the earth to be a sphere of radius 4000 miles 5x5

b) In a spherical triangle on a unit sphere (radius = 1), the sides $a$ $b$, and $c$ are 1.045 radians, 1.22 radians, and 1.40 radians respectively. Calculate the angle $A$ opposite side $a$.

c) The difference between the furthest and the closest points in a satellite's elliptical orbit from the surface of the Earth is 30 000 km and the sum of the distances is 50 000 km. If the mean radius of the Earth is considered to be 6400 km, determine orbit eccentricity.

b) Calculate the great-circle distance between two points on the Earth's surface: Point A (latitude 40°N, longitude 75°W) and Point B (latitude 34°N, longitude 118°W). Assume the Earth is a perfect sphere with a radius of 6371 km.

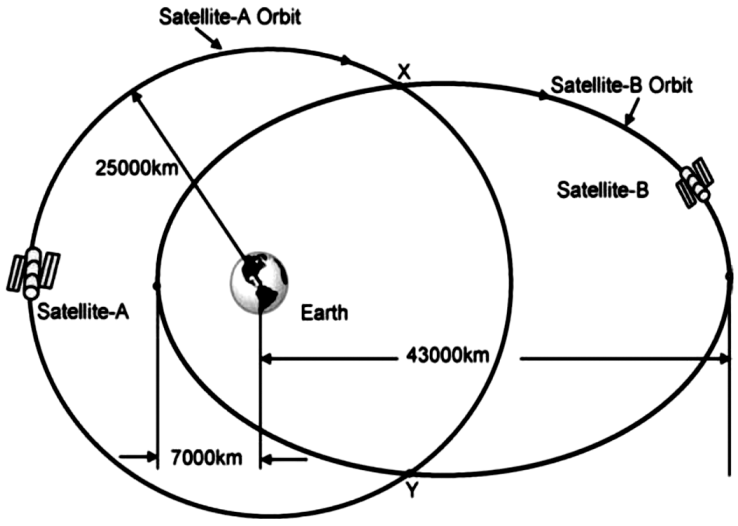
c) How do weather satellites differ from other types of satellites in terms of their sensors and data collection methods?

d) How do orbital parameters impact the energy requirements and propulsion systems needed for satellite deployment and station-keeping?

e) A simulated missile is launched from Kolkata targeting a location 30 km east of Islamabad . If the missile travels at an average speed of 1.5 km/s, how long will it take to reach the target, [ for calculation of the direct great-circle distance between Islamabad and Kolkata, Islamabad: 33.6844° N, 73.0479° E; Kolkata: 22.5726° N, 88.3639° E]

f) Calculate the orbital parameters of a hypothetical satellite orbiting Earth with the following characteristics:

Semi-major axis: 20,000 km
Eccentricity (e): 0.2
Inclination: 30 degrees (i)
Argument of Periapsis (ω): 60 degrees




i) Satellite A is orbiting Earth in a circular orbit of radius 30000 km. Satellite B is orbiting Earth in an elliptical orbit with apogee and perigee distances of 43000 km and 7000 km respectively. Determine the velocities of the two satellites at the indicated points X and Y. (Take $\mu = 39.8 \times 10^{13}$ $m^3/s^2$.)