VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI.

Scheme of Teaching and Examinations and Syllabus
M.Tech. AEROSPACE PROPULSION TECHNOLOGY (MAP)
(Department of Aerospace Engineering-VTU PG Centre Muddenahalli)
(Effective from the Academic year 2022-23)

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VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examinations – 2022
M.Tech., AEROSPACE PROPULSION TECHNOLOGY(MAP)
Choice Based Credit System (CBCS) and Outcome-Based Education(OBE)

I SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours per Week			Examination				Credits
				Theory	Practical/Seminar	Tutorial/ Skill Development Activities	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	P	T/SDA					
1	BSC	22MAP11	Applied Mathematics	03	00	00	03	50	50	100	3
2	IPCC	22MAP12	Finite Element Methods for Aerospace Engineering	03	02	00	03	50	50	100	4
3	PCC	22MAP 13	Aerospace Propulsion	03	00	02	03	50	50	100	4
4	PCC	22MAP 14	Aerospace Materials and processes	02	00	02	03	50	50	100	3
5	PCC	22MAP 15	Introduction to Space Technology	02	00	02	03	50	50	100	3
6	MCC	22RMI16	Research Methodology and IPR	03	00	00	03	50	50	100	3
7	PCCL	22MAP L17	Propulsion Lab	01	02	00	03	50	50	100	2
8	AUD/AEC	22AUD18/ 22AEC18	NPTL/SWAYAM (Courses Recommended by BoS)	Classes and evaluation procedures are as per the policy of the online course providers.							PP
			TOTAL	**17**	**04**	**06**	**21**	**350**	**350**	**700**	**22**

Note: BSC-Basic Science Courses, PCC: Professional core. IPCC-Integrated Professional Core Courses, MCC- Mandatory Credit Course,
AUD/AEC –Audit Course / Ability Enhancement Course(A pass in AUD/AEC is mandatory for the award of the degree), PCCL-Professional Core Course lab, **L-Lecture, P-Practical, T/SDA-Tutorial / Skill Development Activities**(Hours are for Interaction between faculty and students)

Integrated Professional Core Course (IPCC): **Integrated Professional Core Course (IPCC)**: Refers to Professional Theory Core Course Integrated with practical of the same course. The theory part of the IPCC shall be evaluated both by CIE and SEE. The practical part shall be evaluated by only CIE (no SEE). However, questions from the practical part of IPCC shall be included in the SEE question paper.

Audit Courses /Ability Enhancement Courses Suggested by BOS (ONLINE courses): Audit Courses: These are prerequisite courses suggested by the concerned Board of Studies. Ability Enhancement Courses will be suggested by the BoS if prerequisite courses are not required for the programs. **Ability Enhancement Courses**:

- These courses are prescribed to help students to enhance their skills in fields connected to the field of specialisation as well allied fields that leads to employable skills. Involving in learning such courses are impetus to lifelong learning.
- The courses under this category are online courses published in advance and approved by the concerned Board of Studies.
- Registration to Audit /Ability Enhancement Course shall be done in consultation with the mentor and is compulsory during the concerned semester.
- In case a candidate fails to appear for the proctored examination or fails to pass the selected online course, he/she can register and appear for the same course if offered during the next session or register for a new course offered during that session, in consultation with the mentor.
- The Audit Ability Enhancement Course carries no credit and is not counted for vertical progression. However, a pass in such a course is mandatory for the award of the degree.

Skill development activities: Under Skill development activities in a concerning course, the students should

1. Interact with industry (small, medium, and large).
2. Involve in research/testing/projects to understand their problems and help creative and innovative methods to solve the problem.
3. Involve in case studies and field visits/ fieldwork.
4. Accustom to the use of standards/codes etc., to narrow the gap between academia and industry.
5. Handle advanced instruments to enhance technical talent.
6. Gain confidence in modelling of systems and algorithms for transient and steady-state operations, thermal study, etc.
7. Work on different software/s (tools) to simulate, analyze and authenticate the output to interpret and conclude.

All activities should enhance student's abilities to employment and/or self-employment opportunities, management skills, Statistical analysis, fiscal expertise, etc.

Students and the course instructor/s to involve either individually or in groups to interact together to enhance the learning and application skills of the study they have undertaken. The students with the help of the course teacher can take up relevant technical –activities which will enhance their skill. The prepared report shall be evaluated for CIE marks.

SEMESTER-I

Semester- I

APPLIED MATHEMATICS			
Course Code	22MAP11	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:00:00	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3Hrs

Course Learning objectives:

1. Apply principles of vector operations to engineering problems
2. Solve close form solutions
3. Apply finite difference approximate to solve elliptic, hyperbolic and parabolic form of equations

Module-1 (8 Hours)

Review of Fourier series and Applications, Review of Laplace Transforms and Applications. Classification of second order linear partial differential equations, Canonical forms for hyperbolic, parabolic and elliptic equations, Homogeneous and Non-Homogeneous equations with constant coefficients. Applications

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT

Module-2 (8 Hours)

Vector Functions, General rules for differentiation, Velocity and Acceleration, Gradient of a scalar field, Directional Derivative, Properties of Gradient, Divergence of vector point function, Curl of a vector point function, Properties of Divergence and Curl. Applications Integration of vector functions, Line integral, Circulation, Work done by a force, Surface integrals, Volume integrals, Divergence Theorem of Gauss, Green's Theorem in the plane, Stoke's Theorem, problems on all the three theorems and Applications

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT 2. Assignment of Home/field work on real-life problem

Module-3 (8 Hours)

Review of Complex analysis, Complex analysis applied to potential theory, Electrostatic fields, conformal mapping, Heat problems, Fluid flow, General properties of Harmonic functions, Complex Integration, Cauchy's Theorem, Cauchy's Integral Formula, Cauchy's Integral Formula for Derivatives, Taylor's and Laurent's series. Applications. Singular point, Residue, Method of finding Resides, Residue Theorem, Contour Integration, Integration round the unit circle, Rectangular contour. Applications.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-4 (8 Hours)

Numerical Solutions algebraic and transcendental equations: False position method, Newton –Raphson method, Iteration method, Aitken's method, Solution of linear simultaneous equations. Gauss elimination method, Inverse of a matrix , Gauss-Seidal method, Crout's method. Solution of Ordinary Differential Equations: Taylor's Series method, Picard's method, Euler's method, Euler's Mo dified method, Runge-Kutta 4^{th} order method. Predictor and corrector method (Milen's and Adams-Bashfourth) Applications.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem 3,Practicising the fundamental knowledge

Module-5 (8 Hours)

Finite differences, Interpolation, Newton's Forward & Backward Interpolation formulae, Lagrange's formula, Newton's Divided difference, Central difference formulae (all formulae with proof). Numerical Differentiation, Numerical Integration (all rules with proof).Applications.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem 3. Practicising the fundamental knowledge

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.

The students will have to answer five full questions, selecting one full question from each module .

Suggested Learning Resources:

Text Books:

1. Advanced Engineering Mathematics, Erwin Kreyszing, John Wiley &Sons (Asia) Pvt. Ltd, 9th edition & 2011.
2. Advanced Engineering Mathematics, H K Dass, S Chand and Company Ltd, 12th edition &2006

Reference books:

1. Engineering Mathematics, Bali and Iyengar, Laxmi Publications (P) Ltd, 6thedition &2005
2. Advanced Engineering, C. Ray Wylie and Louis C Barret, Mathematics Tata McGraw Hill Publishing Co. Ltd., 6th edition.
3. Advanced Engineering Mathematics, Michael D Greenberg, Pearsons India Ltd, 2nd edition&2002.
4. Higher Engineering Mathematics, B S Grewal, khanna publisher, 12th edition.

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=KCS-VTm398I&list=PLhSp9OSVmeyLke5_cby8i8ZhK8FHpw3qs
- https://www.youtube.com/watch?v=0vdrqijpwoM
- https://www.youtube.com/watch?v=YThPIdcwr78
- https://nitkkr.ac.in/docs/15-%20Solutions%20of%20Algebric%20and%20Transcendental%20Equations.pdf
- https://www.youtube.com/watch?v=i38MSuBRZaE

Skill Development Activities Suggested

- **Solve an ODE using MATLAB/SCILAB**

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Apply principles of vector operations to engineering problems	L1,L2
CO2	Solve close form solutions	L3,L4
CO3	Apply finite difference approximate to solve elliptic, hyperbolic and parabolic form of equations	L1,L2

Program Outcome of this course

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	**1**	**1**	**2**	**2**	**1**	**2**	**2**	**3**
CO2	**2**	**2**	**3**	**2**	**1**	**3**	**2**	**3**
CO3	**1**	**2**	**1**	**2**	**1**	**2**	**2**	**3**

Semester- I

FINITE ELEMENT METHODS FOR AEROSPACE ENGINEERING			
Course Code	22MAP12	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:02:00	SEE Marks	50
Total Hours of Pedagogy	40 Theory (Lecture) + 10-12 Lab slots	Total Marks	100
Credits	4	Exam Hours	3

Course objectives:

1. Understand Finite Element Method (FEM)
2. Acquire the knowledge on two and three dimensional finite element analysis
3. Gain knowledge on FEM in aero structure analysis of beams and trusses.
4. Acquire foundations of FEM for fluid flow, heat transfer and dynamics problems.

MODULE-1 (8 Hours)	
Introduction to Finite Element Method, One-Dimensional Elements-Analysis of Bars: Engineering Analysis, History, Advantages, Classification, Basic steps, Convergence criteria, Role of finite element analysis in computer-aided design., Mathematical Preliminaries, Differential equations formulations, Variational formulations, weighted residual methods. Basic Equations and Potential Energy Functional, 1-0 Bar Element, Strain matrix, Element equations, Stiffness matrix, Consistent nodal force vector: Body force, Initial strain, Assembly Procedure, Boundary and Constraint Conditions, Single point constraint, Multi-point constraint, 2-D Bar Element.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

MODULE-2 (8 Hours)	
Two-Dimensional Elements-Analysis, Three-Dimensional Elements-Applications and Problems: Three-Noded Triangular Element (TRIA 3), Four-Noded Quadrilateral Element (QUAD 4), Shape functions for Higher Order Elements (TRIA 6, QUAD 8). Basic Equations and Potential Energy Functional, Four-Noded Tetrahedral Element (TET 4), Eight-Noded Hexahedral Element (HEXA 8), Tetrahedral elements, Hexahedral elements: Serendipity family, Hexahedral elements: Lagrange family. Shape functions for Higher Order Elements.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

MODULE-3 (8 Hours)	
Aero Structural analysis through FEM for Beams and Trusses: 1–D Beam Element, 2–D Beam Element, shape functions and stiffness matrixes, Problems, trusses with one, two, three and four bar elements.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

MODULE-4 (8 Hours)	
FEM analysis of Heat Transfer and Fluid Flow: Steady state heat transfer, 1 D heat conduction governing equation, boundary conditions, One dimensional element, Functional approach for heat conduction, Galerkin approach for heat conduction, heat flux boundary condition, 1 D heat transfer in thin fins. Basic differential equation for fluid flow in pipes, around solid bodies, porous media.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem 3. Adoption of Project-based/Activity Based learning

MODULE-5 (8 Hours)	
FEM for Dynamics: Formulation for point mass and distributed masses, Consistent element mass matrix of one dimensional bar element, truss element, axi-symmetric triangular element, quadrilateral element, beam element. Lumped mass matrix, Evaluation of eigen values and eigen vectors, Applications to bars, stepped bars and beams, familiarization with commercial FEM softwares.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem 3.Practising the foundational knowledge

PRACTICAL COMPONENT OF IPCC *(May cover all / major modules)*

Sl.NO	Experiments(10 to 12 Hours)
1	Bars of constant cross section area, tapered cross section area and stepped bar
2	Trusses – (Minimum 2 exercises of different types)

3	Beams – Simply supported, cantilever, beams with point load, UDL, beams with varying load etc (Minimum 6 exercises different nature)
4	Stress analysis of a rectangular plate with a circular hole
5	Thermal Analysis – 1D & 2D problem with conduction and convection boundary conditions (Minimum 4 exercises of different types)
6	Dynamic Analysis to find a) Fixed – fixed beam for natural frequency determination b) Bar subjected to forcing function c) Fixed – fixed beam subjected to forcing function
7	Demonstrate the use of graphics standards (IGES, STEP etc) to import the model from modeler to solver
8	Demonstrate one example of contact analysis to learn the procedure to carry out contact analysis
9	Demonstrate at least two different type of example to model and analyze bars or plates made from composite material

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

1. Two Tests each of **20 Marks**
2. Two assignments each of **10 Marks/One Skill Development Activity of 20 marks**
3. Total Marks of two tests and two assignments/one Skill Development Activity added will be CIE for 60 marks, marks scored will be proportionally scaled down to **30 marks**.

CIE for the practical component of IPCC

- On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The**15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to 15 marks.
- The laboratory test at the end /after completion of all the experiments shall be conducted for 50 marks and scaled down to 05 marks**.**

Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **20 marks**.

.**SEE for IPCC**

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (duration 03 hours)

1. The question paper will be set for 100 marks and marks scored will be scaled down proportionately to 50 marks.
2. The question paper will have ten questions. Each question is set for 20 marks.
3. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
4. The students have to answer 5 full questions, selecting one full question from each module.

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only.

Questions mentioned in the SEE paper shall include questions from the practical component).

- The minimum marks to be secured in CIE to appear for SEE shall be the 15 (50% of maximum marks-30) in the theory component and 10 (50% of maximum marks -20) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included**.** The maximum of 04/05 questions to be set from the practical component of IPCC, the total marks of all questions should not be more than the 20 marks.
- SEE will be conducted for 100 marks and students shall secure 40% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50. (Student has to secure an aggregate of 50% of maximum marks of the course(CIE+SEE)

Suggested Learning Resources:

Text books:

1. "Finite Elements in engineering", Chandrupatla T. R- 2nd Edition, PHI, 2007.
2. A first course in Finite element method, Daryl L. Logan, 6th Edition Cengage Learning, 2017.

Reference books:

1. "Finite Elements Analysis"– Procedures in Engineering Lakshminarayana H. V, Universities Press, 2004
2. "Finite Elements Method in Engineering", Rao S. S. - 4th Edition, Elsevier, 2006.
3. "Textbook of Finite Element Analysis" P.Seshu, -PHI, 2004.
4. "Finite Element Method" J.N.Reddy, - McGraw -Hill International Edition.
5. "Finite Elements Procedures", Bathe K. J. - PHI. 5. Cook R. D., et al., "Concepts and Application

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=KR74TQesUoQ&list=PLbMVogVj5nJRjnZA9oryBmDdUNe7lbnB0
2. https://www.youtube.com/watch?v=zL-wJW8VnzY
3. https://www.youtube.com/watch?v=1-s2neOAlU4
4. https://www.youtube.com/watch?v=JphRVN9Eezc
5. https://www.youtube.com/watch?v=la8SjMeJ5f8

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Writing a small program to solve Truss and beam problem
- Take an open source FEA Software, Compile and generate an executive Problem
- Experimentation – gathering knowledge through experience through lab.
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Apply FEA the one, two and three dimensional problems.	L1,L2
CO2	Simulate the real life problems of aero structure analysis using FEM.	L3,L4
CO3	Distinguish the use of different commercial FEM softwares for static and dynamic problems.	L1,L3,L4

Program Outcome of this course

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

Mapping of COS and POs :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	**1**	**1**	**2**	**2**	**1**	**2**	**2**	**3**
CO2	**2**	**2**	**3**	**2**	**1**	**3**	**2**	**3**
CO3	**1**	**2**	**1**	**2**	**1**	**1**	**2**	**3**

Semester- I

AEROSPACE PROPULSION			
Course Code	22MAP13	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:00:02	SEE Marks	50
Total Hours of Pedagogy	**40 Theory (Lecture) + 10 -12 T/SDA**	Total Marks	100
Credits	04	Exam Hours	3Hrs

Course objectives:

1. Identify the various types of gas turbine engines.
2. Distinguish between different types of rocket engines and aircraft engines.
3. Carry out engine performance analysis and health monitoring.

Module-1 (8 hours)

Introduction to Gas Turbine Engines: Atmospheric Properties. Turbojet, Turbofan, Turboprop, Turbo-shaft Engine Construction and Nomenclature, theory and performance, introduction to compressors, turbines, combustors and after burners for aircraft engines.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem 3.Practising the foundational knowledge

Module-2 (8 hours)

Fuel and Fuel Systems for Gas Turbine Engines: Fuel specification, fuel properties, liquid fuel handling and treatment, heavy fuels, fuel gas handling and treatment, equipment for removal of particulate and liquids from fuel gas systems, fuel heating, cleaning of turbine components, fuel economics, operating experience, heat tracing of piping systems. Types of heat tracing systems, storage of liquids.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-3 (8 hours)

Engine Air Frame Integration: Engine Performance theory, Propeller theory – pusher and tractor mode. Thrust vectoring nozzles.
Introduction to Rocket Propulsion and Space Mission: Classification and fundamentals. Fuels and propellants. Rocket combustion processes. Introduction to Space mission. Fuel cells for space mission.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-4 (8 hours)

Solid Propellant Rocket Description: Performance Estimation, Flame spread and Ignition transient. Mechanical characterization of propellants. Grain design. Burn rate estimation.
Liquid Propellant Rocket Description: Performance estimation. Injectors. Cooling systems. Combustion instabilities.
Hybrid Propellant Rocket Description: Performance estimation, Mission requirements and Power plant selection. Cryogenic engines. Ramjet and Scramjet engines, introduction to Electric propulsion.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-5 (8 Hours)

Engine Performance and Health Monitoring: Performance and Matching of modules of gas turbines-turbomachine aerothermodynamics, aerothermal equations, efficiencies, dimensional analysis, compressor performance characteristic, turbine performance characteristics, Engine health monitoring techniques.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1.Three Unit Tests each of **20 Marks**

2.Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**
to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2, The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text books:

1. Aerospace Propulsion, Dennis G Shepherd, AmericanElsovier Publishing Co Inc NY.
2. Rocket Propulsion Elements, George P Sutton and Donald M Ross, John Wiley & Sons NY

Reference books:

1. Aircraft power plants, Michael J Kroes and Thomas W Wild, Macmillan/McGraw Hill NY.
2. Aircraft Gas Turbine Engine Technology, E. Irwin Treager, 3rd Edition, 1995, 'ISBN-002018281
3. Mechanics & Thermodynamics of Propulsion, Hill, P.G. , Peterson, C.R. Addison, Wesley Longman INC, 1999.
4. Design of Liquid Propellant Rocket Engines, Huzel and Houng, NASA SP 125, 1971.
5. Rocket Propulsion, Barrere et al., Elsevier Co., 1960
6. Fundamental Aspects of Solid Propellant Rockets, Williams F A. et al., Agardograph, 116,Technivision, 1970.
7. Gas turbine engineering handbook, Meherwan P. Boyce, Gulf professional publisher, Elsevier, 2006

Web links and Video Lectures (e-Resources):

1. https://archive.nptel.ac.in/courses/101/106/101106033/
2.https://archive.nptel.ac.in/courses/101/106/101106033/
3.https://archive.nptel.ac.in/courses/101/104/101104018/
4.https://www.digimat.in/nptel/courses/video/101101002/L42.html

Skill Development Activities Suggested

- Making a model of various Aircraft engine integration using available software
- Tutorials
- Group discussions
- Assignment
- Technical Quiz and seminar
- Exploration – gathering knowledge and attaining skills through active investigation.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Explain construction and operation of various propulsion devices	L1,L2
CO2	Solve problems related to combustion Engine and performance analysis	L3,L4
CO3	Specify space mission propulsion requirements	L1,L3,L4

Program Outcome of this course

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

Mapping of COS and POs :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	**1**	**1**	**2**	**2**	**1**	**2**	**2**	**3**
CO2	**2**	**2**	**3**	**2**	**1**	**3**	**2**	**3**
CO3	**1**	**2**	**1**	**2**	**1**	**2**	**2**	**2**

Semester- I

Aerospace Materials and Processes			
Course Code	22MAP14	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02:00:02	SEE Marks	50
Total Hours of Pedagogy	**25 Lecture + 10 -12 T/SDA**	Total Marks	100
Credits	03	Exam Hours	3Hrs

Course Learning objectives:

1. Understand materials for Gas Turbine engines
2. Acquire the knowledge alloys of Titanium, Nickel, Composite materials and their technologies
3. Understand the casting and forging technology for Gas Turbine components
4. Gain knowledge on sheet metal making process

Module-1 (5 Hours)

The Gas Turbine Engine: Major engine components, material trends, component operating environments and material requirements, compressor and turbine discs, blades. Combustion chambers, shafts, bearings.

