Indian Institute of Technology, Kanpur

Proposal for a New Course for M.Tech./Undergraduate studies

1. Course No: SPA6XX (Level 6 course for M.Tech./final year B.Tech. students of interdisciplinary departments)

2. Course Title: Satellite Based Communication & Navigation Techniques

3. Per Week Lectures: 3(L), Tutorial: 0 (T), Laboratory: 0 (P), Additional Hours[0-2]:0 (A), Credits (3*L+2*T+P+A): 9, Duration of Course: Full Semester

4. Department : Space, Planetary & Astronomical Sciences & Engineering (SPASE)

5. Instructor: Sumitesh Sarkar, Soumyabrata Chakrabarty,
6. Course Description:

   A. Objectives: The objective of this course is to introduce the students from interdisciplinary Engineering and science streams to the fundamentals of Engineering topics related to Satellite based Communication and Navigation.
   B. Contents (*preferably in the form of 5 to 10 broad titles*):

S No.	Broad Title	Topics	No. of lectures
Part1: Instructor, Sumitesh Sarkar			
I	Introduction to Satellite Systems	Evolution of satellite communication and navigation systems, Satellite orbits, Keplerian elements, launches, orbit determination, Satellite subsystems overview: payload, bus, TT&C, power, thermal, Satellite mission classification: communication, navigation, EO, scientific.	3
II	Basic elements of Communication system	Link design basics, Frequency bands for RF Communication, propagation environment, Analogue & Digital Modulation techniques, Coding & Multiple access.	6
III	Satellite Communication	Concepts Transponder (bent-pipe, regenerative), payload subsystems, Antenna systems: Reflector based, phased arrays, spot beams, Earth stations and VSAT networks, broadcast services (DTH, DAB), maritime & aeronautical SATCOM.	6
IV	Modern Satcom Systems	HTS, VHTS, Satellite based internet, optical satellite communication, LEO/MEO Constellations, Flexible Satellites, Direct to Device systems.	5
Part 2: Instructor- Soumyabrata Chakrabarty			
V	Fundamentals of Satellite systems	Principles of navigation & positioning, GNSS constellations: GPS, GLONASS, Galileo, BeiDou.	3

	for Global Navigation	Regional systems: NavIC, QZSS, augmentation systems (SBAS, GAGAN, WAAS).	
VI	Segments of Navigation Satellite Service	Space segment, Control Segment & Ground Segment. Navigation Payload elements, Time & Frequency: atomic clocks, UTC & GPS time. GNSS Receivers: architecture & algorithms	6
VII	GNSS Signals & Measurements	GNSS signal structure, frequencies, codes (C/A, P(Y), M-code), Ranging, pseudorange, Dual frequency measurements, carrier-phase, Doppler measurement.	5
VIII	Sources of Errors & interferences	Effects of ionosphere, troposphere, multipath, receiver noise, Orbit Geometry & Dilution of Precision (DOP), Jamming, Spoofing, Orbit determination & integrity monitoring.	4
IX	Applications & Precision services	Applications in Geospatial services: Surveying, mapping, GIS. DGPS, RTK & PPP.	2

C. Pre-requisites: Not Applicable.

D. Short summary of the Courses: The aim of this course is to introduce the students from the departments of SPASE, AE and EE to the fundamentals of the science and engineering topics related to satellite-based communication & navigation. The students will learn about the various parts of an artificial satellite, suitable orbits, communication links, modulation, coding and multiple access techniques and various applications. In the navigation part the course will cover the basic principles of navigation, example of existing global and regional systems, the three segments of GNSS, viz., Space segment, Control segment and Ground segment, navigation signal structures, measurements, sources of error and applications. The course is targeted for all engineering and science disciplines.

7. Recommended books:

Textbooks:

- Timothy Pratt, Jeremy E. Allnutt, “Satellite Communications”, Wiley, 2016
- Gerard Maral, Michel Bousquet, Zhili Sun, “Satellite communications systems : systems, techniques and technology”, John Wiley & Sons, 2020
- Bernhard Hofmann-Wellenhof , Herbert Lichtenegger , Elmar Wasle, “GNSS – Global Navigation Satellite Systems”

Reference Books:

- Pratap Misra, “Global Positioning System: Signals, Measurements, and Performance”, Ganga Jamuna Press, 2012
- Dennis Roddy, ‘Satellite Communications’ McGraw-Hill, 2001