

Indian Institute of Technology, Kanpur

Proposal for a New Course

1. **Course No:** AE 6XX
2. **Course Title:** Rocket and Spacecraft Propulsion
3. **Per Week Lectures:** 3 (L), Tutorial: 0 (T), Laboratory: 0 (P), Additional Hours: 0, Credits: 9
4. **Duration of Course:** Full Semester
5. **Proposing Department:** Aerospace Engineering (AE)
6. **Other Departments which may be interested in the proposed course:** ME, SPASE
7. **Other faculty members interested in teaching the proposed course:** Dr. Sathesh Mariappan
8. **Proposing Instructor:** Dr. D. Chaitanya Kumar Rao
9. **Course Description:**

A) Objectives: The course covers the basic principles of rocket and spacecraft propulsion systems, including the details of some of the advanced propulsion systems being developed around the world. The students will be exposed to the different types of rocket propulsion systems, followed by the basic principles of chemical rocket engines. Thereafter, an in-depth study of distinct propulsion systems: liquid propellant rocket engines, solid and hybrid rocket motors, electric propulsion, nuclear rockets, and other novel propulsion technologies will be covered. The primary aim of this course is to provide the students with a broad overview of this rapidly evolving field, including the recent advancements at different space agencies such as NASA, ISRO, ULA, and SpaceX. The course is intended to be self-sufficient and targeted towards students from all the engineering and science disciplines.

B) Contents: 40 lectures, each of 50 minutes duration

S. No	Broad Title	Topics	No. of Lectures
1	Introduction to Rocket Propulsion	History and Classification of Rocket Propulsion: Chemical, Electric, Nuclear, and Advanced Propulsion Concepts, Applications: Space Launch Vehicles, Spacecraft, Military Applications	3
2	Principles of Rocket Propulsion	Thermodynamic Relations, Ideal Rocket Equation, Single and Multi-Stage Rockets, Rocket Engine Performance	5
3	Liquid Propellant Rocket Engines	Monopropellant and Bipropellant, Pressure-Fed and Pump-Fed Systems, Injection, Ignition and Combustion, Thrust Vector Control, Applications	8
4	Solid and Hybrid Propellant Rocket Motors	Propellant Composition, Propellant Burning Rate, Propellant Grain Configuration, Solid Propellant Ignition and Combustion, Hybrid Rocket Motors, Applications and Missions	8
5	Electric Propulsion	Principles of Electric Propulsion, Electrothermal, Electrostatic, and Electromagnetic Thrusters, Applications and Missions	5

6	Nuclear Propulsion	Nuclear Fission Basics, Principles of Nuclear Thermal Propulsion, Nuclear Thermal Rocket Engine, Nuclear Propelled Missions, Operational and Safety Issues	3
7	Advanced Propulsion Technologies	Laser Thermal Rocket, Pulsed and CW Plasma Propulsion, Solar Sails, Hypothetical Propulsion Techniques, Technology Maturity Assessment	4
8	Human Space Flight and Planetary Exploration	Launch Systems for Human Space Flight, Crewed Launchers and Re-Entry Vehicles, NASA and ISRO Human Space Flight Programs, Planetary and Atmospheric Propulsion	4

C) Recommended Pre-requisites: Undergraduate level Thermodynamics and Fluid Mechanics

D) Short summary for including in the Courses of Study Booklet:

This course will provide an overview of various types of rockets and spacecraft propulsion systems. Primary emphasis will be on the basic principles of each propulsion technology followed by their applications in space missions.

10. Recommended text/reference books:

- 1) **Rocket Propulsion Elements** by G. P. Sutton and O. Biblarz, 9th Edition, John Wiley and Sons, 2001.
- 2) **Rocket and Spacecraft Propulsion: Principles, Practice and New Developments** by M. J. L. Turner, Third Edition, Springer, 2009.
- 3) **Spacecraft Propulsion** by C. D. Brown, AIAA Education Series, 1996.
- 4) **Mechanics and Thermodynamics of Propulsion** by P. Hill and C. Peterson, Second Edition, Addison-Wesley, 1992.
- 5) **Propellants and Explosives** by N. Kubota, Second Edition, Wiley-VCH, 2007.

11. Any other remarks: NA

Dated: 16/08/24 Proposer: Dr. D. Chaitanya Kumar Rao

Dated: _____ DUGC/DPGC Convener: _____

The course is approved / not approved

Chairman, SUGC/SPGC

Dated: _____