Steels: Compressor and turbine discs, processing of steel to billets, future trends in disc materials, compressor and turbine blading, transmission materials-bearings, shafts and gears

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-2 (5 Hours)

Titanium Alloys: Classification of alloys, development of titanium alloys, production of titanium, Future development

Nickel Base Alloys: Metallurgy of Nickel base alloys, Phases present in Nickel base alloys, Strengthening mechanism, Heat treatment of Nickel base alloys, application of Nickel base alloys for turbine discs and blades, powder metallurgy discs, sheet materials, dispersion strengthened alloys.

Composite materials: Glass fibre reinforced plastics, high temperature glass fibre composites, carbon fiber reinforced plastics, pressure resisted resin injection, autoclave moulding resin system, future developments like organic resins, reinforcing fibres, high temperature materials. Ceramic materials, properties and their applications in rotating parts.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT

Module-3 (5 Hours)

Casting Technology: Light alloy casting, moulding practice, melting practice, precision investment casting, effect of casting parameters on properties, techniques for special or small quantity castings, titanium casting, directional solidification, hot isostatic pressing, future trends in casting technology, Processing of ceramics like slip casting, powder metallurgy technique.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-4 (5 Hours)

Forging of Gas Turbine components: Historical back ground, forging equipment, press, recent trends, quality control aspects of thermo mechanical processing, processing to improve mechanical properties, Incoloy 901, titanium 6-4 alloy,12% chromium steels, super alloy powder metallurgy. Forging of compressor and turbine blades.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-5 (5 hours)

Sheet Materials fabrication and joining: Alloy requirements, sheet materials, steels, titanium alloys, high temperature super alloys, heat treatment and de-scaling, forming, chemical machining, electron beam welding, brazing of super alloys, ultrasonic machining, water jet cutting, electrochemical processing, laser cutting for rotating machinery components, Joining technologies like plasma technique, laser welding, use of rapid prototyping machines in manufacturing components.

Surface degradation and protective treatments: Corrosion behavior, coatings and surface treatments, erosion behavior of compressor components, surface degradation and protection of combustor and turbine components, hot corrosion, high temperature coating technology.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem **3.**Practising the foundational knowledge

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1.Three Unit Tests each of **20 Marks**

2.Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module.

Suggested Learning Resources:

Text books:

1. Developemnt of Gas Turbine Materials, G. W. Meetham, Applied Science Publications, London
2. of Modern Manufacturing: Materials, Processes, and Systems, Mikell P. Groover, Fundamentals, 2nd Edition, Wiley, 2005

Reference books:

1. Materials for High Temperature Engineering Applications, G. W. Meetham and M. H. Van de Voorde, Springer, 2006
2. Mechanical Metallurgy, SI Metric Edition, George E. Dieter, McGraw-Hill, 1988
3. Materials Science and Engineering: an Introduction, William D. Callister, 6th edition, John Wiley and sons, 2005
4. Manufacturing Engineering and Technology, Serope Kalpakjian, Steven R Schmid, Pearson Education, 2003

Web links and Video Lectures (e-Resources):

1. https://www.sciencedirect.com/book/9780124104617/gas-turbines
2. https://www.azom.com/article.aspx?ArticleID=1218
3. https://www.youtube.com/watch?v=TY-Ia025fKA
4. https://www.machinemfg.com/types-of-casting/
5. **https://www.linquip.com/blog/gas-turbine-parts-components/**

Skill Development Activities Suggested :

- To understand the different coatings, coating processes and Testing of different component of gas turbine in the material testing lab to understand their failure analysis due to corrosion as skill activity.
- Conducting Tutorials classes
- Group discussions on newer aerospace Materials
- Technical Quiz and Seminars
- Assignments
- Exploration – gathering knowledge and attaining skills through active investigation.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Apply materials for Gas Turbine engines	**L1,L2**
CO2	Distinguish and apply the alloys of Titanium, Nickel, Composite materials and their technologies	**L3,L4**
CO3	Use casting and forging technology for Gas Turbine components	**L5**

Program Outcome of this course

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

Mapping of COs and POs :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	**1**	**1**	**2**	**2**	**1**	**2**	**2**	**3**
CO2	**2**	**2**	**3**	**2**	**1**	**3**	**2**	**2**
CO3	**1**	**2**	**1**	**2**	**1**	**2**	**2**	**2**

Semester- I

Introduction to Space Technology			
Course Code	22MAP 15	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02:00:02	SEE Marks	50
Total Hours of Pedagogy	**25 Lecture + 10 -12 T/SDA**	Total Marks	100
Credits	03	Exam Hours	3Hrs

Course Learning objectives:

1. Understand the fundamentals of rocket propulsion and reentry vehicles.
2. Acquire knowledge on orbit mechanics and satellite dynamics
3. Acquire knowledge on space mission operation.

Module-1 (5 Hours)

Fundamentals of Rocket Propulsion: Space Mission-Types-Space Environment-Launch Vehicle Selection. Introduction to rocket propulsion-fundamentals of solid propellant rockets- Fundamentals of liquid propellant rockets-Rocket equation.
Two-dimensional trajectories of rockets and missiles-Multi-stage rockets-Vehicle sizing-Two stage Multi-stage Rockets-Trade-off Ratios-Single Stage to Orbit-Sounding Rocket-Aerospace Plane-Gravity Turn Trajectories-Impact point calculation-injection conditions-Flight dispersions.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT 2. Assignment of Home/field work on real-life problem

Module-2 (5 Hours)

Atmospheric Reentry: Introduction-Steep Ballistic Reentry-Ballistic Orbital Reentry-Skip Reentry-"Double-Dip" Reentry - Aero-braking - Lifting Body Reentry.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT 2. Assignment of Home/field work on real-life problem

Module-3 (5 Hours)

Fundamentals of Orbit Mechanics, Orbit Maneuvers: Two-body motion-Circular, elliptic, hyperbolic, and parabolic orbits-Basic Orbital Elements-Ground trace In-Plane Orbit changes-Hohmann Transfer-Bielliptical Transfer-Plane Changes - Combined Maneuvers - Propulsion for Maneuvers

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-4 (5 Hours)

Satellite Attitude Dynamics: Torque free Axi-symmetric rigid body-Attitude Control for Spining Spacecraft - Attitude Control for Non-spinning Spacecraft - The Yo-Yo Mechanism - Gravity - Gradient Satellite-Dual Spin Spacecraft- Attitude Determination.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-5 (5 Hours)

Space Mission Operations: Supporting Ground Systems Architecture and Team interfaces - Mission phases and Core operations - Team Responsibilities - Mission Diversity - Standard Operations Practices.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1.Three Unit Tests each of **20 Marks**

2.Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each Module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module.

Suggested Learning Resources:

Text books:

1. "Spaceflight Dynamics", W.E. Wiesel, McGraw Hill, 1997.

2."Rocket Propulsion and Space flight dynamics", Cornelisse, Schoyer HFR and Wakker KF, Pitman, 1984.

Reference books:

1. "Fundamentals of Space Systems", Vincet L. Pisacane, Oxford University Press, 2005.

2. "Understanding Space: An Introduction to Astronautics", J.Sellers, McGraw Hill, 2000.

3. "Introduction to Space Flight", Francis J Hale, Prentice-Hall, 1994.

4. "Spacecraft Mission Design", Charies D. Brown, AIAA education Series, 1998.

5. "Elements of Space Technology for aerospace Engineers", Meyer Rudolph X, Academic Press, 1999.

Web links and Video Lectures (e-Resources):

1.https://www.faa.gov/about/office_org/headquarters_offices/avs/offices/aam/cami/library/online_libraries/aerospace_medicine/tutorial/media/III.4.2.1_Rockets_and_Launch_Vehicles.pdf

2. https://www.youtube.com/watch?v=N6dzEELLoeg.

3. https://www.youtube.com/watch?v=nJ_f1h49jfM&list=PLOIRBaljOV8hBJS4m6brpmUrncqkyXBjB

4. **https://www.youtube.com/watch?v=Q_P3S7t5lS4&list=PLbRMhDVUMngfOt5ATLzSIlqia0-IZbDI0**

5.https://www.youtube.com/watch?v=N8nRpf79Uy4

Skill Development Activities Suggested

- Research lab visit at NAL/ISRO/AFTC/GTRE
- Conducting Tutorials classes
- Group discussions on advancement in space Technology
- Technical Quiz and Seminars
- Assignments
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Apply the fundamentals of rocket propulsion and reentry vehicles.	**L1,L2**
CO2	Apply knowledge on orbit mechanics and satellite dynamics.	**L3,L4**
CO3	Solve space mission operation.	**L5**

Program Outcome of this course

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

Mapping of COS and POs :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	**1**	**1**	**2**	**1**	**1**	**2**	**2**	**3**
CO2	**2**	**2**	**3**	**2**	**1**	**3**	**2**	**2**
CO3	**1**	**2**	**1**	**1**	**1**	**2**	**2**	**2**

Semester- I

Research Methodology and IPR			
Course Code	22RMI16	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:00:00	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3Hrs

Course Learning objectives:

1. To give an overview of the research methodology and explain the technique of defining a research problem
2. To explain the functions of the literature review in research.
3. To explain carrying out a literature search, its review, developing theoretical and conceptual
4. Frameworks and writing a review.
5. To explain various research designs and their characteristics.
6. To explain the details of sampling designs, measurement and scaling techniques and also different Methods of data collections.
7. To explain several parametric tests of hypotheses and Chi-square test.
8. To explain the art of interpretation and the art of writing research reports.
9. To explain various forms of the intellectual property, its relevance and business impact in the changing Global business environment.
10. To discuss leading International Instruments concerning Intellectual Property Rights

Module-1 (8 Hours)

Research Methodology: Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research is Done, Research Process, Criteria of Good Research, and Problems Encountered by Researchers in India. **Defining the Research Problem:** Research Problem, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, An Illustration.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT

Module-2 (8 Hours)

Reviewing the literature: Place of the literature review in research, Bringing clarity and focus to your research problem, Improving research methodology, Broadening knowledge base in research area, Enabling contextual findings, How to review the literature, searching the existing literature, reviewing the selected literature, Developing a theoretical framework, Developing a conceptual framework, Writing about the literature reviewed. **Research Design:** Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs, Important Experimental Designs.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT

Module-3 (8 Hours)

Design of Sampling: Introduction, Sample Design, Sampling and Non-sampling Errors, Sample Survey versus Census Survey, Types of Sampling Designs. **Measurement and Scaling:** Qualitative and Quantitative Data, Classifications of Measurement Scales, Goodness of Measurement Scales, Sources of Error in Measurement Tools, Scaling, Scale Classification Bases, Scaling Techniques, Multidimensional Scaling, Deciding the Scale. **Data Collection**: Experimental and Surveys, Collection of Primary Data, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-4 (8 Hours)

Testing of Hypotheses: Hypothesis, Basic Concepts Concerning Testing of Hypotheses, Testing of Hypothesis, Test Statistics and Critical Region, Critical Value and Decision Rule, Procedure for Hypothesis Testing, Hypothesis Testing for Mean, Proportion, Variance, for Difference of Two Mean, for Difference of Two Proportions, for Difference of Two Variances, P-Value approach, Power of Test, Limitations of the Tests of Hypothesis. Chi-square Test: Test of Difference of more than Two Proportions, Test of Independence of Attributes, Test of Goodness of Fit, Cautions in Using Chi Square Tests.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-5 (8 Hours)

Interpretation and Report Writing: Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports.

Intellectual Property: The Concept, Intellectual Property System in India, Development of TRIPS Complied Regime in India, Patents Act, 1970, Trade Mark Act, 1999,The Designs Act, 2000, The Geographical Indications of Goods (Registration and Protection) Act1999, Copyright Act,1957,The Protection of Plant Varieties and Farmers' Rights Act, 2001,The Semi-Conductor Integrated Circuits Layout Design Act, 2000, Trade Secrets, Utility Models, IPR and Biodiversity, The Convention on Biological Diversity (CBD) 1992, Competing Rationales for Protection of IPRs, Leading International Instruments Concerning IPR, World Intellectual Property Organisation (WIPO),WIPO and WTO, Paris Convention for the Protection of Industrial Property, National Treatment, Right of Priority, Common Rules, Patents, Marks, Industrial Designs, Trade Names, Indications of Source, Unfair Competition, Patent Cooperation Treaty (PCT), Advantages of PCT Filing, Berne Convention for the Protection of Literary and Artistic Works, Basic Principles, Duration of Protection, Trade Related Aspects of Intellectual Property Rights(TRIPS) Agreement, Covered under TRIPS Agreement, Features of the Agreement, Protection of Intellectual Property under TRIPS, Copyright and Related Rights, Trademarks, Geographical indications, Industrial Designs, Patents, Patentable Subject Matter, Rights Conferred, Exceptions, Term of protection, Conditions on Patent Applicants, Process Patents, Other Use without Authorization of the Right Holder, Layout-Designs of Integrated Circuits, Protection of Undisclosed Information, Enforcement of Intellectual Property Rights, UNSECO

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module .

Suggested Learning Resources:

Text books:

1. Research methodology: Methods and Techniques, C.R. Kothari, Gaurav Garg, New Age International,4th Edition, 2018.
2. Research Methodology a step-by-step guide for beginners. (For the topic Reviewing the literature under module 2) , Ranjit Kumar, SAGE Publications Ltd.,3rd Edition, 2011

Reference books:

1.An introduction to Research Methodology, Garg B.L et al ,RBSA Publishers 2002
2.An Introduction to Multivariate Statistical Analysis Anderson T.W,Wiley 3rd Edition, 2003
3.Research Methodology, Sinha, S.C, Dhiman ,EssEss Publications2002
4.Research Methods: the concise knowledge base ,Trochim ,Atomic Dog Publishing ,2005
5.How to Write and Publish a Scientific Paper, Day R.A ,Cambridge University Press ,1992
6.Conducting Research Literature Reviews: From the Internet to Paper ,Fink A ,Sage Publications ,2009
7.Proposal Writing ,Coley S.M. Scheinberg, C.A ,Sage Publications ,1990
8.Intellectual Property Rights in the Global Economy ,Keith Eugene Maskus ,Institute for International Economics ,2000

Web links and Video Lectures (e-Resources):

1. https://gradcoach.com/what-is-research-methodology/
2. file:///D:/books/3.ResearchMethodologyandResearchMethod.pdf
3. https://www.youtube.com/watch?v=UXV-A0Zo1Jk
4. https://www.youtube.com/watch?v=lD786g7zQqE
5. https://www.youtube.com/watch?v=4PzOdMSvxW0

Skill Development Activities Suggested

- Exploration – gathering knowledge and attaining skills through active investigation.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Discuss research methodology and the technique of defining a research problem	**L1,l2**
CO2	Explain various research designs and their characteristics.	**L3,l4**
CO3	Discuss various forms of the intellectual property, its relevance and business impact in the changing global business environment and leading International Instruments concerning IPR	**L5**

Program Outcome of this course

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

Mapping of COS and POs :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	**1**	**1**	**2**	**1**	**2**	**2**	**2**	**1**
CO2	**2**	**2**	**3**	**2**	**1**	**3**	**2**	**1**
CO3	**1**	**2**	**1**	**1**	**1**	**2**	**2**	**1**

Semester- I

Propulsion Laboratory			
Course Code	**22MAPL17**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	01:02:00	SEE Marks	50
Credits	02	Exam Hours	3

Course objectives:

1. Familiarization with various propulsion experimental facilities
2. Familiarize with different propulsion experiments and measurement techniques
3. Conduct the test, acquire the data and analyse and document

Sl.NO	Experiments
1	Cascade testing of a model of turbine blade row and study of wake survey.
2	Estimation of propeller performance
3	Forced Convective heat transfer on a flat surface and
4	Measurement of Burning Velocity of a Premixed Flame
5	Determination of heat of combustion of aviation fuels
6	Measurement of static overall pressure rise & rotor static pressure rise & fan overall efficiency through axial flow fan unit
7	Effect of inlet flow distortion on measurement of static overall pressure rise & rotor static pressure rise & fan overall efficiency through axial flow fan unit .
8	Study of Jet Engine characteristics (thrust, static and total pressures, temperatures, exhaust velocity & fuel consumption)
	Demonstration Experiments (For CIE) if any
9	Performance studies on 2 dimensional diffuser (Stable flow and separated flow)
10	Free and wall jet experimental studies
11	Natural convective heat transfer over an aerofoil wing model
12	Measurement of Nozzle flow setup

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

Sl. No.	Description	Blooms Level
CO1	Demonstrate various experimental facilities	**L1,L2**
CO2	Apply the knowledge to use of different sensors and measurement techniques	**L3**
CO3	Perform the test, acquire the data and analyse and document	**L4**

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 40% of maximum marks in the semester-end examination(SEE). In total of CIE and SEE student has to secure 50% maximum marks of the course.

Continuous Internal Evaluation (CIE):

CIE marks for the practical course is **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment to be evaluated for conduction with observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled downed to 30 marks (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 02 tests for 100 marks, the first test shall be conducted after the 8^{th} week of the semester and the second test shall be conducted after the 14^{th} week of the semester.
- In each test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The average of 02 tests is scaled down to **20 marks** (40% of the maximum marks).

The Sum of **scaled-down** marks scored in the report write-up/journal and average marks of two tests is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University.

All laboratory experiments are to be included for practical examination.

(Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.

Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.

Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 10% Marks allotted to the procedure part to be made zero.

The duration of SEE is 03 hours

Suggested Learning Resources:

- Propulsion lab Manual

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI.

Scheme of Teaching and Examinations and Syllabus
M.Tech. AEROSPACE PROPULSION TECHNOLOGY (MAP)
(Department of Aerospace Engineering-VTU PG Centre Muddenahalli)
(Effective from the Academic year 2022-23)

Registrar,
Visvesvaraya Technological University
Jnana Sangam, Machhe, Belagavi-590018
eMail: registrar@vtu.ac.in
contact: 0831-2498112

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examinations – 2022
M.Tech., AEROSPACE PROPULSION TECHNOLOGY(MAP)
Choice Based Credit System (CBCS) and Outcome-Based Education(OBE)

II SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week			Examination				Credits
				Theory	Practical/ Seminar	Tutorial/ Skill Development Activities	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	P	T/SDA					
1	PCC	22MAP21	Computational Fluid Dynamics	02	00	02	03	50	50	100	3
2	IPCC	22MAP22	Aerodynamics	03	02	00	03	50	50	100	4
3	PEC	22MAP23x	Professional elective 1	02	00	02	03	50	50	100	3
4	PEC	22MAP24x	Professional elective 2	02	00	02	03	50	50	100	3
5	MPS	22MAP25	Mini Project with Seminar	00	04	02	--	100	--	100	3
6	PCCL	22MAPL26	Computational Fluid Dynamics Lab	01	02	00	03	50	50	100	02
7	AUD/ AEC	22AUD27	Suggested ONLINE courses (NPTL/SWAYAM)	Classes and evaluation procedures are as per the policy of the online course providers.							PP
TOTAL				**10**	**08**	**08**	**15**	**350**	**250**	**600**	**18**

Note: PCC: Professional core courses, PEC: Professional Elective Courses, IPCC-Integrated Professional Core Courses. MPS-Mini Project With Seminar; AUD/AEC; Audit Courses / Ability Enhancement Courses (Mandatory), PCCL-Professional Core Course lab,
L-Lecture, P-Practical, T/SDA-Tutorial / Skill Development Activities(Hours are for Interaction between faculty and students)

Professional Elective 1		**Professional Elective 2**	
Course Code under 22MAP24X	**Course title**	**Course Code under 22MAP25X**	**Course title**
22MAP231	Fatigue and Fracture Mechanics	22MAP241	Ramjet and Scramjet
22MAP232	Engine Performance Control & Simulation	22MAP242	Mechanical Aspects of Rotating Machinery
22MAP233	Aerospace Structures	22MAP243	Advanced Composite Materials
22MAP234	Numerical methods in combustion	22MAP244	Introduction to reacting flows.
22MAP235	Hypersonic aerothermodynamics	22MAP245	Fuels and Combustion

Note:

1 Mini Project with Seminar: This may be hands-on practice**,** survey report, data collection and analysis, coding, mobile app development, field visit and report preparation, modelling of system, simulation, analysing and authenticating, case studies, etc.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any, and a senior faculty of the department. Students can present the seminar based on the completed mini-project. Participation in the seminar by all postgraduate students of the program shall be mandatory.

The CIE marks awarded for Mini-Project work and Seminar, shall be based on the evaluation of Mini Project work and Report, Presentation skill and performance in Question and Answer session in the ratio 50:25:25. Mini-Project with Seminar shall be considered as a head of passing and shall be considered for vertical progression as well as for the award of degree. Those, who do not take-up/complete the Mini Project and Seminar shall be declared as fail in that course and have to complete the same during the subsequent semester. There is no SEE for this course.

