UTTARANCHAL UNIVERSITY

(Established vide Uttaranchal University Act, 2012)
(Uttarakhand Act No. 11 of 2013)
Arcadia Grant, P.O. Chandanwari, Premnagar, Dehradun, Uttarakhand

Programme Name	**Pre-Ph.D. Course Work**	Programme Code	23-
Course Code	DSE704	Credit	3
Year/Sem	1/1	L-T-P	3-0-0
Course Name	Rocket and Missile Technology		

Objectives of the Course:

1. Provide a comprehensive understanding of rocket and missile systems.
2. Explore propulsion mechanisms and performance analysis.
3. Introduce guidance, navigation, and control systems.
4. Study aerodynamic and structural aspects of high-speed vehicles.
5. Familiarize students with modern advancements and strategic applications.

UNIT I (Total Topics-8 and Hrs-8)

Fundamentals of Rocket and Missile Technology: History and evolution of rockets and missiles, Classification of rockets and missiles, sounding rockets, launch vehicles, ballistic and cruise missiles, Differences between rockets and missiles, Basic principles of rocket motion, Mission requirements and system overview, Introduction to strategic and tactical missile systems.

UNIT II (Total Topics-7 and Hrs-7)

Rocket Propulsion Systems: Fundamentals of rocket propulsion**,** Rocket equation and performance parameters**,** Specific impulse, thrust, and efficiency**,** Solid propellant rockets: composition, grain geometry, and burning rates**,** Liquid propellant rockets: monopropellant and bipropellant systems**,** Hybrid rocket propulsion**,** Cryogenic and semi-cryogenic engines**,** Electric and nuclear propulsion (overview)**,** Nozzle theory and design

UNIT- III (Total Topics-6 and Hrs-7)

Aerodynamics and Flight Mechanics, Aerodynamics of rockets and missiles, Subsonic, supersonic, and hypersonic flows, Drag estimation and aerodynamic heating, Stability and control derivatives, Atmospheric flight mechanics, Ballistic and boost-phase trajectories, Re-entry dynamics and thermal effects, Stage performance and optimization.

UNIT- IV (Total Topics-7 and Hrs-7)

Structures, Materials, and Launch Systems, Structural design of rockets and missiles, Materials for high-temperature and high-speed applications, Composite materials and thermal protection systems, Aeroelasticity and vibration considerations, Launch systems and platforms: land, sea, and air-based, Stage separation mechanisms and payload integration, Warhead technologies (overview) and safety considerations, Reliability, quality assurance, and system integration, Environmental and ethical considerations.

UNIT- V (Total Topics-4 and Hrs-8)

Guidance, Navigation, and Control (GNC), Principles of missile guidance systems, Navigation techniques: inertial, satellite-based (GNSS), and celestial, Guidance methods: command, beam-rider, homing, and proportional navigation, Autopilot and control systems, Sensors and actuators, Control mechanisms: thrust vector control, jet vanes, canards, and fins, Kalman filtering and state estimation, Electronic warfare and countermeasures.

CO-1 Explain the fundamentals of rocket and missile technologies.
CO-2 Analyze rocket propulsion systems and evaluate performance parameters.
CO-3 Design and assess missile trajectories and aerodynamic characteristics.
CO-4 Understand structural, thermal, and staging considerations.
CO-5 Evaluate guidance, navigation, and control systems.

Reference Books

1. Sutton, G. P., & Biblarz, O. *Rocket Propulsion Elements*. Wiley.
2. Fortescue, P., Stark, J., & Swinerd, G. *Spacecraft Systems Engineering*. Wiley.
3. Hill, P., & Peterson, C. *Mechanics and Thermodynamics of Propulsion*. Addison-Wesley.
4. Humble, R., Henry, G., & Larson, W. *Space Propulsion Analysis and Design*. McGraw-Hill.
5. Zarchan, P. *Tactical and Strategic Missile Guidance*. AIAA.

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Programme Name	**Pre-Ph.D. Course Work**	Programme Code	23-
Course Code	DSE704 (i)	Credit	3
Year/Sem	1/1	L-T-P	3-0-0
Course Name	Advanced Space Propulsion System		

Objectives of the Course:

1. Provide in-depth knowledge of advanced propulsion systems used in space missions.
2. Develop an understanding of electric and emerging propulsion technologies.
3. Familiarize learners with modern research trends and design methodologies in space propulsion.
4. Prepare students for research and development in space agencies and industries.

