Indian Institute of Technology, Kanpur

Proposal for a new course

1. Course No: ME6~~XX~~ 46

2. Course Title: Introduction to Space Materials and Manufacturing

3. Per Week Lectures: 3 (L), Tutorial: 0 (T), Laboratory: 0 (P), Additional Hours [0-2]: 0 (A)

Credits: 3×3-0-0-0 (9)

Duration of Course: Full semester

4. Proposing Department: Mechanical Engineering (ME)

Other Departments/IDPs which may be interested in the proposed course: Material Science and Engineering, Earth Sciences, and SPASE.

Other faculty members interested in teaching the proposed course: Dr. Ishan Sharma, Dr. J Ramkumar

Proposing Instructor(s): Dr. Sarvesh Mishra

5. Course Description:

A) ***Objectives***: This course aims to challenge the existing manufacturing processes from the perspective of space manufacturing. The course will enable students to learn about the availability of resources and their in-situ utilization for projected human needs in the Martian and Lunar ambience. With the increasing demand for crewed missions and India's ambitious participation in the space economy, the course will offer our students an opportunity to understand, contemplate and receive exposure to the future of manufacturing.

B) ***Contents***:

1. **Introduction (4 lectures)**

   Space race, industrialisation, colonies and stations, Exploration activities, Natural resources (Earth vs. Space), Space factories, Economy, Benefits and challenges, Future of space activities.

2. **Space Environment (6 lectures)**

   Lunar/Martian topography, Petrology, Solar cycle, Abundance/scarcity of energy, Impacts and volcanism, Asteroids/meteoroids, Extreme conditions, Identification and fulfilment of human needs, Space-food, Extreme condition habitats, Spacesuits, Physiological and psychological health, Utilization of local resources.

3. **Challenging factors for space manufacturing (4 lectures)**

   Vacuum conditions, Reduced/micro/quasi-absent/zero gravity, Gaseous environments,

Radiation, Meteoritic impacts, Solar storms, Space objects, Physical/chemical/mineralogical properties of rocks, Simulating space environment on earth.

4. **Material processing in space conditions (6 lectures)**

   Material processing methods, Solar energy-based material processing, Lunar and Martian environments, Asteroidal ores, steels, composites, and Soil, Major/minor/incompatible/siderophile elements, Vapor-mobilized/solar-wind implanted elements, Location-specific rocks on Lunar and Martian environments, Methods and techniques of characterization, Rock disintegration, Soil refining, Lunarcrete, Solar furnace, Oxygen production, Metallic and rare elements processing.

5. **In-space manufacturing using local resources (6 lectures)**

   Basic manufacturing operations, Art of space manufacturing, Containerless processes, Ultrahigh vacuum processing, Qualification of manufacturing processes, Simulating space gravity, Plausibility of space manufacturing, Governing physics and anomalies, Metal printing and defects under extreme conditions, robotic operations for manufacturing.

6. **Machining and assembly in space (4 lectures)**

   Cutting and assembly processes, Vacuum and oxygen-free cutting, Maintenance of spacecraft/spaceships from outer space, Mining and He-3 production, Deep-drilling on Lunar/Martian surfaces, Cutting and drilling tool materials.

7. **Miscellaneous space technologies and processes (5 lectures)**

   Materials, design and manufacturing for launch pads/spaceships/lander/rover systems, Sample collectors, Engineered components, Functional performance requirements and processing methods.

8. **Experiments on Space Manufacturing (5 lectures)**

   Experiments on space materials at Space Manufacturing Cell @ IITK, Development and characterization of LUNES and MARTES regolith simulants, Space-simulated environments.

C) **Pre-requisites if any**: NA

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

Introduction, Space environment and its description, Challenging factors in outer space and celestial bodies (Moon and Mars, specifically), Materials and resources available, Processing of space materials, Material processing in space for in-situ resource generation, Manufacturing for space conditions, In-space manufacturing, Challenges for conventional manufacturing on Moon/Mars, Miscellaneous processing, Experiments at Space Manufacturing Cell @ IITK.

Recommended books:

Reference book:

1. The cosmos economy, Jack Gregg, Springer Nature, ISBN 978-3-030-62568-9, Switzerland
2. Space mining and manufacturing, D. Sivolella, Springer Nature, ISBN 978-3-030-30881, Switzerland
3. Materials Processing in Space: Theory, Experiments, and Technology, L.L. Regel, Springer, ISBN 978-0306110269
4. Fundamentals of modern manufacturing, M.P.Groover, Wiley & Sons, ISBN 978-0470-467002

Remarks:

This course will be open to students in their final year, dual degree, PG, and MSc levels.

Proposer:

Sarvesh Mishra

Dr. Sarvesh Mishra

Date: 15/04/2024

DUGC/DPGC Convener: Santanu De

Date: 16-4-2024

The course is approved / not approved

Abhijeet 19/4/24

Chairperson, SUGC/SPGC

Dated: _____