2. **Internship:** All the students shall have to undergo a mandatory internship of **06 weeks** during the vacation of II and III semesters. A University examination shall be conducted during III semester and the prescribed internship credit shall be counted in the same semester. The internship shall be considered as a head of passing and shall be considered for vertical progression as well asfor the award of degree. Those, who do not take-up/complete the internship shall be declared as fail in the internship course and have to complete the same during the subsequent University examination after satisfying the internship requirements.

SEMESTER-II

Semester- II

Computational Fluid Dynamics			
Course Code	22MAP21	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02:00:02	SEE Marks	50
Total Hours of Pedagogy	25 Lecture+ 10-12 T/SDA	Total Marks	100
Credits	03	Exam Hours	3Hrs

Course Learning objectives:

1. Understand CFD ideas and Mathematical behaviour of PDEs
2. Acquire the knowledge to solve CFD problems through finite difference discritization
3. Gain knowledge for grid generation and optimize grids
4. Transform the grids to computational domain
5. Acquire the knowledge to solve CFD problems through finite volume technique

Module-1 (5 Hours)	
Introduction: CFD ideas to understand, CFD Application, Governing Equations (no derivation) of flow; continuity, momentum, energy. Conservative & Non-conservative forms of equations, Integral vs Differential Forms of Equations. Form of Equations particularly suitable for CFD work. Shock capturing, Shock fitting, Physical Boundary conditions. **Mathematical Behaviour of Partial Differential Equations and Discretization:** Classification of partial differential equations and its Impact on computational fluid dynamics; case studies. Essence of discritization, order of accuracy and consistency of numerical schemes, Lax's Theorem, convergence, Reflection Boundary condition.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT
Module-2 (5 Hours)	
Mathematical Behavior of Partial Differential Equations and Discretization: Higher order Difference quotients. Explicit & Implicit Schemes. Error and analysis of stability, Error Propagation. Stability properties of Explicit & Implicit schemes. **Solution Methods of Finite Difference Equations:** Time & Space Marching. Alternating Direction Implicit (ADI) Schemes. Relaxation scheme, Jacobi and Gauss-Seidel techniques, SLOR technique. Lax-Wendroff first order scheme, Lax-Wendroff with artificial viscosity, upwind scheme, midpoint leap frog method**.**	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT
Module-3 (5 Hours)	
Grid Generation: Structured Grid Generation: Algebraic Methods, PDE mapping methods, use of grid control functions, Surface grid generation, Multi Block Structured grid generation, overlapping and Chimera grids. Unstructured Grid Generation: Delaunay-Voronoi Method, advancing front methods (AFM Modified for Quadrilaterals, iterative paving method, Quadtree& Octree method)	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem
Module-4 (5 Hours)	
Adaptive Grid Methods: Multi Block Adaptive Structured Grid Generation, Unstructured adaptive Methods. Mesh refinement methods, and Mesh enrichment method. Unstructured Finite Difference mesh refinement. **Approximate Transformation & Computing Techniques:** Matrices & Jacobian. Generic form of governing Flow Equations with strong conservative form in transformed space. Transformation of Equation from physical plane into computational Plane -examples. Control function methods. Variation Methods. Domain decomposition. Parallel Processing.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem
Module-5 (5 Hours)	
Finite Volume Techniques: Finite volume Discritisation-Cell Centered Formulation. High resolution finite volume upwind scheme Runge-Kutta stepping, Multi-Step Integration scheme. Cell vertex Formulation. Numerical Dispersion. **CFD Application to Some Problems:** Aspects of numerical dissipation & dispersion. Approximate factorization, Flux Vector splitting. Application to Turbulence-Models. Large eddy simulation, Direct Numerical Solution. Post-processing and visualization, contour plots, vector plots etc, Familiarization with CFD softwares and solvers.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each Module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module .

Suggested Learning Resources:

Text books:

1. Computational Fluid Dynamics, The Basics with Applications, John D Anderson Jr., McGraw Hill International Edn., 1995.
2. Computational Fluid Dynamics, T J Chung, Cambridge University Press, 2008

Reference books:

1. Computational Fluid Dynamics - An Introduction, F. Wendt (Editor), Springer – Verlag, Berlin; 1992.
2. Numerical Computation of Internal and External Flows, Charles Hirsch, Vols. I and II. John Wiley & Sons, New York; 1988.
3. Computational Fluid Dynamics- A Practical Approach, JiyuanTu, Guan HengYeoh, and Chaoqun Liu, , Elsevier Inc; 2008.

Web links and Video Lectures (e-Resources):

1. https://dragonfly.tam.cornell.edu/teaching/mae5230-cfd-intro-notes.pdf
2. https://www.youtube.com/watch?v=zpxe5yoB0xg
3. https://www.youtube.com/watch?v=CinWCHCTjJA
4. https://www.youtube.com/watch?v=nRZNzrMIBfQ
5. https://www.youtube.com/watch?v=LY215hdSFd4,
6. https://www.youtube.com/watch?v=6hgYYa00TSw
7. https://www.youtube.com/watch?v=4n3DPwcoy4E
8. https://www.youtube.com/watch?v=rQmlfGiGMKY

Skill Development Activities Suggested

- Flow analysis in convergent and divergent Nozzle
- Conducting Tutorials classes
- Group discussions on different CFD Software tools
- Technical Quiz and Seminars
- Assignments
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Develop grids around given shapes and transform the physical domain in to computational domain	L1,2,L4
CO2	Develop adaptive structured and unstructured grids	L3,L4
CO3	Apply knowledge to solve CFD problems through finite difference and finite volume techniques and Analyse	L5

Program Outcome of this course

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

Mapping of COs and POs :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	**1**	**1**	**2**	**1**	**2**	**1**	**2**	**2**
CO2	**1**	**1**	**3**	**2**	**1**	**2**	**2**	**2**
CO3	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**3**

Semester- II

AERODYNAMICS			
Course Code	22MAP22	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:02:00	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 10-12 Lab slots	Total Marks	100
Credits	4	Exam Hours	3

Course objectives:

1. Understand the basics of fluid mechanics as a prerequisite to Aerodynamics
2. Acquire knowledge on typical airfoil characteristics and two-dimensional flows over airfoil and study the incompressible over finite wings
3. Understand the concept of compressible flow and acquire the knowledge of shocks & wave formation

MODULE-1 (8 Hours)

Basics of Aerodynamics: Properties of fluids, Characteristics of Atmosphere, Type of fluid flows, Generation of Lift, Drag and Moment, Incompressible flows over airfoils, calculation of lift and drag from measured pressure distribution, Streamlined and bluff-body, Reynolds number and Mach number, Conservation law of mass and momentum, Euler and Bernoulli's equations, pitot-tube measurement of airspeed. Pressure coefficient. Streamlines, path lines and streak lines. Angular velocity, vorticity, circulation Stream function, velocity potential and their relationship. Governing equation for irrotational and incompressible fluid flow.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

MODULE-2 (8 Hours)

Aerodynamics of airfoils and wings: Airfoil nomenclature and classification, Low speed aerodynamic characteristics of symmetric and cambered airfoils, Centre of pressure, aerodynamic centre and aerodynamic moment, Concept of point vortex, line vortex and vortex sheet, Kutta condition, Kelvins circulation theorem and starting vortex, Classical thin airfoil theory and symmetric airfoil. Finite wing nomenclature. Incompressible flow over wing, vortex filament, bound vortex, horse shoe vortex, downwash, induce angle of attack and drag. Type of drag.Biot-Savart law and Helmholtzs vortex theorem. Prandtls lifting line theory and limitations. Elliptic lift distributions, expression for induced angle of attack and induce drag. Two dimensional and three dimensional wings lift curve slope and effect of aspect ratio. High lift devices.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

MODULE-3 (8 Hours)

High speed Aerodynamics: Fundamentals of thermodynamic concepts, conservation of energy. Speed of sound, Mach wave and Mach angle. Normal shock wave, Oblique shock wave, Expansion fan, Prandtl-Meyer expansion. Family of shocks. Flow through convergent divergent nozzle. Hodograph and pressure turning angle. Rankine- Hugoniot relation.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

MODULE-4 (8 Hours)

Compressible flow over airfoil: Full velocity potential equation. Small perturbation theory. Linearized velocity potential equation and boundary conditions. Pressure coefficient for small perturbation. Prandtl- Glauret compressibility correction. Critical Mach number, Drag Divergence Mach Number, Sound barrier. Transonic area rule, supercritical airfoil, swept wing and delta wing.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

MODULE-5 (8 Hours)

One dimensional flow through constant area duct: Fanno flow and fanno line, Rayleigh flow and Rayleigh line. Method of characteristics and its application. Flow past Wedge and cone.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

PRACTICAL COMPONENT OF IPCC

Sl.NO	Experiments (10 to 12 hours)
1	Calibration of test section of a subsonic wind tunnel.
2	Smoke flow visualization on a wing model at different angles of incidence at low speeds.
3	Tuft flow visualisation on a wing model at different angles of incidences at low speeds: Identify zones of attached and separated flows
4	Surface pressure distribution around building models in multiple model arrangement
5	Surface pressure distribution on a cambered wing at different angles of incidence and calculation of lift and pressure drag.
6	Calculation of total drag of a cambered airfoil at a low incidence using pitot-static probe wake survey.
7	Measurement of typical boundary layer velocity profile on the wind tunnel wall (at low speeds) using a pitot probe and calculation of boundary layer displacement and momentum thickness in the presence of a circular cylinder model.
8	Study the effect of Blockage ratio on drag & pressure distribution of a circular cylinder.
9	Determination of turbulence level in a low speed wind tunnel.
10	Study of pressure distribution on hemispherical objects.
11	Study on internal/external flow distribution of hollow tube structure.
12	Conduct a series of test to obtain the stagnation pressure response of pitot probe in a wind tunnel for varied yaw angle and obtain the response curve in terms of error, (percentage of velocity head) to yaw angle.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

1. Two Tests each of **20 Marks**
2. Two assignments each of **10 Marks/One Skill Development Activity of 20 marks**
3. Total Marks of two tests and two assignments/one Skill Development Activity added will be CIE for 60 marks, marks scored will be proportionally scaled down to **30 marks**.

CIE for the practical component of IPCC

- On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The**15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to 15 marks.
- The laboratory test at the end /after completion of all the experiments shall be conducted for 50 marks and scaled down to 05 marks**.**

Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **20 marks**.

SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (duration 03 hours)

1. The question paper will be set for 100 marks and marks scored will be scaled down proportionately to 50 marks.
2. The question paper will have ten questions. Each question is set for 20 marks.
3. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
4. The students have to answer 5 full questions, selecting one full question from each module.

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only.

Questions mentioned in the SEE paper shall include questions from the practical component).

- The minimum marks to be secured in CIE to appear for SEE shall be the 15 (50% of maximum marks-30) in the theory component and 10 (50% of maximum marks -20) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included**.** The maximum of 04/05 questions to be set from the practical component of IPCC, the total marks of all questions should not be more than the 20 marks.
- SEE will be conducted for 100 marks and students shall secure 40% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50. (Student has to secure an aggregate of 50% of maximum marks of the course(CIE+SEE)

Suggested Learning Resources:

Text books:

1. Fundamentals of Aerodynamics ,John D. Anderson, McGraw-Hill publication, 5th edition and 2010
2.Modern compressible flow, John D. Anderson , McGraw-Hill publication, 3rd edition and 2002

Reference books:

1. Aerodynamics for Engineering students, E L Houghton and P W Carpenter, Edward Arnold publication, 7th edition and 2016
2. Fundamentals of compressible flow , Yahya, S M.New Age International, 5th edition and 2016
3. Introduction to flight, John D. Anderson, McGraw-Hill publication, 6th Edition And 2008

Web links and Video Lectures (e-Resources):

1. https://archive.nptel.ac.in/courses/101/106/101106033/
2.https://archive.nptel.ac.in/courses/101/106/101106033/
3.https://archive.nptel.ac.in/courses/101/104/101104018/
4.https://www.digimat.in/nptel/courses/video/101101002/L42.html

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Experimentation – gathering knowledge through experience through lab.
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Solve aerodynamic problems related to pressure distribution and pressure coefficients	L1,L2
CO2	Demonstrate knowledge of compressible flows to solve one dimensional flows through constant area ducts	L3,L4
CO3	Solve problems related to normal and oblique shock waves	L3,L5

Program Outcome of this course

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

Mapping of COS and POs :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	**1**	**1**	**2**	**1**	**2**	**2**	**2**	**2**
CO2	**1**	**1**	**3**	**2**	**1**	**3**	**2**	**2**
CO3	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**3**

Semester- II

Professional elective 1			
Fatigue and Fracture Mechanics			
Course Code	22MAP231	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02:00:02	SEE Marks	50
Total Hours of Pedagogy	25 Lecture+10-12 T/SDA	Total Marks	100
Credits	03	Exam Hours	3Hrs

Course Learning objectives:
1. Understand the principles of fracture mechanics
2. Acquire knowledge of plastic fracture mechanics
3. Know the computational fracture mechanics

Module-1 (5 Hours)	
Fracture Mechanics Principles: Introduction, Mechanisms of Fracture, a crack in a structure, the Graffiti's criterion, modem design, - strength, stiffness and toughness. Stress intensity approach. **Stress Analysis for Members with Cracks:** Linear elastic fracture mechanics, Crack tip stress and deformations; Relation between stress intensity factor and fracture toughness, Stress intensity based solutions. Crack tip plastic zone estimation, Plane stress and plane strain concepts. The Dugdale approach, the thickness effect.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT
Module-2 (5 Hours)	
Elastic - Plastic Fracture Mechanics: Introduction, Elasto-plastic factor criteria, crack resistance curve, I-integral, Crack opening displacement, crack tip opening displacement. Importance of R-curve in fracture mechanics, Experimental determination of I-integral, COD and CTOD.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT
Module-3 (5 Hours)	
Dynamic and Crack Arrest: Introduction, the dynamic stress intensity and elastic energy release rate, crack branching, the principles of crack arrest, and the dynamic fracture toughness.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem
Module-4 (5Hours)	
Fatigue and Fatigue Crack Growth Rate: Fatigue loading, Various stages of crack propagation, the load spectrum, approximation of the stress spectrum, the crack growth integration, fatigue crack growth laws. **Fracture Resistance of Materials**: Fracture criteria, fatigue cracking criteria, effect of alloying and second phase particles, effect of processing and anisotropy, effect of temperature, closure.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem
Module-5 (5 Hours)	
Computational Fracture Mechanics: Overview of numerical methods, traditional methods in computational fracture mechanics – stress and displacement marching, elemental crack advance, virtual crack extension, the energy domain integral, finite element implementation. Limitations of numerical fracture analysis. **Fracture Toughness testing of metals:** Specimen size requirements, various test procedures, effects of temperature, loading rate and plate thickness on fracture toughness. Fracture testing in shear modes, fatigue testing, NDT methods.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each Module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module .

Suggested Learning Resources:

Text books:

1. Introduction to Fracture Mechanics - Karen Helen, McGraw Hill Pub 2000.
2. Fracture of Engineering Brittle Materials - Jayatilake, Applied Science, London. 2001.

Reference books:

1. ELEMENTS OF FRACTURE MECHNAICH BY PRASHANT KUMAR

1. Fracture Mechanics Application - T. L. Anderson, CRC press 1998.
2. Elementary Engineering Fracture of Mechanics - David Broek, Artinus Nijhoff, London 1999.

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=G5mcTw-PLEI
2. https://www.youtube.com/watch?v=gS93bQDjkd0
3. https://www.youtube.com/watch?v=Nbvpr8hsWnk
4. https://www.youtube.com/watch?v=jOrmklAzOV4
5. **https://www.youtube.com/watch?v=AAmZJWB_Q9o**
6. **https://www.youtube.com/watch?v=5waFYGj9Dko**
7. **https://www.youtube.com/watch?v=MJEgC7XWS10**
8. **https://www.youtube.com/watch?v=ygGX09hCHj4**

Skill Development Activities Suggested

- Study of Mechanisms associated with transient fatigue crack growth under variable-amplitude loading: An experimental and numerical study
- Conducting Tutorials classes
- Group discussions on different Software tools used in fracture analysis and Fracture Toughness testing of metals
- Technical Quiz and Seminars
- Assignments
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Apply principles of fracture mechanics	**L1,L2**
CO2	Solve problems related to plastic fracture mechanics	**L3,L4**
CO3	Model Computational fracture mechanics	**L5**

Program Outcome of this course

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

Mapping of COs and POs :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**
CO2	**1**	**1**	**1**	**2**	**1**	**3**	**2**	**2**
CO3	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**3**

Semester- II

Professional elective 1			
Engine Performance Control & Simulation			
Course Code	22MAP232	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02:00:02	SEE Marks	50
Total Hours of Pedagogy	25 Lecture+10-12 T/SDA	Total Marks	100
Credits	03	Exam Hours	3Hrs

Course Learning objectives:

1. Understand the basics of aero engine performance and evaluation, control and simulation.
2. Know different performance parameters and characteristics.
3. Know aero-engine component performance and engine integration.

Module-1 (5Hours)

Gas turbine engine, Turbojet, turbofan, turboprop schematic, identification of components flow properties along gas path, Definition of Engine Performance parameters specific thrust and specific fuel consumption, installed and uninstalled performance, Importance of by-pass ratio and afterburning, concept of multi spooling, importance of bleed and power off-take, engine systems and accessories.

Component performance, atmospheric model, correlations for variation of gas properties, inlet and diffuser pressure recovery, compressor and turbine isentropic and polytrophic efficiencies, Burner efficiency, pressure loss and pattern factor. Exit nozzle loss, propeller performance parameters, variable and constant pitch propellers, component performance with variable gas properties.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT

Module-2 (5Hours)

Parametric cycle analysis of real engine, turbojet, turbo jet with after burner, turbofan with separate exhaust streams, turbofan with after burning separate exhaust streams, turbofan with after burning mixed exhaust streams, turbo prop engine.
Engine operating line on compressor characteristics, Equilibrium running of gas generator, matching procedure for twin spool engines, behaviour of twin spool engines, Method of displacing equilibrium running line, matching procedure for turbofan engine, performance deterioration.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT

Module-3 (5 Hours)

Aero engine evaluation, engine test bed types, schematic layout of test beds, instrumentation on test beds, engine and component performance from gas path data, engine health monitoring parameters, sensors, analysis of vibration and blade tip gap signals, high temperature sensors, oil debris monitoring, engine trend analysis for engine diagnostics and prognostics. Noise characterization, Measurement of noise, sources of noise generation in aero engine components, noise propagation due to propellers, comparative noise characteristics for turbojet, turbofan, turbo shaft and turbo prop, active and passive methods for noise reduction, International standards for aero engine noise

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-4 (5 Hours)

Aircraft engine integration, configuration of engine locations in aircrafts, types of nacelles and pylon. Engine mounts, basic loads on engine mounts. Nacelle-pylon-wing integration, Types of thrust reverser and its mechanism. Drag due to nacelle, engine installed performance

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-5 (5 Hours)

Aero engine control, FADEC architecture, Digital electronic control unit for aero engine, Gas generator control, engine limit protection, engine automatic and manual starting, power management, engine data for cockpit indication, engine condition parameters display in the cockpit, thrust reverser control and feedback, fuel control and computation, fuel recirculation control, cooling of FADEC, management of engine subsystems like lubrication, on board power, fuel scavenge, starting system, Engine gas path data in FADEC, Engine health management from flight data recorder.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each Module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module.

Suggested Learning Resources:

Text books:

1. " Elements of Gas Turbine Propulsion", Jack D. Mattingly, Tata McGraw-Hill Publishing Company Limited, New Delhi, 1996
2. "Aerothermodynamics of Gas Turbine and Rocket Propulsion", Gordon C. Oates, AIAA Education Series

Reference books:

1. "Aircraft Engine Design", Jack. D. Mattingly, William H. Heiser, David.T. Pratt, AIAA Education Series
2. "Jet Propulsion", Nicholas Cumpsty, Cambridge University Press, 1997
3. "Aircraft Propulsion", Saeed Farokhi, John Wiley & Sons, Inc
4. "Aircraft Propulsion and Gas Turbine Engines", Ahmed F. E1-Sayed, CRC Press, Taylor and Francis Group
5. "Gas Turbine Performance", Philip P. Walsh and Paul Fletcher, 1998, Blackwell Science Ltd, Blackwell Publishing company
6. "Systems of Commercial Turbo Fan Engines-An Introduction to System Functions", Andreas Linke-Diesinger, Springer Publications.