UNIT I **(**Total Topics-12 and Hrs-10)

Fundamentals of Space Propulsion, Review of classical rocket propulsion**,** Rocket equation and performance parameters, Specific impulse, thrust, and efficiency, Mission requirements and propulsion selection, Limitations of chemical propulsion

UNIT II **(**Total Topics-10 and Hrs-8)

Electric Propulsion Systems: Introduction to electric propulsion, Electrothermal propulsion: Resistojets and Arcjets, Electrostatic propulsion: Ion thrusters and Hall effect thrusters, Electromagnetic propulsion: Magnetoplasmadynamic (MPD) and Pulsed Plasma Thrusters (PPT), Plasma physics fundamentals, Power generation and energy sources for electric propulsion, Applications in satellite station-keeping and deep-space missions**.**

UNIT- III **(**Total Topics-12 and Hrs-10)

Solar and Advanced Propulsion Technologies: Solar sail propulsion and photon momentum transfer, Laser propulsion and beamed energy systems, Solar thermal propulsion, Fusion-based propulsion concepts**,** Antimatter propulsion (theoretical concepts), Hybrid propulsion technologies**.**

UNIT IV **(**Total Topics-15 and Hrs-10)

Emerging Trends and Mission Applications: Green propulsion technologies, In-space propulsion and refueling, Propulsion for small satellites and CubeSats, Interstellar propulsion concepts, Additive manufacturing in propulsion systems, Case studies: ISRO, NASA, ESA and SpaceX missions, Future trends and challenges in space propulsion**.**

Course Outcomes (CO)

CO1: Analyze performance parameters of advanced space propulsion systems.
CO2: Evaluate electric propulsion technologies for satellite and deep-space missions.
CO3: Design propulsion systems for specific mission requirements.
CO4: Assess emerging propulsion technologies and their feasibility.

Reference Books:

1. Sutton, G. P., & Biblarz, O. *Rocket Propulsion Elements*. Wiley.
2. Jahn, R. G., & Choueiri, E. Y. *Electric Propulsion*. Dover Publications.
3. Fortescue, P., Stark, J., & Swinerd, G. *Spacecraft Systems Engineering*. Wiley.
4. Humble, R., Henry, G., & Larson, W. *Space Propulsion Analysis and Design*. McGraw-Hill.
3. Meyer, R. X. *Ion Propulsion for Space Flight*. McGraw-Hill.

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Programme Name	**Pre-Ph.D. Course Work**	Programme Code	23-
Course Code	DSE704 (ii)	Credit	3
Year/Sem	1/1	L-T-P	3-0-0
Course Name	Advanced Composite Materials		

Objectives of the Course:

1. Provide in-depth knowledge of advanced composite materials and their classifications.
2. Understand the mechanical behavior and failure mechanisms of composites.
3. Explore modern manufacturing and processing techniques.
4. Introduce testing, characterization, and non-destructive evaluation methods.
5. Examine the applications of composites in aerospace, automotive, marine, and energy sectors.

UNIT I **(**Total Topics-12 and Hrs-8)

Fundamentals of Composite Materials: Introduction and historical development, Definition, characteristics, and advantages of composites, Classification of composite materials, Reinforcements: fibers and particulates, Matrix materials: polymers, metals, and ceramics, Interfaces and interphases, Rule of mixtures and micromechanics, Comparison with conventional materials.

UNIT II **(**Total Topics-15 and Hrs-10)

Mechanics of Composite Materials, Elastic behavior of lamina and laminates, Stress-strain relationships in anisotropic materials, Hooke's law for orthotropic materials, Micromechanics of composites, Classical Lamination Theory (CLT), Hygrothermal effects in laminates, Bending, buckling, and vibration of composite plates, Design considerations for composite structures**.**

UNIT- III **(**Total Topics-12 and Hrs-10)

Failure Mechanisms and Damage Analysis, Failure theories for composites: Maximum Stress and Maximum Strain Criteria, Tsai-Hill and Tsai-Wu Criteria, Hashin and Puck Failure Criteria, Interlaminar stresses and delamination, Fatigue and creep behavior, Fracture mechanics of composites, Impact damage and damage tolerance, Environmental degradation and durability.

UNIT IV **(**Total Topics-15 and Hrs-10)

Manufacturing and Processing Techniques, Open and closed moulding processes, Hand lay-up and spray lay-up, Filament winding and pultrusion, Resin Transfer Moulding (RTM) and Vacuum Assisted RTM (VARTM), Compression and injection moulding, Autoclave curing and prepreg technology, Automated Fiber Placement (AFP) and Tape Laying (ATL), Additive manufacturing of composites, Quality control and process optimization.

UNIT V **(**Total Topics-10 and Hrs-10)

Testing, Characterization, and Applications, Mechanical testing of composites (ASTM standards), Thermal and chemical characterization techniques: DSC, TGA, DMA, Microstructural characterization: SEM, TEM, XRD, Smart and nano-composites, Applications in: Aerospace and defense, Automotive and marine industries, Biomedical devices Recycling and sustainability of composite materials.

Course Outcomes (CO)

CO1: Classify and evaluate different types of advanced composite materials.
CO2: Analyze mechanical and thermal properties of composites using theoretical models.
CO3: Assess failure mechanisms and predict structural performance.
CO4: Select appropriate manufacturing and processing techniques for specific applications.
CO5: Design composite components for aerospace and engineering applications.

Reference Books:

1. Jones, R. M. *Mechanics of Composite Materials*. CRC Press.
2. Kaw, A. K. *Mechanics of Composite Materials*. CRC Press.
3. Agarwal, B. D., Broutman, L. J., & Chandrashekhara, K. *Analysis and Performance of Fiber Composites*. Wiley.
4. Daniel, I. M., & Ishai, O. *Engineering Mechanics of Composite Materials*. Oxford University Press.
5. Gibson, R. F. *Principles of Composite Material Mechanics*. CRC Press.