# Indian Institute of Technology, Kanpur

## Proposal for a New Course for Postgraduate studies

1. Course No:

2. Course Title: Space Environments and Space Systems

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. Proposing Department/IDP : Space, Planetary & Astronomical Sciences & Engineering (SPASE)

5. Proposing Instructor(s): Rohit Sharma and Soumyabrata Chakrabarty

   Other faculty members interested in teaching the proposed course:

6. Course Description:

   A. Objectives: This course aims to provide the students the exposure to understand different aspects of the space environment, including space weather, space climate, space debris and how these impact on spacecraft design, terrestrial infrastructure systems and will enable students to explore particular topics at a deeper level.

   B. Contents (*preferably in the form of 5 to 10 broad titles*):

| S No. | Broad Title | Topics | No. of lectures |
|---|---|---|---|
| 1 | Introduction | Space weather definition; solar activity, solar wind, solar flare, coronal mass ejection, effects of solar activity on our earth, magnetosphere, magnetic storm and magnetic substorm, spacecraft systems and its orbits, classification of space environments for a spacecraft. | 5 |
| 2 | Neutral particles environment | Neutral gas flow around a spacecraft, earth's atmosphere, pressure variation with altitude, planetary atmospheres, aerodynamic force; contamination, erosion by atomic oxygen, glow, particle impacts on spacecraft, scattering of EM | 5 |

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|---|---|---|---|
| 3 | Plasma Environment | The geomagnetic field, the external and disturbance fields; low earth orbit, polar orbits, the geosynchronous plasma environment; spacecraft-plasma interactions, spacecraft surface charging and current collection, current sources to a spacecraft, spacecraft-plasma interactions, spacecraft surface charging and current collection, current sources to a spacecraft, current from the ambient plasma, photoelectric currents, backscattered and secondary electrons, effect of magnetic fields on current collection, artificial current and charge sources; general probe theory: the thin-sheath limit the thick-sheath limit, spacecraft potentials, barrier potentials, potentials, anomalies, and arcing on geo-spacecraft. | 8 |
| 4 | Macroscopic particle environment | The physics of macroscopic particles, cometary meteoroids, asteroidal meteors, space debris. | 3 |
| 5 | Radiation Environment: | Electromagnetic radiation, electromagnetic radiation at radio frequencies, visible and infrared, UV, EUV, and X-rays; energetic particle radiation; trapped radiation, cosmic rays, solar proton events, radiation interactions with matter, single-particle interactions, photon interactions, charged-particle interactions, neutron interactions. | 6 |
| 6 | Spacecraft induced Environments | Spacecraft outgassing; chemical thrusters; plasma thrusters; the space radiation environment; solar-array degradation. | 3 |
| 7 | Spacecraft operations | Spacecraft charging; single event upsets; spacecraft drag; space radiation, radiation hazards to satellite electronic systems; radiation due to heavy ions, radiation charging of dielectric materials; particulate interactions: particle impacts on spacecraft scattering of EM radiation from particles, environmental effects of space systems. | 7 |
| 8 | Mission Planning and Safety | Coupling, victim, spacecraft radiation hardening, test and evaluation, design guidelines, material selection, wiring and cable shields and their bonding | 3 |

C. Pre-requisites: Not Applicable.

D. Short summary for including in the Courses of Study Booklet: The hazardous interactions between the space environment and the orbiting spacecraft may lead to the degradation of spacecraft and its subsystem performance and possibly even may lead to the loss of the spacecraft itself. This course aims to provide the students with the introduction to the understanding of different aspects of the space environment, including space weather, space climate, space debris and how these impact on spacecraft design, human and robotic spaceflight, terrestrial infrastructure systems and will enable students to explore a particular topic at a deeper level. Emphasis is laid on problem solving techniques and design guidelines

that will provide the student with an understanding of how space environment effects may be minimized through proactive spacecraft design.

7. Recommended books:

Textbooks:

- Hastings, D., & Garrett, H. 'Spacecraft-Environment Interactions', (Cambridge Atmospheric and Space Science Series). Cambridge: Cambridge University Press, 1996.
- Vincent L. Pisacane, 'The Space Environment and Its Effects on Space Systems', Second Edition, American Institute of Aeronautics and Astronautics, Inc, 2008.
- Alan C. Tribble, 'The Space Environment: Implications for Spacecraft Design', Princeton University Press, Princeton New Jersey, 2003.
- Thomas F Tascione, 'Introduction to the Space Environment', 2nd Edition, Krieger Publishing, Florida, 1994.
- Shu T. Lai, 'Fundamentals of Spacecraft Charging: Spacecraft Interactions with Space Plasmas' Princeton University Press, 2012.

Reference Books:

- Volker Bothmer, Ioannis A. Daglis, 'Space Weather: Physics and Effects', Springer Berlin, Heidelberg, 2007
- Yohsuke Kamide Abraham C.-L. Chian, 'Handbook of the Solar-Terrestrial Environment', Springer Berlin Heidelberg New York, 2007
- George V. Khazanov, 'Space Weather Fundamentals', CRC Press Taylor & Francis Group, 2006.

8. Any other remarks:

Dated:25.12.2023 Proposer: Soumyabrata Chakrabarty

Dated:_____ DUGC/DPGC Convener:_____

The course is approved / not approved

Chairman, SUGC/SPGC

Dated:_____