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=LLtiZxlrDww
2. https://www.youtube.com/watch?v=E8VfieYhsjg
3. https://www.youtube.com/watch?v=O2AM8jPomDo
4. https://www.youtube.com/watch?v=11u6uaxavF0.
5. https://www.youtube.com/watch?v=sNSUCrams2Q
6. https://www.youtube.com/watch?v=ug40WM3DmNE
7. https://www.youtube.com/watch?v=3Nl11tSz4OE
8. https://www.youtube.com/watch?v=LNA07iwSUP8
9. https://www.youtube.com/watch?v=uh-FxVYUx-k
10. https://www.youtube.com/watch?v=K4S1jtv69SY

Skill Development Activities Suggested

- A visit to Public sector unit like NAL/AFTC Engine division
- Conducting Tutorials classes
- Group discussions on Engine Performance Control & Simulation
- Technical Quiz and Seminars
- Assignments
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Apply the basics of aero engine performance and evaluation, control and simulation.	**L1,L2**
CO2	Distinguish different performance parameters and characteristics	**L3,L4**
CO3	Evaluate aero-engine component performance and engine integration	**L5**

Program Outcome of this course

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

Mapping of COs and POs :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**
CO2	**1**	**1**	**1**	**2**	**1**	**3**	**2**	**2**
CO3	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**3**

Semester- II

Professional elective 1			
Aerospace Structures			
Course Code	22MAP233	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02:00:02	SEE Marks	50
Total Hours of Pedagogy	25 Lecture+10-12 T/SDA	Total Marks	100
Credits	03	Exam Hours	3Hrs

Course Learning objectives:

1. Describe the roles that structures and structural materials play in aerospace vehicles;
2. Explain the general design concepts for aerospace structures: vehicles, components, and materials;
3. Demonstrate the tools and skills needed to analyze the static and dynamic performance of aero structures;
4. Analyzing, formulating, and solving aerospace structural engineering problems .

Module-1 (5 hours)

Structural Components and Loads of Aerospace components: Loads on Structural components, Function of structural components, Fabrication of structural components, Connections; Airworthiness: Factors of Safety- flight envelope, Load factor determination, Airframe loads: Aircraft inertia loads, Symmetric maneuver loads, Normal accelerations associated with various types of maneuvers, Gust loads

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT

Module-2 (5 hours)

Shear Flow and Shear Center in Open and Closed Thin Wall Sections Open Sections: Shear center and elastic axis, Concept of shear flow, Beams with one axis of symmetry; Closed Sections: Bradt-Batho formula, Single and multi-cell closed box structures, Semi monocoque and mono cocque structures, Shear flow in single and multi-cell monocoque and semimonocoque box beams subject to torsion.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT

Module-3 (5 hours)

Thin Plate Theory Bending of thin plates: Pure bending of thin plates, Plates subjected to bending and twisting, Plates subject to distributed transverse load, Combined bending and in-plane loading of a thin rectangular plate, Bending of thin plates having a small initial curvature, Energy method for bending of thin plates structural instability in thin plates Buckling of thin plates, Inelastic buckling of plates, Experimental determination of critical loads for a flat plate, Local instability, Instability of stiffened panels, Failure stress in plates and stiffened panels, Tension field beams.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-4 (5 hours)

Bending, Shear and Torsion of Thin-Walled Beams-I Bending and Open Thin-Walled Beams: Symmetrical bending, Unsymmetrical bending, Deflections due to bending, Calculation of section properties, Applicability of bending theory, Temperature effects bending, shear and torsion of thin-walled beams-II Shear of Beams: General stress, strain and displacement relationships for open and single cell closed section thin-walled beams, Shear of open and closed section beams; Torsion of Beams: Torsion of closed and open section beams; Combined Open and Closed Section Beams: Bending, Shear, Torsion

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-5 (5 hours)

Stress Analysis of Aircraft Components : Wing spars, Fuselages, Wings, Fuselage frames and wing ribs, Laminated composite structures smart materials and adaptive structures Smart Materials Technologies and Control Applications: Control requirements, Smart Materials Piezoelectric elements, Electrostrictive elements, Magentostrictive transducers, Electrorheological fluids, Shape memory alloys, Fiber optic sensors, Applications of smart materials, Adaptive Structures: Adaptive aerospace structures-Structural Health Monitoring

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem 3. Practising the foundational knowledge

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each Module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module.

Suggested Learning Resources:

Text books:

1. "Analysis & Design of Flight Vehicle Structures", E.F. Bruhn, Tristate Offset Co., 1980.
2. Aircraft Structures for Engineering Students, Megson, T.M.G, Edward Arnold, 1995

Reference books:

1. Mechanics of Composite Materials, Autar K. Kaw, CRC Press LLC, 1997
2. Aircraft Structures, Peery, D.J. and Azar, J.J.,2nd Edition, McGraw-Hill, New York, 1993
3. Theory and Analysis of Flight structures, Rivello, R.M., McGraw-Hill, N.Y., 1993
4. "Analysis and Performance of fiber composites", B.D. Agarwal and L.J. Broutman, John-Wiley and Sons, 1990.

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=JltYcdVvzXE
2. https://www.youtube.com/watch?v=LKqfhyomVfc
3. https://www.youtube.com/watch?v=Zn6ic1yczT8
4. https://www.youtube.com/watch?v=0nkbs_V2MD8
5. https://www.youtube.com/watch?v=EIBeShVFPp8
6. https://www.youtube.com/watch?v=eXdWs7xPM4Q
7. https://www.youtube.com/watch?v=tl8SWNcAiPw.
8. https://www.youtube.com/watch?v=3ovJEGcpbns.

Skill Development Activities Suggested :

- Stress Analysis of Aircraft Components : Wing spars, Fuselages, Wings, Fuselage frames and wing ribs, Laminated composite structures using available software
- Conducting Tutorials classes
- Group discussions on aerospace Structure
- Technical Quiz and Seminars
- Assignments
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Identify and solve problems of beam that satisfies the given engineering requirements.	**L1,L2**
CO2	Understand the concepts of composite materials for aircraft structures for both stiffness and strength requirements	**L3**
CO3	Explain the failure criteria in the design of aircraft structures on environment including safety	**L4**

Program Outcome of this course

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

Mapping of COs and POs :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**
CO2	**1**	**1**	**1**	**2**	**1**	**3**	**2**	**2**
CO3	**1**	**1**	**1**	**1**	**1**	**2**	**1**	**3**

Semester- II

Professional elective 1			
Numerical Methods in Combustion			
Course Code	22MAP234	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02:00:02	SEE Marks	50
Total Hours of Pedagogy	25 Lecture+10-12 T/SDA	Total Marks	100
Credits	03	Exam Hours	3Hrs

Course Learning objectives:

1. Understanding Numerical methods and its application in combustion problem ;
2. Demonstrate the different combustion flame regimes.
3. Numerical Analyse the different gas turbine burner

Module-1 (5 hours)

Conservation equations for reacting flows:

General forms; choice of primitive variables, conservation of momentum, conservation of mass and species, diffusion velocities, conservation of energy. Usual simplified forms; constant pressure flames, equal heat capacities for all species, constant heat capacity for the mixture only

Laminar premixed flames:

Introduction, conservation equation and numerical solution, steady one-dimensional laminar premixed flames, theoretical solutions for laminar premixed flames, premixed flame thicknesses, flame stretch, flame speeds, instabilities of laminar flame fronts.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT

Module-2 (5 hours)

Laminar Diffusion Flames:

Diffusion flame configurations, theoretical tools for diffusion flames, flame structure for irreversible infinity fast chemistry, full solutions for irreversible fast chemistry flames, extensions of theory to other flame structures, real laminar diffusion flames.

Introduction to turbulent:

Interaction between flames and turbulence, elementary descriptions of turbulence, influence of turbulence on combustion, computational approaches for turbulent combustion, RANS simulations for turbulent combustion, Direct numerical simulations, large eddy simulations, chemistry for turbulent combustion.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT

Module-3 (5 hours)

Turbulent Premixed Flames:

Phenomenological description premixed turbulent combustion regimes, RANS of turbulent premixed flames, LES of turbulent premixed flames, DNS of turbulent premixed flames.

Turbulent non-premixed flames:

Introduction, phenomenological description, turbulent non-premixed combustion regimes, RANS of turbulent non-premixed flames. LES of turbulent non-premixed flames, DNS of turbulent non-premixed flames.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-4 (5 hours)

Flame/wall interactions:

Introduction, flame-wall interaction in laminar flows, Flame/wall interaction in turbulent flows

Flame/acoustics interactions:

Introduction, acoustics for non-reacting flows, acoustics for reacting flows, combustion instabilities, large eddy simulations of combustion instabilities.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-5 (5 hours)

Boundary conditions:

Introduction, classification of compressible Navier-Stokes equations formulations, description of characteristic ,boundary condition, examples of implementation, applications to steady non-reacting flows, applications to steady reacting flows, unsteady flows and numerical waves control, applications to low Reynolds number flows.

Examples of LES applications:

Introduction, small scale gas turbine burner, large-scale gas turbine burner, self-excited laboratory burner.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each Module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module.

Suggested Learning Resources:

Text books:

1. Theoretical and Numerical Combustion , Thierry Poinsot, Denis Veynante , Edwards, 2005
2. Numerical Modeling In Combustion, TJ Chung, CRC Press, 1993

Reference books:

1. Modeling and Simulation of Reactive Flows ,A.L. De Bortoli, Greice Andreis, Felipe Pereira ,Elsevier,2015.
2. Numerical Prediction of Flow, Heat Transfer, Turbulence and Combustion ,D. Brian Spalding , Elsevier , 1983

Web links and Video Lectures (e-Resources):

1. **https://www.youtube.com/watch?v=O0PnENWNjo4**
2. https://www.youtube.com/watch?v=0Y0ssPcX-gw
3. https://www.youtube.com/watch?v=TUk55L5EJDw
4. https://www.youtube.com/watch?v=2tYa2JZiGNg
5. https://www.youtube.com/watch?v=4VoBKQuomd4

Skill Development Activities Suggested :

- Numerical study of the effects of material properties on flame stabilization in a porous burner for Turbulent Premixed Flames and Turbulent non Premixed Flames
- Conducting Tutorials classes
- Group discussions on Gas turbine combustion process and new design of combustor
- Technical Quiz and Seminars
- Assignments
- Exploration – gathering knowledge and attaining skills through active investigation.

outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Solve laminar premixed and diffusion flame problems in combustion	**L1,L2**
CO2	Distinguish different types of turbulent flames numerically	**L3**
CO3	Appreciate the reactive and non-reactive combustion through numerical methods	**L4**

Program Outcome of this course

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

Mapping of COS and POs :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**
CO2	**1**	**1**	**1**	**2**	**1**	**3**	**2**	**2**
CO3	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**

Semester- II

Professional elective 1			
Hypersonic aerothermodynamics			
Course Code	22MAP235	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02:00:02	SEE Marks	50
Total Hours of Pedagogy	25 Lecture+10-12 T/SDA	Total Marks	100
Credits	03	Exam Hours	3Hrs

Course Learning objectives:

1.Understand Fundamental aspects of hypersonic flows and aerothermodynamics of high-speed vehicles

2.Description of the hypersonic environment; inviscid hypersonic flows; hypersonic laminar boundary layers

3. Analyse basic aspects of high-temperature gas dynamics and thermochemical nonequilibrium flows.

Module-1(5 Hours)	
Some Preliminary Thoughts : Hypersonic Flight—Some Historical Firsts, Hypersonic Flow—Why Is It Important ?, Hypersonic Flow—What Is It? Fundamental Sources of Aerodynamic Force and Aerodynamic Heating . Hypersonic Flight Paths: Velocity-Altitude Map . **The hypersonic gas environment.** Historical aspects. Engineering applications: Re-entry spacecrafts, inter-continental ballistic missiles, hypersonic cruise aircrafts. Distinguished flight conditions leading to hypersonic flow phenomena.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT
Module-2 (5 Hours)	
Inviscid hypersonic flows. Hypersonic limit relations for shock waves. Newtonian theory. Newton-Busemann centrifugal corrections. The role of the density ratio in hypersonics. The combined limit of high Mach numbers and large density ratios. The Taylor-Maccoll theory for supersonic flows over cones. Mach-number independence principle. Van Dyke's small-disturbance equations for slender bodies. Tsien's hypersonic similarity parameter. The shock standoff distance from blunted bodies. Shock layer and entropy layer.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT
Module-3 (5Hours)	
Viscous hypersonic flows. The role of flight altitude. Boundary-layer transition phenomenology: The Shuttle Orbiter case. Endo-atmospheric and trans-atmospheric hypersonic vehicles. Non-continuum effects. Compressible laminar boundary layers. Recovery factor. Basic self-similar formulations for flat plates and forebody stagnation-point flows. The Fay-Riddell correlation. Aerodynamic heating.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem
Module-4 (5 Hours)	
High-speed thermo-chemical effects. Non-calorically and non-thermally perfect effects at high flight speeds. Air dissociation, ionization, and vibrational excitation. Chemical and vibrational non-equilibrium effects.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem
Module-5 (5Hours)	
Re-entry aeromechanics. Particle mechanics of re-entering spacecrafts and missiles. The role of the ballistic coefficient, the nose curvature, and the atmospheric density gradient. Deceleration, heating, and downrange precision landing.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**
   to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each Module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module.

Suggested Learning Resources:

Text books:

1. "Hypersonic and High-Temperature Gasdynamics", J.M. Anderson, , AIAA, 2006.
2. "Hypersonic Aerothermodynamics", J. Bertin, AIAA, 1991.

Reference books

1. "Hypersonic Flow Theory", W. Hayes & R.F. Probstein, Academic Press, 1959.
2 . "Elements of Gas Dynamics", H.W. Liepmann & A. Roshko, Dover, 1957.

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=cW1-7SWXnIk&list=PL04kBjbWQWOPYBfbw2zqnMbWHNjU3MDYB&index=2
2. https://www.youtube.com/watch?v=cW1-7SWXnIk&list=PL04kBjbWQWOPYBfbw2zqnMbWHNjU3MDYB&index=2
3. https://www.youtube.com/watch?v=S17EuAJZy1U&list=PL04kBjbWQWOPYBfbw2zqnMbWHNjU3MDYB&index=11
4. https://www.youtube.com/watch?v=alsrtqs3mrs&list=PL04kBjbWQWOPYBfbw2zqnMbWHNjU3MDYB&index=15
5. https://www.youtube.com/watch?v=ojaR-n5eWtw&list=PL04kBjbWQWOPYBfbw2zqnMbWHNjU3MDYB&index=18

Skill Development Activities Suggested :

- Computational challenges in Hypersonic flow Simulation
- Conducting Tutorials classes
- Group discussions on Hypersonic vehicles
- Technical Quiz and Seminars
- Assignments
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Demonstrate and distinguish flight conditions leading to hypersonic flow phenomena	**L1,L2**
CO2	Understand and apply the concepts Inviscid Hypersonic flow .	**L3**
CO3	Analyses the Gas Dynamics in Hypersonic Vehicles and solve the problems of failure during re-entry of vehicle into different atmosphere.	**L4**

Program Outcome of this course

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

Mapping of COS and Pos :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	**2**	**1**	**1**	**1**	**2**	**2**	**2**	**3**
CO2	**1**	**1**	**1**	**2**	**1**	**3**	**2**	**2**
CO3	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**3**

Semester- II

Professional Elective 2			
Ramjet and Scramjet			
Course Code	22MAP241	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02:00:02	SEE Marks	50
Total Hours of Pedagogy	25 Lecture+10-12 T/SDA	Total Marks	100
Credits	03	Exam Hours	3Hrs

Course Learning objectives:

1. Understand the basics of ramjet and scramjet engines.
2. Acquire knowledge of principles of operation and engine performance.
3. Know the different progresses in ramjet and scramjet propulsions.

Module-1 (5 hours)	
Introduction, Background Description, Fundamentals of Propulsion, Motivation to Study Ramjet and Scramjet, Thrust, Modes of Thrust Generation, Hypersonic Air breathing propulsion Ramjet. Basics of compressible one dimensional flows, Compressibility of Fluid, Mach number, T-S diagram of Compressible flow, Types of Ramjet Engines, Analysis of Ramjet Engines, performance, Thrust Equation.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT

Module-2 (5 hours)	
The ramjet engine, concept and performance. Different kinds of ramjets: the ram-rocket, the scramjet, Ram jet engine components like inlet, combustion chamber, nozzle, fuel control system and their design. Influence of component performance on the ram jet engine. Supersonic intakes, internal compression intake, Normal shock diffuser, converging diverging diffuser, external compression intakes, flow distortion, mixed compression intake, axisymmetric intake.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT

Module-3 (5 hours)	
Ramjet Operating principle – Sub critical, critical and supercritical operation – Combustion in ramjet engine – Ramjet performance – Sample ramjet design calculations – Introduction to scramjet – Preliminary concepts in supersonic combustion – Integral ram- rocket- Numerical problems. Types of Scramjet Engines, Analysis of Scramjet Engines, performance, Thrust Equation, Problem, TS Diagram, Loss coefficient, Combustion Chamber, Types of Injection.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-4 (5 hours)	
Scramjet Propulsion: Practical Progress, Heat addition in duct with Area variations, Isolators, Aerothermodynamics of dual mode combustion system, Real H-K diagram, Interoperation of Experimental Data, Fuel-air mixing processes, Measures of local goodness of mixing, Mixing in a Turbulent shear layer	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-5 (5 hours)	
Hypersonic Air breathing Engine Performance Analysis, Thermodynamics Closed Cycle Analysis ,Maximum Allowable Compression Temperature, First Law Analysis Results, Stream Thrust Analysis, Compression Components, Influence of Boundary Layer Friction, Burner Entry Pressure, Leading-Edge Oblique Shock Wave geometry	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**
   to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each Module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module.

Suggested Learning Resources:

Text books:

1. Hypersonic air breathing propulsion, William H. Heiser, David T. Pratt, Daniel H. Daley, AIAA. 1994
2. Scramjet Propulsion, ET Curran and S N B Murthy, Progress in Astronautics and Aeronautics, Volume 189, AIAA. 2001

Reference books:

1. AGARD, Advisory Group for Aerospace Research and Development. Vol.2,2005
2. Ramjet Technology, EA Bunt and others.
3. RAMJETS, AIAA.

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=59hbc_DnacQ
2. https://www.youtube.com/watch?v=2JQ-PAJGLrM
3. https://www.youtube.com/watch?v=4JCFufx6BVI
4. https://www.youtube.com/watch?v=P1-a8XRpXdk
5. https://www.youtube.com/watch?v=AMadcKOW6j8
6. https://www.youtube.com/watch?v=AMadcKOW6j8

Skill Development Activities Suggested

- Numerical study of a scramjet engine flow field
- Conducting Tutorials classes
- Group discussions on Ramjet and scramjet.
- Technical Quiz and Seminars
- Assignments
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Use the basics of ramjet and scramjet engines	L1,
CO2	Apply principles of operation and engine performance	L2, L3
CO3	Distinguish different ramjet and scramjet propulsions	L3,

Program Outcome of this course

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

Mapping of COs and Pos :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	**2**	**2**	**1**	**1**	**1**	**2**	**2**	**3**
CO2	**2**	**1**	**1**	**2**	**1**	**3**	**3**	**3**
CO3	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**

Semester- II

Professional Elective 2			
Mechanical Aspects of Rotating Machinery			
Course Code	22MAP242	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02:00:02	SEE Marks	50
Total Hours of Pedagogy	25 Lecture+10-12 T/SDA	Total Marks	100
Credits	03	Exam Hours	3Hrs

Course Learning objectives:
1. Understand the basics of vibration loads in Rotating Machinery systems.
2. Acquire knowledge systems in use.
3. Know the background of systems and optimization of their designs.

Module-1 (5 hours)	
Introduction: Definition of a rotating machinery, parts of a rotating machinery with respect to different aero engine configurations namely like turboprop, turbo shaft, turbojet and turbo fan. Basic issues in rotating machinery like vibrations, unbalance, casing rub and oil debris. Vibration: An overview of basics of vibrations and their significance in rotating machinery, Sources of vibrations in rotating machinery and its characterization. Vibration isolators, vibration measurement, sensors and analysis, industrial standards for vibration.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT
Module-2 (5hours)	
Analytical modeling and solution for vibration: Single DOF systems, free vibration, un-damped and viscously damped cases. Forced vibration, impulse and Fourier excitation. Response spectra, and modal frequency response, one & two degrees of freedom system. General multi-DOF systems including stiffness, flexibility and mass matrices. Natural frequencies and mode shapes (Eigen values and Eigen vectors), Coupled modes. **Energy methods:** Lagrange's equations, Application to rotor- shaft systems, Branched gear- shaft systems, Rigid body modes, Continuous (distributed parameter) systems. Critical Speeds and Response to Imbalance: Classical whirl, Coriolis effects, Euler angles, Coriolis matrix, Quadratic Eigen value problem solution, Campbell diagrams.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT
Module-3(5 hours)	
Fatigue and creep: Definition of fatigue and creep, creep and fatigue in gas turbine components, low and high cycle fatigue, life estimation of turbine blades estimation for creep, typical examples of gas turbine components failure due to creep and fatigue	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem
Module-4 (5hours)	
Imbalance characterization in engines: Rigid and flexible rotors, impact of unbalance on aero engine performance, sources of unbalance, single and multi-plane balancing , Shaft Alignment , Balancing standards for rotating machinery in industries. Bearings, Lubrication and Seals: Types of bearings in aero engines, Load and life evaluation of aircraft engine bearings, lubrication and its characterization. Application of magnetic and foil bearings in aero engines, Different types of seals used in aero engines.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem
Module-5 (5 hours)	
Engine noise and Inspection: Shaft and casing stiffness measurement and methods for control, Measurement of noise, sources of noise generation and methods for noise reduction, Various methods for inspecting Engine rotating component including non-destructive methods and CMM. Engine fault diagnosis and tools	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each Module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module.

Suggested Learning Resources:

Text books:

1. Mechanical Vibration, W.T. Thomson, 5th Edition, Prentice- Hall, 1997.
2. Rotordynamics Prediction in Engineering, Michell Lalanne and Ferraris, John Wiley, 1998.

Reference books:

1. Engineering Vibration, Daniel J. Inman, Prentice Hall, 2007.
2. Vibration problems in Engineering, S.P. Timoshenko et al, Wolfenden Press, 2008.
3. Rotor dynamics of Turbomachinery, John M. Vance, Wiley-Interscience, 1988.
4. Rotating Machinery Vibration, Maurice L Adams, CRC Press, 2000.

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=5qqFdc1GJO0
2. https://www.youtube.com/watch?v=30-FdRgygI0
3. https://www.youtube.com/watch?v=tJNaPt5aPmg
4. https://www.youtube.com/watch?v=76OBC0BGRzY
5. https://www.youtube.com/watch?v=8xN0xolGGqo
6. https://www.youtube.com/watch?v=roDKWbANFKE
7. https://www.youtube.com/watch?v=JIx-Jr3bg2E

Skill Development Activities Suggested

- Conducting Tutorials classes
- Group discussions on Vibrations and Noise in Rotating Machinery
- Technical Quiz and Seminars
- Assignments
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Distinguish the basics of concept and different kind of loads in rotating components of systems.	L1,
CO2	Apply knowledge systems in use.	L2,
CO3	Appreciate different systems and do optimization of their designs.	L3, L4, L5

Program Outcome of this course

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	**2**	**2**	**1**	**1**	**1**	**2**	**2**	**3**
CO2	**2**	**1**	**1**	**2**	**1**	**3**	**3**	**3**
CO3	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**

Semester- II

Advanced Composite Materials			
Course Code	22MAP243	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02:00:02	SEE Marks	50
Total Hours of Pedagogy	25 Lecture+10-12 T/SDA	Total Marks	100
Credits	03	Exam Hours	3Hrs

Course Learning objectives:

1. Understand the science of composite materials and micro and macro behaviour of a lamina.
2. Understand the composite materials for thermal, electrical/electro-magnetic applications.
3. Gain knowledge on composites for thermoelectric, dielectric and smart structure applications.

Module-1 (5 hours)	
Science of composite materials: Polymer-matrix composites, Carbon-matrix, Metal-matrix, Ceramic-matrix. Advance processing techniques: Filament winding, pultrusion, pulforming, thermoforming, injection, injection molding, liquid molding, blow molding. Application to aircraft, missiles & spacecraft.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT
Module-2 (5 hours)	
Macro& Microbehavior of a lamina: Stress strain relationship for an orthotropic Lamina- Restriction on elastic constantsStrengths of an orthotropic lamina and failure theories for an orthotropic lamina. Determination of elastic constants-Rule of mixtures, Macro-mechanical behavior of a laminate: Classical plate theory-stress and strain variation in laminate. Strength analysis of a laminate.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT
Module-3 (5 hours)	
Composite materials for thermal application, electrical/electro- magnetic application: Materials for high thermal conductivity, thermal interface materials, materials for thermal insulation, materials for heat retention Application to micro-electronics, resistance heating Mechanism behind electromagnetic application, materials for electromagnetic application.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem
Module-4 (5 hours)	
Materials for thermoelectric, dielectric application, optical & magnetic application: Non-structural & Structural composites, dielectric behavior, piezoelectric behavior, Piezoelectric/ferroelectric composite principles. Pyroelectric behavior. Materials for optical wave guide, materials for lasers. Metal-matrix composites for magnetic application.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem
Module-5 (5 hours)	
Smart structure application: Polymer matrix composites for damage sensing, temperatures Sensing & vibration reduction. Introduction to testing: Environmental effects testing, Design allowable & Damage tolerance Testing. Test Techniques.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each Module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module.

Suggested Learning Resources:

Text books:

1. Composite Materials-Functional Material for modern Technologies-Deborah D. L. Chung, Springer-Verlag London Ltd., 2004.
2. Mechanics of Composite Materials-R M Chawla, Springer Verlag,1998

Reference books:

1. Composite materials-Testing & Design-Ravi B Deo& Charles R, Editor, ASTM STP Publication, 1996.
2. Composite materials-Properties as Influenced by Phase geometry- Nielson, Springer- Verlag Berlin Heidelberg 2005.

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=0kB0G6WKhKE&list=PLSGws_74K01-bdEEUElQ9-obrujIKGEhg
2. https://www.youtube.com/watch?v=2FJbmTMkbB8
3. https://www.youtube.com/watch?v=S5oFmOsu7Lg
4. https://www.youtube.com/watch?v=fmsQJYPpZ2o

Skill Development Activities Suggested

- Analysis and selection of Composite materials for thermal application, electrical/electro- magnetic application.
- Conducting Tutorials classes
- Group discussions on advanced Composite materials for aerospace applications
- Technical Quiz and Seminars
- Assignments
- Exploration – gathering knowledge and attaining skills through active investigation.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Use the science of composite materials and micro and macro behaviour of a lamina.	**L1, L2**
CO2	Distinguish and apply the composite materials for thermal, electrical/electro-magnetic applications.	**L3,**
CO3	Apply composites for thermoelectric, dielectric and smart structure applications.	**L4, L5**

Program Outcome of this course

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

Mapping of COs and POs :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	**2**	**2**	**1**	**1**	**1**	**2**	**2**	**3**
CO2	**2**	**1**	**1**	**2**	**2**	**3**	**3**	**3**
CO3	**2**	**1**	**1**	**1**	**1**	**2**	**2**	**2**

Semester- II

Professional Elective 2			
Introduction to Reacting Flows			
Course Code	22MAP244	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02:00:02	SEE Marks	50
Total Hours of Pedagogy	25 Lecture+10-12 T/SDA	Total Marks	100
Credits	03	Exam Hours	3Hrs

Course Learning objectives:

1 Understand transport processes fuel reaction of fuels
2 Acquire the knowledge on Mechanism momentum transport
3 Gain knowledge on combustion of Mass Transport Mechanisms, Rates, and Coefficients

Module-1 (5 hours)

Introduction to Transport Processes: Physical Factors Governing Reaction Rates and Pollutant Emission, Gaseous Fuel Jet, Single Fuel Droplet and Fuel Droplet Spray Combustion, Conservation of Mass, Conservation of Momentum, Conservation of Energy, Approach (Reynolds') to Treatment of Turbulence via Time- Averaging the Conservation Equations, Approach to the Treatment of Multiphase Continua via Volume-Averaging the Conservation Equations, Continuum/Molecular, Compressible/Incompressible, Viscous/Inviscid, Newtonian/Non-Newtonian, Steady/Unsteady, Laminar/Turbulent.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT

Module-2 (5 hours)

Constitutive laws: Constitutive Laws/Coefficient, Equations of State, Chemical Kinetics, Diffusion Flux-Driving Force Laws/Coefficients, Linear-Momentum Diffusion (Contact Stress), Stokes' Extra Stress vs. Rate of Deformation Relation, Energy Equation in Terms of the Work Done, Viscous Dissipation, The Dynamic Viscosity Coefficient of Gases and Liquids, Energy Diffusion Flux and Gradients of Temperature and Species Concentration, Fourier's Heat-Flux Law, Thermal Conductivity Coefficient of Gases, Liquids, and Solids,Mass Diffusion Flux, Fick's Diffusion-Flux Law for Chemical Species, Nonlinear Fluids, Nonlocal Temporal Behavior-Fluids with Memory, Multiphase Effects: Nonlinear Species "Drag" Laws.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT

Module-3 (5 hours)

Momentum Transport Mechanisms, Rates, and Coefficients: Classification of Fluid Flow System, Mechanisms of Momentum Transport, Transport Properties, Energy and Mass Transport, Steady One Dimensional Compressible Fluid Flow, "Shock" Waves, Sound Waves, Detonation Waves, and "Deflagration" Waves, Local Velocity Fields, Wall Momentum Transfer Rates, and Wall Coefficients Conservation Equations Governing Velocity and Pressure, Velocity Fields and Surface Momentum-Transport Coefficients: Steady Laminar Flow of an Incompressible Newtonian Fluid, Example duct and plate, Laminar Round Jet of an Incompressible Newtonian Fluid: Far-Field Momentum Transfer for Fluid Flow in Porous Media or Packed Beds

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-4 (5 hours)

Energy Transport Mechanisms, Rates, and Coefficients: Mechanisms of Energy Transport, Transfer Rates and Coefficients, Conservation Equation, Boundary Conditions, and Solution Methods, Temperature and Surface Heat Transfer (Quiescent Media of Uniform Composition), Temperature and Surface Heat-Transfer (Steady Laminar Flows), Time-Averaged Temperature Distributions and Surface Heat-Transfer ("Steady" Turbulent Flows), Energy and Momentum Transport, Fully Turbulent Jet Flow into a Co-Flowing Surrounding Stream, Convective Energy Transport in Chemically Reacting Systems, Radiation-Energy Transfer.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-5 (5 hours)

Mass Transport Mechanisms, Rates, and Coefficients: Transport-Controlled Situations, Kinetically Limited Situations, Mechanisms of Mass Transport and Associated Transport, Properties, Concentration Fields and Surface-Transfer, Rates/Coefficients, Concentration Distributions and Surface Mass-Transfer Coefficients (Quiescent Media), Convective Mass Transfer in Laminar- and Turbulent-Flow, Two-Phase Flow: Mass-Transfer Effects, Inertial "Slip" and "Isokinetic", Eddy, Residence-Time Distributions: Tracer "Diagnostics" with Application to the Mathematical Modeling of Non ideal-Flow Reactors.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each Module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module.

Suggested Learning Resources:

Text books:

1. Transport Processes in Chemically Reacting Flow Systems, Daniel E. Rosner, Dover Publ, Inc. USA., 2000
2. Principles of Combustion, 2nd Edition by K.K. Kuo, Wiley & Sons, 2005**.**

Reference books:

1. Multiphase Flow and Transport Process in Subsurface, Rainer Helmig, Springer Publ Inc., Germany., 1997.

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=4ZXU3hsxnjw
2. https://www.youtube.com/watch?v=hJGjw8qawlA
3. https://www.youtube.com/watch?v=QM1aUdII-ZM&list=PLvSNXOe4nVGpGgfOXdFsk9KtPhM1ZyxW6
4. https://www.youtube.com/watch?v=i-gf-7Ad9Rc

Skill Development Activities Suggested

- Conducting Tutorials classes
- Group discussions onreacting flows in gas turbine and Rocket propulsion
- Technical Quiz and Seminars
- Assignments
- Exploration – gathering knowledge and attaining skills through active investigation.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Analyze the transport processes.	**L5**
CO2	Apply constitutive laws for engineering applications	**L2,**
CO3	Describe momentum transport mechanisms, rates, and coefficients in a flow.	**L3, L4**
CO4	Understand energy transport mechanisms, rates, and coefficients in a flow.	**L4**
CO5	Explain mass transport mechanisms, rates, and coefficients	**L3**

Program Outcome of this course

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

Mapping of COs and POs :

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	**1**	**2**	**1**	**1**	**1**	**2**	**2**	**3**
CO2	**1**	**1**	**1**	**2**	**1**	**3**	**3**	**3**
CO3	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**
CO4	**2**	**2**	**2**	**3**	**1**	**1**	**2**	**3**
CO5	**1**	**1**	**1**	**2**	**2**	**1**	**3**	**3**

Semester- II

Professional Elective 2			
Fuels and Combustion			
Course Code	22MAP245	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02:00:02	SEE Marks	50
Total Hours of Pedagogy	25 Lecture+10-12 T/SDA	Total Marks	100
Credits	03	Exam Hours	3Hrs

Course Learning objectives:

1. Understand fuels, their properties, their treatment for aerospace application
2. Acquire the knowledge on fundamentals of combustion.
3. Gain knowledge on combustion flame characterization, combustion performance, fuel stabilisation and classification

Module-1 (5 hours)	
Fuel Properties: Fuel Properties, Relative Density, API Gravity, Molecular Mass, Distillation Range, Vapor Pressure, Flash Point, Volatility Point, Viscosity, Surface Tension, Freezing Point, Specific Heat, Latent Heat, Thermal Conductivity, Combustion Properties of Fuels, Calorific Value, Enthalpy, Spontaneous-Ignition temperature, Limits of Flammability, Smoke Point, Luminometer Number, Smoke Volatility Index, Pressure and Temperature Effects, Sub atmospheric Pressure, Low Temperature, High Temperature.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT
Module-2 (5hours)	
Fuel Treatment: Introduction, Types of Hydrocarbons, Paraffins, Olefins, Naphthenes, Aromatics, Production of Liquid Fuels, Removal of Sulfur Compounds, Contaminants, Asphaltenes, Gum, Sediment, Ash, Water, Sodium, Vanadium, Additives, Gum Prevention, Corrosion Inhibition/Lubricity Improvers, Anti-Icing, Antistatic–Static Dissipators, Metal Deactivators, Antismoke **Alternative Fuels aerospace applications**: Hydrogen, Methane, Propane, Ammonia, Alcohols, Slurry fuels, Synthetic fuels, Fuels Produced by Fischer–Tropsch Synthesis of Coal/Biomass, Biofuels, Alternative fuel Properties, Combustion and Emissions Performance, Fischer–Tropsch Fuels, Biodiesel Fuels, Highly Aromatic (Broad Specification).	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT
Module-3 (5 hours)	
Basic Considerations: Introduction to Gas turbine Combustor, Basic Design Features, Combustor Requirements, Combustor Types and parts, Fuel Preparation, Atomizers, liner wall-cooling Techniques, combustor stability limits, combustor exit temperature traverse quality (pattern factors), Combustors for Low Emissions. **Combustion Fundamentals:** Deflagration, Detonation, Classification of Flames, Physics of combustion Chemistry, Flammability Limits, Global Reaction-Rate Theory, Weak Mixtures, Rich Mixtures, Laminar Premixed Flames, laminar and turbulent flame burning velocity, measurement techniques for flame velocity, Factors Influencing Laminar Flame Speed, Equivalence Ratio, Initial Temperature, Pressure, Laminar Diffusion Flames, Turbulent Premixed Flames, Flame Propagation in Heterogeneous Mixtures of Fuel Drops, Fuel Vapor and Air.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem
Module-4 (5 hours)	
Combustion flame characterization: Droplet and Spray Evaporation, Heat-Up Period, Evaporation Constant, Convective Effects, Effective Evaporation Constant, Spray Evaporation, Ignition Theory, Gaseous Mixtures, Heterogeneous Mixtures, Spontaneous Ignition, Flashback, Stoichiometry, Adiabatic Flame Temperature, Factors Influencing the Adiabatic Flame Temperature, Fuel/Air Ratio, Initial Air Temperature, Pressure. **Combustion Performance:** Combustion Efficiency, The Combustion Process, Reaction-Controlled Systems, Burning Velocity Model, Stirred Reactor Model, Mixing-Controlled Systems, EvaporationControlled Systems, Reaction- and Evaporation-Controlled Systems.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem
Module-5 (5 hours)	
Flame Stabilization & Fuel Classification: Definition of Stability Performance, Measurement of Stability Performance, Bluff-Body Flame holders, Stabilization, Mechanisms of Flame Stabilization, Flame Stabilization in Combustion Chambers, Classification of Liquid Fuels, Aircraft Gas Turbine Fuels, Engine Fuel System, Aircraft Fuel Specifications, Classification of Gaseous Fuels.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**
   to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each Module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module.

Suggested Learning Resources:

Text books:

1. Gas Turbine Combustion, Alternative fuels and Emissions, Arthur H.Lefebvre &Dilip R. Ballal, CRC Press 3rd Edition, 2010
2. Chemistry of Combustion Reaction, Minkoff, G.J., and C.F.H. Tipper, Butterworths,London, 1962

Reference books:

1. , Coal, Coke and Coal Chemicals, Wilson, P.J. and J.H. Wells, New York, McGraw-Hill, 1960.
2. Liquid Fuels, Williams, D.A. and G. James, London Pergamon, 1963.
3. Gas Engineers Handbook, New York, Industrial Press, 1966.
4. Fuels & Combustion, Samir Sarkar, Orient Long man 1996.

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=Fyq4Q5yWDDU&list=PLyqSpQzTE6M927gXIZdVbbsyj9cmxam-b

Skill Development Activities Suggested :

- Conducting Tutorials classes
- Group discussions on Fuels and combustion in gas turbine engine for aviation and military aircrafts.
- Technical Quiz and Seminars
- Assignments
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Distinguish fuels, their properties, their treatment for aerospace application	**L1,**
CO2	Use the knowledge on fundamentals of combustion.	**L2, L3**
CO3	Apply the combustion flame characterization, combustion performance, fuel stabilisation and classification	**L4**

Program Outcome of this course

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

Mapping of COs and POs :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	**1**	**2**	**1**	**1**	**1**	**2**	**2**	**3**
CO2	**2**	**1**	**1**	**2**	**1**	**3**	**3**	**3**
CO3	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**

MINI PROJECT WITH SEMINAR			
Course Code	**22MAP25**	CIE Marks	100
Number of contact Hours/Week	**0-4-2**	SEE Marks	--
Credits	**03**	Exam Hours/Batch	--

Course objectives:

- To support independent learning and innovativeattitude.
- To guide to select and utilize adequate informationfrom varied resources upholdingethics.
- To guide to organize the work in the appropriate mannerand present information (acknowledging the sources)clearly.
- To develop interactive, communication, organisation,time management, and presentationskills.
- To impart flexibility andadaptability.
- To inspire independent and teamworking.
- To expand intellectual capacity, credibility,judgement, intuition.
- To adhere to punctuality, setting and meetingdeadlines.
- To instil responsibilities to oneself andothers.
- To train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

Mini-Project with seminar: This may be hands-on practice**,** survey report, data collection and analysis, coding, mobile app development, field visit and report preparation, modelling of system, simulation, analysing and authenticating, case studies, etc.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any, and a senior faculty of the department. Students can present the seminar based on the completed mini-project. Participation in the seminar by all postgraduate students of the program shall be mandatory.

The CIE marks awarded for Mini-Project work and Seminar, shall be based on the evaluation of Mini Project work and Report, Presentation skill and performance in Question-and-Answer session in the ratio 50:25:25. Mini-Project with Seminar shall be considered as a head of passing and shall be considered for vertical progression as well as for the award of degree. Those, who do not take-up/complete the Mini Project and Seminar shall be declared as fail in that course and have to complete the same during the subsequent semester.

There is **no SEE** for this course.

Course outcomes:

At the end of the course the student will be able to:

- Present the mini-project and be able to defendit.
- Make links across different areas of knowledge and to generate, develop and evaluate ideas and information to apply these skills to the projecttask.
- Habituated to critical thinking and use problem solvingskills.
- Communicate effectively and to present ideas clearly and coherently in both the written and oralforms.
- Work in a team to achieve commongoal.
- Learn on their own, reflect on their learning andtake appropriate actions to improve it.

Computational Fluid Dynamics Laboratory			
Course Code	**22MAPL26**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	01:02:00	SEE Marks	50
Credits	02	Exam Hours	3Hrs

Course objectives:

1. Gain knowledge for grid generation and optimize grids
2. Transform the grids to computational domain
3. Acquire the knowledge to solve CFD problems through finite volume technique.
4. Analysis of reacting flow analysis in Engine components

Sl.NO	Experiments
1	Laminar Flow over a flat plate and determination of flow variables.
2	Turbulent Flow over a flat plate and determination of flow variables
3	Flow over an airfoil and computation of basic flow variables (velocities and pressure).
4	Computation of flow parameter in a Convergent & Convergent- Divergent nozzle using commercially available software.
5	Computation of Fluid Flow variables in a cascade of blades using commercially available software.
6	Computations of Flow variables in a compressor/turbine stage using commercially available software.
7	Experiment on One-dimensional heat conduction and computation of different parameters.
8	Computation of one dimensional conduction-convection mode of heat transfer using commercially available software.
	Demonstration Experiments (For CIE) if any
9	Computation in a quasi-steady Rotor-Stator Interaction using commercially available software.
10	Computational Fluid dynamics in any one Industrial example relevant to aerospace propulsion technology using commercially available software.
	Basic concepts and computation in multiphase flow in propulsion using commercially available software.
12	Computations of flow variables in combustion modeling in a gas turbine propulsion system using commercially available software.

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

Sl. No.	Description	Blooms Level
CO1	Develop grids around given shapes and transform the physical domain in to computational domain	L1,2,L4
CO2	Develop adaptive structured and unstructured grids	L3,L4
CO3	Apply knowledge to solve CFD problems through finite difference and finite volume techniques and Analyse using available fluid flow software.	L5

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 40% of maximum marks in the semester-end examination(SEE). In total of CIE and SEE student has to secure 50% maximum marks of the course.

Continuous Internal Evaluation (CIE):

CIE marks for the practical course is **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment to be evaluated for conduction with observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled downed to 30 marks (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 02 tests for 100 marks, the first test shall be conducted after the 8^{th} week of the semester and the second test shall be conducted after the 14^{th} week of the semester.
- In each test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The average of 02 tests is scaled down to **20 marks** (40% of the maximum marks).

The Sum of **scaled-down** marks scored in the report write-up/journal and average marks of two tests is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University.

All laboratory experiments are to be included for practical examination.

(Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.

Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.

Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 10% Marks allotted to the procedure part to be made zero.

The duration of SEE is 03 hours

Suggested Learning Resources:

- Computational Fluid Dynamics lab Manual

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI.

Scheme of Teaching and Examinations and Syllabus
M.Tech. AEROSPACE PROPULSION TECHNOLOGY (MAP)
(Department of Aerospace Engineering-VTU PG Centre Muddenahalli)
(Effective from the Academic year 2022-23)

Registrar,
Visvesvaraya Technological University
Jnana Sangam, Machhe, Belagavi-590018
eMail: registrar@vtu.ac.in
contact: 0831-2498112

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examinations – 2022
M.Tech., AEROSPACE PROPULSION TECHNOLOGY (MAP)
Choice Based Credit System (CBCS) and Outcome-Based Education(OBE)

III SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week			Examination				Credits
				Theory	Practical/ Mini–Project/ Internship	Tutorial/ Skill Development Activities	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	P	SDA					
1	PCC	22MAP31	Aerospace Instrumentation and Control Engineering	03	00	02	03	50	50	100	4
2	PEC	22MAP32X	Professional elective 3	03	00	00	03	50	50	100	3
3	OEC	22MAP33X	Professional elective 4	03	00	00	03	50	50	100	3
4	PROJ	22MAP34	Project Work phase -1	00	06	00	--	100	--	100	3
5	SP	22MAP35	Societal Project	00	06	00	--	100	--	100	3
6	INT	22MAPI36	Internship	(06 weeks Internship Completed during the intervening vacation of II and III semesters.)			03	50	50	100	6
TOTAL				**09**	**12**	**03**	**12**	**400**	**200**	**600**	**22**

Note: PCC: Professional core courses, PEC: Professional Elective Courses, IPCC-Integrated Professional Core Courses. MPS-Mini Project With Seminar; AUD/AEC; Audit Courses / Ability Enhancement Courses (Mandatory), PCCL-Professional Core Course lab, **L-Lecture, P-Practical, T/SDA-Tutorial / Skill Development Activities**(Hours are for Interaction between faculty and students)

Professional elective 3		**Professional elective 4**	
Course Code under	**Course title**	**Course Code**	**Course title**
22MAP321	Advanced Bearings and Rotor Dynamics	22MAP331	Elements of Aeronautics
22MAP322	Advanced Gas Turbines	22MAP332	Unmanned Air Vehicles
22MAP323	Advanced materials for aerospace applications.	22MAP333	Basic of Propulsion systems
22MAP324	Aerospace System Engineering	22MAP334	Cryogenic Engineering
22MAP325	Missile and Launch Vehicles	22MAP335	Fundamentals of aerodynamics theory

Note:

1p. Project Work Phase-1: The project work shall be carried out individually. However, in case a disciplinary or interdisciplinary project requires more participants, then a group consisting of not more than three shall be permitted.

Students in consultation with the guide/co-guide (if any) in disciplinary project or guides/co-guides (if any) of all departments in case of multidisciplinary projects, shall pursue a literature survey and complete the preliminary requirements of the selected Project work. Each student shall prepare a relevant introductory project document, and present a seminar.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, all Guide/s and co-guide/s (if any) and a senior faculty of the concerned departments. The CIE marks awarded for project work phase -1, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question and Answer session in the ratio of 50:25:25.

2. Societal Project: Students in consultation with the internal guide as well as with external guide (much preferable) shall involve in applying technology toworkout/proposing viable solutions for societal problems.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide if any, and a senior faculty of the department. The CIE marks awarded, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question and Answer session in the ratio of 50:25:25.

Those, who have not pursued /completed the Societal Project, shall be declared as fail in the course and have to complete the same during subsequent semester/s after satisfying the Societal Project requirements. There is no SEE (University examination) for this course.

3. Internship: Those, who have not pursued /completed the internship, shall be declared as fail in the internship course and have to complete the same during subsequent University examinations after satisfying the internship requirements. Internship SEE (University examination) shall be as per the University norms.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide if any, and a senior faculty of the department. The CIE marks awarded for project work phase -1, shall be based on the evaluation of Project Report, Project

Presentation skill, and performance in the Question and Answer session in the ratio of 50:25:25.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
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M.Tech., AEROSPACE PROPULSION TECHNOLOGY (MAP)
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IV SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week		Examination				Credits
				Theory	Practical/ Field work	Duration in hours	CIE Marks	SEE Marks Viva voce	Total Marks	
				L	P					
1	Project	22MAP41	Project work phase -2	--	08	03	100	100	200	18
			TOTAL	--	**08**	**03**	**100**	**100**	**200**	**18**

Note:

1. Project Work Phase-2:

Students in consultation with the guide/co-guide (if any) in disciplinary project or guides/co-guides (if any) of all departments in case of multidisciplinary projects, shall continue to work of Project Work phase -1to complete the Project work. Each student / batch of students shall prepare project document, and present a seminar.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, all Guide/s and co-guide/s (if any) and a senior faculty of the concerned departments. The CIE marks awarded for project work phase -2, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question and Answer session in the ratio of 50:25:25.

SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check, shall be as per the University norms.

Total Credits 22+18+22+18 =**80**

SEMESTER-III

emester- III

Aerospace Instrumentation and Control Engineering			
Course Code	22MAP31	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:00:02	SEE Marks	50
Total Hours of Pedagogy	40 Lecture + 10-12 SDA	Total Marks	100
Credits	04	Exam Hours	3Hrs

Course Learning objectives:

1. Understand the basics of aerospace instrumentations for force, torque, power, pressure , flow and acoustic measurements
2. Know the transducers and controls
3. Understand the designs of control systems

Module-1 (8 hours)

Motion - Force - Torque - Power - Pressure Measurements: Relative and absolute motion measurement. Force measurement- balance, hydraulic and pneumatic load cell, elastic force device. Torque and Power measurement- transmission, driving, absorption dynamometers. Pressure measurement- Low, moderate and high pressure measurement

Temperature – Flow- Acoustics measurement: Temperature measurement – non electrical, electrical, radiation method. Flow measurement- primary, positive displacement, secondary or rate meter. Acoustics measurement- characteristics of sound, sound pressure, power and intensity levels, loudness, typical sound measuring systems, microphones

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT

Module-2 (8 hours)

Instrumentation and their Representation: Introduction, functional elements of a measurement system, classification of instruments, microprocessor based instrumentation, standard and calibration. Static and Dynamic characteristic of instruments – error and uncertainties in performance parameters, propagation of uncertainties in compound quantities, static performance parameter, impedance loading and matching, specification and selection of instrument. Dynamic characteristics – formulation of system equation, dynamic response, compensation.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT

Module-3 (8 hours)

Transducer, Intermediate, Indicating, Recording and Display Elements: Transducer elements–analog and digital transducers.
Intermediate elements – amplifiers, differentiating and integrating elements, filters, A-D and D-A converters, terminology and conversions, data transmission elements. Digital voltmeter, cathode ray oscilloscopes, galvanometric recorder, servo type potentiometric recorders, magnetic tape recorders, digital recorder of memory type, data acquisition systems, data displace and storage.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-4 (8 hours)

Introduction to Automatic Controls: Introduction, closed loop and open loop control systems, mathematical modeling of mechanical, electrical, hydraulic and pneumatic systems, Types of control actions. State-Space Methods - Introduction, Vector matrix representation of State-Space equations, State Transition Matrix and equations, Characteristics equations, eigen values and eigen vectors, similarities transformations, decomposition of transfer functions.

Controllability and observeability of control systems: General concept of controlability, definition of state controllability, alternate tests on controlability, Definition of observability, alternate tests on observability, relationship among controllability, observability and transfer functions.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem 3. Practising the foundational knowledge

Module-5 (8 hours)

Design of control systems in state space: Pole placement, Design of servo systems, state observers, design of regulator systems with observers, design of control systems with observers, quadratic optimal regulator systems.

Design of discrete data control systems: Digital implementation of analog controllers, digital controllers, design in frequency domain and z plane.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem 3, Practising the foundational knowledge

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module .

Suggested Learning Resources:

Text Books:

1. Instrumentation, Measurement and Analysis Nakra and Chaudhry, B C Nakra K KChaudhry, Tata McGraw-Hill Companies, Inc, New York, Seventh Edition 2006.
2. Modern Control Engineering, K. Ogata, Prentice Hall Inc.

Reference books:

1. Mechanical measurements, R. S. Sirohi, H. C. Radha Krishna, New Age International Pvt. Ltd., New Delhi, 2004.
2. Automatic Control Systems, B.C. Kuo, Prentice Hall Inc
3. Introduction to Measurements and Instrumentation, Arun K. Ghosh, Prentice-Hall of India Ltd, New Delhi, 2nd Edition 2007.
4. Automatic Control Systems, Harrison & Bollinger, International Text Book Company.
5. Automatic Control Engineering, Francis H. Raven, McGraw- Hill International

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=Nwwga-TA3WI
2. https://www.youtube.com/watch?v=Pv0i-9wWrCI&list=PLSGws_74K018thqvpXHrs5DkeJcx8lX7u
3. https://www.youtube.com/watch?v=BEngBq49Ibo
4. https://www.youtube.com/watch?v=CrXOMBlYFp0

Skill Development Activities Suggested

- Conducting Tutorials classes
- Group discussions on Aerospace Instrumentation and Control Engineering.
- Technical Quiz and Seminars
- Assignments
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Use the basics of aerospace instrumentations for force, torque, power, pressure , flow and acoustic measurements	L1,L2
CO2	Apply and Distinguish the transducers and controls	L3,L4
CO3	Apply the concepts of designs of control systems	L1,L2

Program Outcome of this course

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

Mapping of COS and POs :

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	**1**	**2**	**1**	**1**	**1**	**2**	**2**	**3**
CO2	**1**	**1**	**1**	**2**	**1**	**3**	**3**	**3**
CO3	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**

Semester- III

Professional elective 3			
Advanced Bearings and Rotor Dynamics			
Course Code	22MAP321	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:00:00	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3Hrs

Course Learning objectives:

1. Understand the fundamentals of bearings and rotor dynamics
2. Acquire knowledge of vibration related phenomenon in bearings and their challenges
3. Know the bearing materials, sensors and measurements

Module-1 (8 hours)	
Introduction to bearings: Introduction to Fluid Film Bearings, Anti friction bearings, Advanced Bearings and Rotor dynamics. Variable geometry tilted pad bearings, Fluid film bearing dynamic coefficients & load bearing capability and methods of obtaining them, Influence of preload on the dynamic coefficients of journal bearings.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT
Module-2 (8 hours)	
Fundamentals of rotor dynamics: Objective of Rotor dynamic Analysis**,** Concept of rigid and flexural critical speeds and modeshapes, External Dampers, Single degree spring-mass-damper system analysis as applied to Jeffcott rotors. Bending Critical Speeds of Simple Shafts, whirling of an unbalanced simple elastic rotor, Transfer Matrix Analysis for bending Critical Speeds, Effect of axial stiffness.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT
Module-3 (8 hours)	
Concept of rotating Machinery: Torsional vibrations in rotating machinery, modeling of rotating machinery shafting, Transfer matrix analysis for free vibration, equivalent discrete system, transient response in torsional vibration. Hydrodynamic Bearings, Viscosity, mechanism of pressure development in the film, a simple rotor in fluid film bearing, optimum design of bearings, Shafts with dissimilar moment of inertia.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT 2. Assignment of Home/field work on real-life problem
Module-4 (8 hours)	
Application of smart materials in rotor dynamics: : Introduction to Smart Materials, Structures and Products Technologies. Overview of application of smart materials to rotor dynamics. Shape Memory Materials, Fiber-Optic Sensors.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT 2. Assignment of Home/field work on real-life problem
Module-5 (8 hours)	
Case study: Ball and Rolling element bearing, Bearing support design for a typical aero engine, FEM methods, Different Types of Models, Bearing and Seal Metrics, Torsional and Axial Models, Transient response using FEM software.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT 2. Assignment of Home/field work on real-life problem

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each Module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module .

Suggested Learning Resources:

Text books:

1. Rotor dynamics by J. S. Rao , New Age International Publishers
2. Machinery Vibration and rotor Dynamics by John Vance, FouadZeidan and Brian Murphy

Reference books:

1. Rotor Dynamics by AgnieszkaMuszyńska
2. Rotor Dynamics of Turbo machinery by John M. Vance

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=aoWBUhlN3-0&list=PLbMVogVj5nJRCfyN1QEiBsNFek8d00kWw
2. https://www.youtube.com/watch?v=ER5nVy4-q6s
3. https://www.youtube.com/watch?v=yXHIlowQntk
4. https://www.youtube.com/watch?v=x9TGlQIlQxA

Skill Development Activities Suggested

- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Apply the fundamentals of bearings and rotor dynamics	L1
CO2	Distinguish vibration related phenomenon in bearings and their challenges	L2
CO3	Apply bearing materials, sensors and measurements	L3

Program Outcome of this course

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

Mapping of COS and POs :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	**2**	**2**	**2**	**1**	**1**	**2**	**2**	**3**
CO2	**1**	**1**	**1**	**2**	**2**	**3**	**3**	**3**
CO3	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**

Semester- III

Professional elective 3			
Advanced Gas Turbines			
Course Code	22MAP322	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:00:00	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3Hrs

Course Learning objectives:

1. Understand jet propulsion cycles and thermodynamics of each component of a turbine engine
2. know the materials for various components and the manufacturing techniques of various parts
3. Gain knowledge on the performance of compressors and turbines

Module-1 (8 hours)	
Jet propulsion cycles and analysis: Introduction, Prime movers, simple gas turbine, energy equation, Dimensional analysis of rotating machine, Ram jet engine, pulse jet engine, turboprop engine, turbojet engine, thrust and thrust equation, specific thrust of turbojet engine, efficiencies, parameters affecting performance, thrust augmentation, problems	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT
Module-2 (8 hours)	
Ideal cycles and their analysis: Introduction, assumptions, Brayton Cycle, reheat cycle, reheat and regenerator, inter cooled cycle with heat exchanger, inter cooled and reheat cycle, comparison of varies cycles, Ericsson cycle, compressor and turbine efficiency, performance of actual cycle.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT
Module-3 (8 hours)	
Centrifugal and axial flow compressors: Essential parts of centrifugal and axial flow compressors, principles of operation, blade shape and velocity triangles, performance characteristics, surging and chocking, degree of reaction, compressor stage efficiency, and mechanical loses, problems.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT 2. Assignment of Home/field work on real-life problem
Module-4 (8 hours)	
Impulse and reaction turbine: single impulse stage and reaction stage, velocity triangles of a single stage machines, expression for work output, blade and stage efficiencies, velocity and pressure compounding, multi stage reaction turbines, performance graphs, losses and efficiencies.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT 2. Assignment of Home/field work on real-life problem
Module-5(8 hours)	
Blade materials, cooling and environmental consideration: Blade materials, manufacturing techniques, blade fixing, blade cooling, liquid cooling, air cooling, practical air cooled blades, NOX formation, noise standards, noise reduction, aircraft emission standards	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT 2. Assignment of Home/field work on real-life problem

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each Module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module .

Suggested Learning Resources:

Text books:

1. Gas turbines - V Ganesan Tata McGraw-Hill Publishing company limited.
2. Gas turbine theory - H.I.H Saravanamuttoo, G.F.C. Rogers and H. Cohen PV Straznicky, Publisher: Pearson Education Canada.

Reference books:

1. Mechanics & Thermodynamics of Propulsion - Hill, P.G. & Peterson, C.R. Addison – Wesley Longman INC, 1999.
2. Aerospace Propulsion - Dennis G Shepherd, American Elsevier Publishing Co Inc NY.
3. Aircraft Gas Turbine Engine Technology, 3rd Edition - E. Irwin Treager, 1995 ISBN- 002018281.

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=V6aU907cxkM
2. https://www.youtube.com/watch?v=Q9SIHFTJbVI
3. https://www.youtube.com/watch?v=PmQxK9PcImE
4. https://www.youtube.com/watch?v=3bhoVSI6VoI
5. https://www.youtube.com/watch?v=TZiUuC5mrV
6. https://www.youtube.com/watch?v=cgbhui1Jwiw
7. https://www.youtube.com/watch?v=knnNYBZbjPw
8. https://www.youtube.com/watch?v=1zHSK-Nlaz0

Skill Development Activities Suggested

- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Model jet propulsion cycles	L1
CO2	Select the materials for various components and involve in manufacturing of various parts	L2, L3
CO3	Solve problems related to performance of compressors and turbines	L4,L5

Program Outcome of this course

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

Mapping of COS and Pos :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	**2**	**2**	**2**	**1**	**1**	**2**	**2**	**3**
CO2	**2**	**1**	**1**	**1**	**2**	**3**	**3**	**3**
CO3	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**

Semester- III

Professional elective 3			
Advanced Materials for aerospace applications.			
Course Code	22MAP323	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:00:00	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3Hrs

Course Learning objectives:

1. To understand the types of materials for aerospace applications.
2. Knowledge of Selecting the materials for various components and involve in manufacturing of various parts
3. To optimise the use of smart and intelligent materials to solve problems related to aerospace vehicle design.

Module-1 (8 hours)	
Introduction: Mechanical Behaviors and their Origins-Atomic packing and bonding of condensed matters-Elasticity-An elasticity-Plasticity and Creep. Aerospace Materials: Design, Fabrication, and Characterization-Grains and interfaces/interphases-Metal alloys-Polymers and composites.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT
Module-2 (8 hours)	
Materials Classification: Classification of materials, mechanical properties, testing of aerospace materials, classification of Alloys – aluminum, steel, titanium and other alloys used in aerospace. Characteristics of composites and ceramics, ceramic reinforced, refractory materials.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT
Module-3 (8 hours)	
Superalloys and other Materials: Iron base, Nickel base, Cobalt base super alloys, composition control, solid solution strengthening, precipitation hardening by gamma prime, grain boundary strengthening, TCP phase, embrittlement, solidification of single crystals, intermetallics, high temperature ceramics.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT 2. Assignment of Home/field work on real-life problem
Module-4 (8 hours)	
Smart and Intelligent Materials: Introduction, piezo, pyro and Ferro electric effects, hysteretic effects, fundamentals of continuum mechanics, Application to aerospace vehicles. Dynamics and controls, concepts, Electro-magnetic materials and shape memory alloys processing and characteristics. Sensing and Actuation: Principals of electromagnetic, acoustics, chemical and mechanical sensing and actuation, Types of sensors and their applications, their compatibility wrt conventional and advanced materials, signal processing, principals and characterization..	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT 2. Assignment of Home/field work on real-life problem
Module-5 (8 hours)	
Advanced Materials: Engineering in Multiple Scales-Case studies: nano-engineered materials, bio-inspired materials, metamaterials - Existing challenges: scalable manufacturing, certification, unknowns.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT 2. Assignment of Home/field work on real-life problem

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each Module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module .

Suggested Learning Resources:

Text books:

1. Engineering Materials 1: An Introduction to their Properties and Applications, Ashby and Jones, Butterworth Heinemann, 1996
2. Smart Materials and Structures, M V Gandhi and B S Thompson, Chapmen & Hall, London, 1992

Reference books:

1. Materials for Missiles and Spacecraft, E.R. Parker, McGraw Hill, 1978
2. Ceramics: Mechanical Properties, Failure Behaviors, Materials Selection., Munz and Fett, Springer, 1999
3. Principle of Polymer Systems, Rodriguez, Cohen, Ober, and Archer, CRC Press, 2003
4. Fracture Mechanics: Fundamentals, Anderson, CRC Press, 1994

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=xooLZ6hJR7s
2. https://www.youtube.com/watch?v=gymWF8OrsOk
3. https://www.youtube.com/watch?v=QBkDDk69-fM
4. https://www.youtube.com/watch?v=46goOKD76kg
5. https://www.youtube.com/watch?v=5s6-1uREV4A
6. https://www.youtube.com/watch?v=MtqugJcsHZs&list=PLbRMhDVUMngdzwQyMgoUgdaGBqi_p4nVM

Skill Development Activities Suggested

- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Identify the types of materials for aerospace applications.	L1, L2
CO2	Select the materials for various components and involve in manufacturing of various parts	L2, L3
CO3	Use the smart and intelligent materials to solve problems related to aerospace vehicle design.	L4

Program Outcome of this course

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

Mapping of COs and POs :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	**2**	**2**	**2**	**2**	**1**	**2**	**2**	**3**
CO2	**1**	**1**	**1**	**2**	**2**	**3**	**3**	**3**
CO3	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**

Semester- III

Professional elective 3			
Aerospace System Engineering			
Course Code	22MAP324	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:00:00	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3Hrs

Course Learning objectives:

1. Understand the aircraft control systems.
2. Understand the aircraft systems.
3. Acquire the knowledge of aircraft instruments.

Module-1(8 hours)	
Airplane Control Systems: Conventional Systems, fully powered flight controls, Power actuated systems, Modern control systems, Digital fly by wire systems, Auto pilot system active control Technology.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT
Module-2 (8 hours)	
Aircraft Systems: Hydraulic systems, Study of typical workable system, components, Pneumatic systems, Advantages, Working principles, Typical Air pressure system, Brake system, Typical Pneumatic power system, Components, Landing Gear systems, Classification.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT
Module-3 (8 hours)	
Engine Systems: Fuel systems for Piston and jet engines, Components of multi engines. lubricating systems for piston and jet engines - Starting and Ignition systems - Typical examples for piston and jet engines.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT 2. Assignment of Home/field work on real-life problem
Module-4 (8 hours)	
Auxiliary System: Basic Air cycle systems, Vapour Cycle systems, Evaporative vapour cycle systems, Evaporative air cycle systems, Fire protection systems, Deicing and anti-icing systems	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT 2. Assignment of Home/field work on real-life problem
Module-5 (8 hours)	
Aircraft Instruments: Flight Instruments and Navigation Instruments, Gyroscope, Accelerometers, Air speed Indicators, TAS, EAS, Mach Meters, Altimeters, Principles and operation, Study of various types of engine instruments, Tachometers, Temperature gauges, Pressure gauges, Operation and Principles.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT 2. Assignment of Home/field work on real-life problem

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each Module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module .

Suggested Learning Resources:

Text books:

1. Aircraft Systems: Mechanical, Electrical and Avionics-Subsystem IntegrationIan Moirand Allan Seabridge, Wiley India Pvt Ltd, 3rd edition, 2012, ISBN-13: 978-8126535217.
2. Aircraft Instruments and Integrated Systems, Longman Scientific and Technical, 1996.

Reference books:

1. Aircraft Systems (Fundamentals of Flight Vol. IV), Lalit Gupta and OP. Sharma, HimalayanBooks;2006.
2. Treager. S, Gas Turbine Technology, McGraw-Hill, 3rd edition,2013, ISBN-13: 978-1259064876.
3. R.W. Sloley and W.H. Coulthard, 'The aircraft Engineers Handbook, No 4, Instruments', 6th Edition, 2005, ISBN-13: 978-8175980518
4. Pneumatic Systems, SR. Majumdar,Tata McGraw Hill Publishing Co,1st Edition, 2001, ISBN-13: 978-0074602317.
5. Aircraft Hydraulic Systems, William A Neese, Himalayan Books, 2007.

Web links and Video Lectures (e-Resources):

1.https://www.youtube.com/watch?v=sqWCnsTieTU
2. https://www.youtube.com/watch?v=-A6f9n3NV_w&list=PL0zm0AQWpaubMakyQJVcAXaWOUE9UeUJX
3. https://www.youtube.com/watch?v=cWDCXFwPLIs&list=PLvAvkZqpoPNNEnHsfkJbjpE8Sc5g5njnO
4.https://www.youtube.com/watch?v=pepuGqDEaCs
5. https://www.youtube.com/watch?v=UfgbXAWpj9M\
6.https://www.youtube.com/watch?v=knn54yonFbk

Skill Development Activities Suggested

- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Distinguish the conventional and modern control systems.	L1
CO2	Classify the aircraft systems.	L2
CO3	Categorize different types of aircraft instruments.	L3

Program Outcome of this course

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	**2**	**2**	**2**	**2**	**1**	**2**	**2**	**3**
CO2	**1**	**1**	**1**	**2**	**2**	**3**	**3**	**3**
CO3	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**

Semester- III

Professional elective 3			
Missile and Launch Vehicles			
Course Code	22MAP325	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:00:00	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3Hrs

Course Learning objectives:

1. Understand the types of space launch vehicles and missiles.
2. Study the solid and liquid rocket motors.
3. Acquire the knowledge on launch vehicle dynamics, attitude control, rocket testing and materials.

Module-1 (8 Hours)

Introduction: Space launch Vehicles and military missiles, function, types, role, mission, mission profile, thrust profile, propulsion system, payload, staging, control and guidance requirements, performance measures, design, construction, operation, similarities and differences. Some famous space launch vehicles and strategic missiles.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT 2. Assignment of Home/field work on real-life problem

Module-2 (8 Hours)

Solid Propellant Rocket Motor Systems: Solid Propellant rocket motors, principal features, applications. Solid propellants, types, composition, properties, performance. Propellant grain, desirable properties, grain configuration, preparation, loading, structural design of grain. Liners, insulators and inhibitors, function, requirements, materials. Rocket motor casing – materials. Nozzles, types, design, construction, thermal protection. Igniters, types, construction. Description of modern solid boosters I) Space Shuttle SRB, II)the Arienne SRB

Liquid Propellant Rocket Motor Systems: Liquid propellants, types, composition, properties, performance. Propellant tanks, feed systems, pressurization, turbo-pumps, valves and feed lines, injectors, starting and ignition. Engine cooling, support structure. Control of engine starting and thrust build up, system calibration, integration and optimisation –
safety and environmental concerns. Description of the space shuttle main engine. Propellant slosh, propellant hammer, geysering effect in cryogenic rocket engines.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT 2. Assignment of Home/field work on real-life problem

Module-3 (8 Hours)

Aerodynamics Of Rockets And Missiles: Classification of missiles. Airframe components of rockets and missiles, Forces acting on a missile while passing through atmosphere, method of describing aerodynamic forces and moments, lateral aerodynamic moment, lateral damping moment, longitudinal moment of a rocket, lift and drag forces, drag estimation, body upwash and downwash in missiles. Rocket dispersion, re-entry body design considerations.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT 2. Assignment of Home/field work on real-life problem

Module-4 (8 Hours)

Launch Vehicle Dynamics: Tsiolskovsky's rocket equation, range in the absence of gravity, vertical motion in the earth's gravitational field, inclined motion, flight path at constant pitch angle, motion in the atmosphere, the gravity turn – the culmination altitude, multi staging. Earth launch trajectories – vertical segment, the gravity turn, constant pitch trajectory, orbital injection. Actual launch vehicle trajectories, types. Examples, the Mu 3-S-II, Ariane, Pegasus launchers. Reusable launch vehicles, future launchers, launch assist technologies.

Attitude Control Of Rockets And Missiles: Rocket Thrust Vector Control – Methods of Thrusts Vector Control for solid and liquid propulsion systems, thrust magnitude control, thrust termination; stage separation dynamics, separation techniques.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT 2. Assignment of Home/field work on real-life problem

Module-5 (8 Hours)

Rocket Testing: Ground Testing and Flight Testing, Types of Tests facilities and safeguards, monitoring and control of toxic materials, instrumentation and data management. Ground Testing, Flight Testing, Trajectory monitoring, post -accident procedures. Description of a typical space launch vehicle launch procedure.

Materials: Criteria for selection of materials for rockets and missiles, requirements for choice of materials for propellant tanks, liners, insulators, inhibitors, at cryogenic temperatures, requirements of materials at extremely high temperatures, requirements of

materials

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT 2. Assignment of Home/field work on real-life problem

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each Module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module .

Suggested Learning Resources:

Text books:

1. 'Rocket Propulsion Element', George P Sutton and Oscar Biblarz, John Wiley and Sons Inc,7th edition, 2010,ISBN-13: 978-8126525775.

2. 'Missile Aerodynamics', Jack N Neilson, AIAA,1st edition, 1988,ISBN-13: 978-0962062902.

Reference books:

1. 'Missile Configuration Design', S S Chin,.

2. Rocket Propulsion and Space-Flight Dynamics, Cornelisse, J.W., Schoyer H.F.R. and Wakker,. K.F., Pitman, 1979,ISBN-13: 978-0273011415

3. Rocket and Spacecraft propulsion, Turner, M.J.L., Springer,3rd edition,2010,ISBN-13: 978-3642088698.

4. Space Vehicle Dynamics, Ball, K.J., Osborne, G.F., Oxford University Press, 1967,ISBN-13: 978-0198561071

5. Materials for Missiles and Spacecraft, Parker, E.R., McGraw Hill, 1982.

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=lbuCMYy7AeI
2. https://www.youtube.com/watch?v=XDtqd0V9N30
3. https://www.youtube.com/watch?v=Ry0tcLC5LJU
4. https://www.youtube.com/watch?v=ZEZV8LwAWcc
5. https://www.youtube.com/watch?v=K8cwhVTJbmg
6. https://www.youtube.com/watch?v=9xHuVQASRLU
7. https://www.youtube.com/watch?v=bT5_RdecM6g
8. https://www.youtube.com/watch?v=qG1O5ViEHes&list=PLUeHTafWecAXDFDYEwunLL2V2kwqKzkvJ
9. https://www.youtube.com/watch?v=6qEqXurSV1s
10. https://www.youtube.com/watch?v=sKkzHrhoSSw
11. https://www.youtube.com/watch?v=--mOplQkKR0

Skill Development Activities Suggested

- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Identify the types of space launch vehicles and missiles.	**L1, L2**
CO2	Distinguish the solid and liquid propellant motors.	**L1, L2, L3**
CO3	Classify different types of materials used for rockets and missiles.	**L1, L2**

Program Outcome of this course

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

Mapping of COs and POs :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	**2**	**2**	**2**	**1**	**1**	**2**	**2**	**3**
CO2	**1**	**1**	**1**	**1**	**2**	**3**	**3**	**3**
CO3	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**

SemesterIII

Professional elective 4			
ElementsofAeronautics			
CourseCode:	**22MAP331**	CIEMarks	50
TeachingHours/Week(L:P:SDA)	03:00:00	SEEMarks	50
TotalHoursofPedagogy	40	TotalMarks	100
Credits	03	ExamHours	03

Courseobjectives:Thiscoursewillenablestudentsto

1. Toknowthehistoryandbasicprincipleofaviation
2. Tounderstandthefoundationof flight,aircraftstructures,materialaircraftpropulsion
3. Todevelopanunderstandingstabilityofanaircraftalongwithits differentsystems

Module-1(8hours)

IntroductiontoAircrafts

History of aviation; Atmosphere and its properties; Classification of aircrafts; Basic components of an aircraft; aircraft axis system;aircraft motions; control surfaces and high lift devices; conventional design configurations; principle of operation of each major part;Helicopters,their partsandfunctions.

AircraftStructuresandMaterials:

Introduction; structural members;general types of construction; monocoque, semi-monocoque and geodesic structures; typical wingandfuselagestructure; metallic andnon-metallic materialsfor aircraftapplication.

Teaching-LearningProcess	**1.** TeachinginclassroomthroughChalk,TalkandICT **2.** AssignmentofHome/fieldworkonreal-lifeproblem

Module-2(8hours)

Basic principles of flight – significance of speed of sound; airspeed and groundspeed; standard atmosphere; Bernoulli's theorem andits application for generation of lift and measurement of airspeed; forces over wing section, airfoil nomenclature, pressure distributionover a wing section. Lift and drag components – generation of lift and drag; lift curve, drag curve, types of drag, factors affecting liftand drag; center of pressure and its significance; aerodynamic center, aspect ratio, Mach number and supersonic flight effects; simpleproblemsonliftanddrag.

Teaching-LearningProcess	**1.** TeachinginclassroomthroughChalk,TalkandICT **2.** AssignmentofHome/fieldworkonreal-lifeproblem **3.** Practisingthefoundationalknowledge

Module-3(8hours)

AircraftPropulsion:

Aircraft power plants, classification based on power plant and location and principle of operation. Turboprop, turbojet and turbofanengines; ramjets and scramjets; performance characteristics. Aircraft power plants – basic principles of piston, turboprop and jetengines;Brayton cycle andits application togas turbine engines; use of propellersandjets forproduction of thrust;comparativemeritsandlimitationsofdifferent typesofpropulsionengines; principleofthrust augmentation.

Teaching-Learning Process	**1.** TeachinginclassroomthroughChalk,TalkandICT **2.** AssignmentofHome/fieldworkonreal-lifeproblem

Module-4(8hours)

AircraftStability:

Forces on an aircraft in flight; static and dynamic stability; longitudinal, lateral and roll stability; necessary conditions for longitudinalstability; basics of aircraft control systems. Effect of flaps and slats on lift, control tabs, stalling, gliding, landing, turning, aircraftmaneuvers; stalling, gliding, turning. Simple problems on these. Performance of aircraft – power curves, maximum and minimumspeedsforhorizontalflightatagivenaltitude;effectofchangesinenginepowerandaltitudeonperformance;correctandincorrect anglesofbank;aerobatics,invertedmaneuvers,maneuverability. Simpleproblems.

Teaching-Learning Process	**1.** TeachinginclassroomthroughChalk,TalkandICT **2.** AssignmentofHome/fieldworkonreal-lifeproblem

Module-5(8hours)

IntroductiontoAircraftSystems:

Aircraftsystems(Mechanical)–hydraulicandpneumaticsystemsandtheirapplications;environmentcontrolsystem;fuelsystem,oxygensystem.

Aircraftsystems(Electrical)–flightcontrolsystem,cockpitinstrumentationanddisplays;communicationsystems;navigation systems;powergenerationsystems– enginedrivenalternators,auxiliarypowerModule,ramairturbine;powerconversion,distributionandmanagement.

Teaching-Learning Process	**1.** TeachinginclassroomthroughChalk,TalkandICT **2.** AssignmentofHome/fieldworkonreal-lifeproblem

AssessmentDetails(bothCIEandSEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark forthe CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall bedeemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures notless than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination)takentogether.

ContinuousInternalEvaluation:

1. ThreeUnitTestseachof **20 Marks**
2. Twoassignments eachof**20Marks**or**oneSkillDevelopmentActivityof40marks**

toattaintheCOsandPOs

Thesumofthreetests,twoassignments/skillDevelopmentActivities,willbe**scaleddownto50marks**

CIEmethods/questionpaperisdesignedtoattainthedifferentlevelsofBloom'staxonomyaspertheoutcomedefinedforthe course.

SemesterEndExamination:

1. TheSEEquestionpaperwillbesetfor100 marksandthemarksscoredwillbe proportionately reducedto50.
2. Thequestionpaperwillhaveten fullquestionscarryingequalmarks.
3. Eachfullquestionisfor20marks.Therewillbetwofullquestions(withamaximumoffoursub-questions)fromeachmodule.
4. Eachfullquestionwill haveasub-questioncoveringallthetopicsunderamodule.
5. Thestudentswillhavetoanswer fivefullquestions,selectingonefullquestionfromeachmodule.

SuggestedLearningResources:

TextBooks

1. "IntroductiontoFlight",JohnD. Anderson,McGraw-HillEducation,8th edition,2015,ISBN:978-0078027673.
2. FundamentalsofFlight,LalitGuptaandOPSharma,Vol-Ito Vol-IV,HimalayanBooks.2006,ISBN:9788170020752

ReferenceBooks

1. "Flightwithoutformulae",A.C.Kermode,PearsonEducationIndia,1989.ISBN:9788131713891.
2. "Flightstabilityandautomaticcontrol",NelsonR.C.,McGraw-HillInternationalEditions,1998.ISBN9780071158381.
3. "AircraftSystems:Mechanical, ElectricalandAvionicsSubsystemsIntegration", IanMoir,AllanSeabridge,JohnWiley &Sons, 2011,ISBN:978111965006.

Weblinksand VideoLectures(e-Resources):

- https://www.digimat.in/nptel/courses/video/101104061/L01.html

ActivityBasedLearning(SuggestedActivitiesinClass)/PracticalBasedlearning

- Exploration–gatheringknowledgeandattainingskillsthroughactiveinvestigation.
- Expression–encouragingstudentstoexpresstheirviewsthroughvisualpresentations.

Courseoutcome(CourseSkillSet)

Atthe endofthecoursethestudentwillbeableto:

Sl.No.	Description	BloomsLevel
CO1	Appreciateandapplythebasicprincipleofaviation.	L1,L2
CO2	Applytheconceptsoffundamentalsofflight,basicsofaircraftstructures,andaircraftpropulsion andaircraftmaterialsduringthedevelopmentofanaircraft.	L3,L4
CO3	Comprehendthecomplexitiesinvolvedduringdevelopmentofflightvehicles.	L1,L3,L4

Programoutcomeofthecourse

PO's	ProgramOutcome
PO1	Anabilitytoindependentlycarry outresearch/investigationanddevelopmentworktosolvepracticalproblems.
PO2	Anabilitytowriteandpresentasubstantialtechnicalreport/document.
PO3	Studentsshouldbeabletodemonstratea degreeofmasteryover theareaasperthespecializationoftheprogram.The masteryshouldbeatalevel higherthantherequirementsintheappropriatebachelorprogram
PO4	Acquiretechnicalcompetence,comprehensiveknowledgeandunderstandingthemethodologiesandtechnologies associatedwithAerospaceEngineering.Applyknowledgetoidentify,formulateandanalysecomplexengineeringproblems
PO5	Havinganabilitytoapplyknowledgeofscience,mathematics,engineering&technologyfordevelopmentofAerospace Propulsiontechnologies.
PO6	Acquiretheskillsforusesofcontemporarytechniques,resourcesandmodernengineeringandIT tools
PO7	Functioneffectivelyasanindividual,andasamemberorleaderin diverseteams,andinmultidisciplinarysettings.
PO8	Apply ethicalprinciplesandcommittoprofessionalethicsandresponsibilitiesandnormsoftheengineeringpractice

COsandPOs Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	2	2	1	1	2	2	3
CO2	1	1	1	1	2	3	3	3
CO3	2	1	1	1	1	2	2	2

Semester III

Professional elective 4			
Unmanned Air Vehicles			
Course Code	22MAP332	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:00:00	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3Hrs

Course objectives: This course will enable students to

1. Comprehend the basic aviation history and UAV systems.
2. Acquire the knowledge of basic aerodynamics, performance, stability and control.
3. Understand the propulsion, loads and structures

Module-1 (08 hours)	
Introduction: Aviation History and Overview of UAV systems, Classes and Missions of UAVs, Definitions and Terminology, UAV fundamentals, Examples of UAV systems-very small, small, Medium and Large UAV	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem
Module-2 (08 hours)	
The Air Vehicle Basic Aerodynamics: Basic Aerodynamics equations, Aircraft polar, the real wing and Airplane, Induced drag, the boundary layer, Flapping wings, Total Air-Vehicle Drag **Performance:** Overview, climbing flight, Range and Endurance – for propeller-driven aircraft, range- a jet-driven aircraft, Guiding Flight	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem
Module-3(08 hours)	
Stability and Control: Overview, Stability, longitudinal, lateral, dynamic stability, Aerodynamics control, pitch control, lateral control, Autopilots, sensor, controller, actuator, airframe control, inner and outer loops, Flight-Control Classification, Overall Modes of Operation, Sensors Supporting the Autopilot.	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem
Module-4(08 hours)	
Propulsion: Overview, Thrust Generation, Powered Lift, Sources of Power, The Two-Cycle Engine, The Rotary Engine, The Gas Turbine, Electric Motors, Sources of Electrical Power **Loads and Structures:**Loads, Dynamic Loads, Materials, Sandwich Construction, Skin or Reinforcing Materials, Resin Materials, Core Materials, Construction Techniques	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem 3.Practising the foundational knowledge
Module-5 (08 hours)	
Mission Planning and Control: Air Vehicle and Payload Control, Reconnaissance/Surveillance Payloads, Weapon Payloads, Other Payloads, Data-Link Functions and Attributes, Data-Link Margin, Data-Rate Reduction, Launch Systems, Recovery Systems, Launch and Recovery Tradeoffs	
Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem 3. Adoption of Project-based/Activity Based learning

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module .

Suggested Learning Resources:

Text Books

1. Introduction to UAV Systems, Paul Gerin Fahlstrom, Thomas James Gleason, 4th Edition, Wiley Publication, 2012 John Wiley & Sons, Ltd
2. Unmanned Aerial Vehicle, Landen Rosen, Publisher: Alpha Editions, ISBN13: 9789385505034.

Reference Books

1. Unmanned Aerial Vehicles: DOD's Acquisition Efforts, Publisher: Alpha Editions, ISBN13: 9781297017544.
2. Unmanned Aerial Vehicles, Valavanis, Kimon P., Springer, 2011.
3. Handbook of Unmanned Aerial Vehicles, Valavanis, K., Vachtsevanos, George J., Springer, 2015.

Web links and Video Lectures (e-Resources):

- https://www.digimat.in/nptel/courses/video/101104061/L01.html

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

Course outcome (Course Skill Set)

At the end of the course the student will be able to:

Sl. No.	Description	Blooms Level
CO1	Apply the basic concepts of UAV systems.	L1,L2
CO2	Explain the basic aerodynamics, performance, stability and control required for UAV.	L3,L4
CO3	Select the propulsion system and materials for structures.	L1,L2

Program Outcome of this course ;

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

COs and POs Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	**2**	**2**	**1**	**1**	**1**	**2**	**2**	**3**
CO2	**1**	**1**	**1**	**1**	**2**	**3**	**3**	**3**
CO3	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**

SemesterIII

Professional Elective - 4			
BasicofPropulsionSystems			
CourseCode	22MAP333	CIEMarks	50
TeachingHours/Week(L:P:SDA)	03:00:00	SEEMarks	50
TotalHoursofPedagogy	40	TotalMarks	100
Credits	03	ExamHours	3Hrs

Courseobjectives:Thiscoursewillenablestudentsto

1. Understandthebasicprincipleandtheoryofaircraftpropulsion.
2. Understandthepurposeofacentrifugal,axialcompressors,axialandradialturbines
3. Acquireknowledgeofimportanceofnozzles&inletsandcombustionchamber

Module-1(08hours)

Introduction: Review of thermodynamic principles, Principles of aircraft propulsion, Types of power plants, Working principles ofinternal combustion engine, Two – stroke and four – stroke piston engines, Gas- turbine engines, Cycle analysis of reciprocatingenginesandjetengines, advantagesanddisadvantages.

Teaching-LearningProcess	1. TeachinginclassroomthroughChalk,TalkandICT 2. AssignmentofHome/fieldworkonreal-lifeproblem

Module-2(08hours)

Propeller Theories & Jet propulsion Types of propeller, Propeller thrust: momentum theory, Blade element theories, propeller bladedesign,propellerselection.

Jet Propulsion: Illustration of working of gas turbine engine – The thrust equation – Factors affecting thrust – Effect of pressure,velocity and temperature changes of air entering compressor – Methods of thrust augmentation – Characteristics of turboprop,turbofanandturbojet –Performancecharacteristics.

Teaching-LearningProcess	1. TeachinginclassroomthroughChalk,TalkandICT 2. AssignmentofHome/fieldworkonreal-lifeproblem

Module-3(08hours)

Inlets&Nozzles
InternalflowandStallinSubsonicinlets,Boundarylayerseparation.Majorfeaturesofexternalflownearasubsonicinlet.Relationbetweenminimum arearatio andeternaldecelerationratio.Diffuser performance.
Supersonicinlets: Supersonicinlets,startingprobleminsupersonicinlets,Shockswallowingbyareavariation,Externaldeceleration.Modesofinlet operation.

Nozzles: Theoryofflowinisentropicnozzles,Convergentnozzlesandnozzlechoking,Nozzlethroatconditions.Nozzleefficiency,Lossesinnozzles.Over-expanded andunder-expandednozzles, Ejectorandvariableareanozzles,Thrust reversal.

Teaching-LearningProcess	1. TeachinginclassroomthroughChalk,TalkandICT 2. AssignmentofHome/fieldworkonreal-lifeproblem

Module-4(08hours)

GasTurbineEngineCompressors
Centrifugalcompressors: Principleofoperationofcentrifugalcompressors.Workdoneandpressurerise-Velocitydiagrams,Diffuservanedesignconsiderations,performancecharacteristics,ConceptofPre-whirl,Rotatingstall.

Axialflowcompressors: Elementarytheoryofaxialflowcompressor,Velocitytriangles,Degreeofreaction,threedimensionalflow.Airangledistribution forfreevortexandconstantreactiondesigns,Compressorbladedesign.Axialcompressorperformance characteristics.

Teaching-LearningProcess	1. TeachinginclassroomthroughChalk,TalkandICT 2. AssignmentofHome/fieldworkonreal-lifeproblem

Module-5(08hours)

CombustionchambersandTurbines
Classificationofcombustionchambers,importantfactorsaffectingcombustionchamberdesign,Combustionprocess,Combustionchamberperformance Effectof operatingvariablesonperformance–Flametubecooling–Flamestabilization–Useofflameholders

AxialFlowTurbines: Introduction,Turbinestage,Multi-stagingofturbine,Exitflowconditions,Turbinecooling,Heattransferinturbinecooling.
Radialturbine:Introduction,Thermodynamicsofradialturbines,Lossesandefficiency.

Teaching-LearningProcess	1. TeachinginclassroomthroughChalk,TalkandICT 2. AssignmentofHome/fieldworkonreal-lifeproblem 3. Practisingthefoundationalknowledge

AssessmentDetails(bothCIEandSEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark forthe CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE.A student shall bedeemedtohavesatisfiedtheacademicrequirementsandearnedthecreditsallottedtoeachsubject/courseifthestudentsecuresnot less than 50%(50marks out of100) in the sumtotal of the CIE(Continuous Internal Evaluation)and SEE(Semester EndExamination)takentogether.

ContinuousInternalEvaluation:

1. ThreeUnitTestseachof **20Marks**
2. Twoassignmentseachof**20Marks**or**oneSkillDevelopmentActivityof40marks** toattaintheCOsandPOs

Thesumofthreetests,twoassignments/skillDevelopmentActivities,willbe**scaleddownto50marks**

CIEmethods/questionpaperisdesignedtoattainthedifferentlevelsofBloom'staxonomyaspertheoutcomedefinedforthe course.

SemesterEndExamination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to50.2,Thequestionpaper willhavetenfullquestionscarryingequalmarks.
3. Eachfullquestionisfor20marks.Therewill betwofullquestions(withamaximumoffoursub-questions)fromeachmodule.
4. Eachfullquestionwill haveasub-questioncoveringallthetopicsunderamodule.
5. Thestudentswill havetoanswerfivefullquestions,selectingonefullquestionfromeachmodule

SuggestedLearningResources:

Books(TitleoftheBook/Nameoftheauthor/Nameofthepublisher/EditionandYear)TextBoo ks

1. "Aircraftpropulsion",BhaskarRoy,,Elsevier(2011),ISBN-13:9788131214213
2. "GasTurbines",V.Ganesan,TataMcGraw-Hill,2010,NewDelhi,India,ISBN:0070681929,9780070681927

ReferenceBooks

1. "Mechanics&ThermodynamicsofPropulsion",Hill,P.G.&Peterson,C.R.,Addison–WesleyLongmanINC,1999,ISBN-13:978-0201146592.
2. "GasTurbineTheory",Cohen,H.Rogers,G.F.C.andSaravanamuttoo,H.I.H.,Longman,1989,ISBN13:9780582236325.
3. "GasTurbineEngineTechnology",IrwinE.Treager,GLENCOEAviationTechnologySeries,7thEdition,TataMcGrawHill PublishingCo.Ltd,2003,ISBN-13:978-0028018287
4. "FundamentalsofCompressibleFlowwithAircraftandRocketpropulsion",S.M.Yahya,4thEdition,NewAgeInternational Publications,NewDelhi2014,ISBN13:9788122426687.

Weblinksand VideoLectures(e-Resources):

- https://archive.nptel.ac.in/courses/112/103/112103281/

ActivityBasedLearning(SuggestedActivitiesinClass)/PracticalBasedlearning

- Exploration–gatheringknowledgeandattainingskillsthroughactiveinvestigation.
- Expression–encouragingstudentstoexpresstheirviewsthroughvisualpresentations.

Courseoutcome(CourseSkillSet)

Attheendofthecoursethestudent willbeableto:

Sl.No.	Description	BloomsLevel
CO1	Applythebasicprincipleandtheoryofaircraftpropulsion.	L1,L2
CO2	Explainthefunctionsofcentrifugal,axialcompressors,axialandradialturbines	L3
CO3	Analysethe performanceofnozzles&inletsandcombustionchamber	L4

Semester III

Professional elective 4			
Cryogenic Engineering			
Course Code	22MAP334	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:00:00	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3Hrs

Course objectives: This course will enable students to

1. Understand the basic of cryogenic engineering.
2. Understand the cryogenic properties and insulation.
3. Acquire the knowledge on storage of cryogenic liquids and equipment's.

Module-1 (08 hours)

Introduction to Cryogenic Engineering: Thermophysical and fluid dynamic properties of liquid and gas hydrogen, Thermo physical and fluid dynamic properties of liquid and gas helium liquefaction systems of hydrogen and helium gases, Liquefaction systems of hydrogen and helium gases, Refrigeration and liquefaction principals; Joule Thomson effect and inversion curve; Adiabatic and isenthalpic expansion with their comparison.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-2 (08 hours)

Properties: Cryogenic fluids, Solids at cryogenic temperatures; Superconductivity, Recuperative - Linde - Hampson, Claude, Cascade, Heylandt, Kapitza, Collins, Simon; Regenerative - Stirling cycle and refrigerator, Slovay refrigerator, Gifford-McMahon refrigerator, Vuilleumier refrigerator, Pulse Tube refrigerator; Liquefaction of natural gas.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-3(08 hours)

Cryogenic Insulation: Vacuum insulation, Evacuated porous insulation, Gas filled Powders and fibrous materials,Solidfoams,Multilayerinsulation,LiquidandvapourShields,Compositeinsulations

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-4(08 hours)

Storage and Instrumentation of Cryogenic liquids: Design considerations of storage vessel; Dewar vessels; Industrial storage vessels; Storage of cryogenic fluids in space; Transfer systems and Lines for cryogenic liquids; Cryogenic valves in transfer lines; Two phase flow in Transfer system; Cool-down of storage and transfer systems, Measurement of strain, pressure, flow, liquid level and Temperature in cryogenic environment; Cryostats.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem

Module-5 (08 hours)

Cryogenic Equipment: Cryogenic heat exchangers-recuperative and regenerative; Variables affecting heat exchanger and system performance;Cryogenic compressors, Pumps, expanders; Turbo alternators; Effect of component inefficiencies; System Optimization,Magneto-caloricrefrigerator; 3He-4 He Dilution refrigerator; Cry pumping; Cryogenic Engineering applications in energy, aeronautics, space, industry, biology, preservation Application of Cryogenic Engineering in Transport.

Teaching-Learning Process	1. Teaching in classroom through Chalk, Talk and ICT **2.** Assignment of Home/field work on real-life problem 3. Practising the foundational knowledge

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module .

Suggested Learning Resources:

Books (Title of the Book/Name of the author/Name of the publisher/Edition and Year)

Text Books

1. Cryogenic Engineering, T.M. Flynn, Marcel Dekker., CRC Press,2nd edition, 2004,ISBN-13: 978-8126504985
2. "Cryogenics: Applications and Progress", A. Bose and P. Sengupta, Tata McGraw Hill.

Reference Books

1. "Handbook of Cryogenic Engineering", J.G. WeisendII, Taylor and Francis, CRC Press,1st edition,1998,ISBN-13: 978-1560323327
2. "Cryogenic Systems", R.Barron, Oxford University Press.
3. "Cryogenic Process Engineering", K.D.Timmer haus and T.M.Flynn, ,Plenum Press,1st edition,2013,ISBN-13: 978-1468487589
4. "Cryogenic Fundamentals", G.G.Haselden, Academic Press.
5. "Advanced Cryogenics", C.A.Bailey, , Springer,1971,ISBN-13: 978-0306304583
6. "Applied Cryogenic Engineering", R.W.Vance and W.M.Duke, ,John Wiley &sons,1962,ISBN-13: 978-0471902706

Web links and Video Lectures (e-Resources):

- http://www.infocobuild.com/education/audio-video-courses/mechanical-engineering/cryogenic-engineering-iit-bombay.html

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

Course outcome (Course Skill Set)

At the end of the course the student will be able to:

Sl. No.	Description	Blooms Level
CO1	Recognize the basic of cryogenic engineering.	L1,L2
CO2	Identify the storage and instrumentation required for cryogenic liquids.	L3
CO3	Classify the types of cryogenic equipment's.	L1,L2

Program Outcome of this course ;

PO's	Program Outcome
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems
PO5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.
PO6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools
PO7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

COs and POs Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	**1**	**2**	**1**	**1**	**1**	**2**	**2**	**3**
CO2	**1**	**1**	**1**	**1**	**2**	**3**	**3**	**2**
CO3	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**

SemesterIII

Professional Elective 4			
FundamentalsofAerodynamicTheory			
CourseCode	22MAP335	CIEMarks	50
TeachingHours/Week(L:P:SDA)	03:00:00	SEEMarks	50
TotalHoursof Pedagogy	40	TotalMarks	100
Credits	03	ExamHours	3Hrs

Courseobjectives:Thiscoursewillenablestudentsto

1. Understandthebasicsoffluidmechanicsasa prerequisite toAerodynamics.
2. Acquireknowledgeontypicalairfoilcharacteristicsand two-dimensionalflowsoverairfoilandstudy theincompressibleoverfinitewings.
3. Assimilatetheunderstandingofapplicationoffinitewingtheoryandhighliftsystems.

Module-1(08hours)	
Review of Basic Fluid Mechanics: Continuity, momentum and energy equation, Control volume approach to Continuity, momentumandenergyequation,Typesofflow,pathlines,streamlines,andstreaklines,unitsanddimensions,inviscidandviscousflows,compressibility,Machnumberregimes.Vorticity,Angularvelocity,Streamfunction,velocitypotentialfunction,Circulation, Numericals,MachconeandMachangle,Speedofsound.	
Teaching-Learning Process	**1.** TeachinginclassroomthroughChalk,TalkandICT **2.** AssignmentofHome/fieldworkonreal-lifeproblem
Module-2(08hours)	
AirfoilCharacteristics: Fundamentalaerodynamicvariables,Airfoilnomenclature,airfoilcharacteristics.wingplanformgeometry,aerodynamicforcesandmoments,centreofpressure,pressurecoefficient,aerodynamiccenter,calculationofairfoilliftanddrag frommeasuredsurfacepressuredistributions,typicalairfoilaerodynamiccharacteristicsatlowspeeds.Typesofdrag-Definitions.	
Teaching-LearningProcess	**1.** TeachinginclassroomthroughChalk,TalkandICT **2.** AssignmentofHome/fieldworkonreal-lifeproblem
Module-3(08hours)	
Two Dimensional Flows& Incompressible Flow Over Airfoil: Uniform flow, Source flow, Sink flow, Combination of a uniform flowwith source and sink.Doublet flow. Non-lifting flow over a circular cylinder. Vortex flow.Lifting flow over a circular cylinder.Kutta-Joukowskitheorem andgenerationofLift, D'Alembert'sparadox, Numericals, **Incompressibleflowoverairfoils:**Kelvin'scirculationtheoremandthestartingvortex,vortexsheet,Kuttacondition,Classicalthin airfoiltheoryforsymmetricandcamberedairfoils.Kutta-JoukowskitheoremandgenerationofLift,Numericals.	
Teaching-LearningProcess	**1.** TeachinginclassroomthroughChalk,TalkandICT **2.** AssignmentofHome/fieldworkonreal-lifeproblem
Module-4(08hours)	
Incompressible Flow Over Finite Wings: Biot-Savart law and Helmholtz's theorems, Vortex filament: Infinite and semi-infinite vortexfilament, Induced velocity.Prandtl's classical lifting line theory:Downwash and induced drag.Elliptical and modified elliptical liftdistribution.Liftdistributiononwings.LimitationsofPrandtl'sliftinglinetheory.Extendedliftinglinetheory-liftingsurfacetheory, vortexlatticemethodforwings. Lift,dragandmomentcharacteristicsofcompleteairplane.	
Teaching-Learning Process	**1.** TeachinginclassroomthroughChalk,TalkandICT **2.** AssignmentofHome/fieldworkonreal-lifeproblem
Module-5(08hours)	
Applications of Finite Wing Theory & High Lift Systems : Simplified horse-shoe vortex model, formation flight, influence of downwashon tail plane, ground effects. Swept wings: Introduction to sweep effects, swept wings, pressure coefficient, typical aerodynamiccharacteristics, Subsonic and Supersonic leading edges. Introduction to high-lift systems, flaps, leading-edge slats and typical high – liftcharacteristics.criticalMachnumbers,Liftanddragdivergence,shockinducedseparation,Effectsofthickness,camberandaspect ratioofwings,Transonicarearule,Tipeffects.IntroductiontoSourcepanel&vortex latticemethod.	
Teaching-Learning Process	**1.** TeachinginclassroomthroughChalk,TalkandICT **2.** AssignmentofHome/fieldworkonreal-lifeproblem

AssessmentDetails(bothCIEandSEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark forthe CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE.A student shall bedeemed tohave satisfied the academicrequirements and earned the credits allotted toeach subject/course ifthe studentsecuresnot lessthan50% (50 marks out of 100) in the sum total of the CIE (Continuous InternalEvaluation) and SEE (Semester EndExamination)takentogether.

ContinuousInternalEvaluation:

1. ThreeUnitTestseachof **20Marks**
2. Twoassignmentseachof**20Marks**or**oneSkillDevelopmentActivityof40marks**
   toattaintheCOsandPOs

Thesumofthreetests,twoassignments/skillDevelopmentActivities,willbe**scaleddownto50marks**
CIEmethods/questionpaperisdesignedtoattainthedifferentlevelsofBloom'staxonomyaspertheoutcomedefinedforthecourse.
SemesterEndExamination:

1. TheSEEquestionpaperwillbesetfor100marksandthemarksscoredwillbe proportionatelyreducedto50.
2. 2Thequestionpaperwillhavetenfullquestionscarryingequalmarks.
3. Eachfullquestionisfor20marks.Therewillbetwofullquestions(withamaximumoffoursub-questions)fromeachmodule.
4. Eachfullquestionwill haveasub-questioncoveringallthetopicsunderamodule.
5. Thestudentswillhavetoanswerfivefullquestions,selectingonefullquestionfromeachmodule

SuggestedLearningResources:
Books(TitleoftheBook/Nameoftheauthor/Nameofthepublisher/EditionandYear)TextBoo ks

1. "FundamentalofAerodynamics",AndersonJ.D,5thedition,McGraw-HillInternationalEdition,NewYork(2011),ISBN-13:978-0073398105.
2. "AerodynamicsforEngineeringStudents",E.L.Houghton,P.W.Carpenter,5thedition,Elsevier,NewYork.(2010),ISBN-13:978-0080966328

ReferenceBooks

1. "Aerodynamics",ClancyL.J.,Sterlingbookhouse,NewDelhi.(2006),ISBN13:9780582988804
2. "TheoreticalAerodynamics",LouisM.Milne-Thomson,ImportedEdition,DoverPublications,USA(2011),ISBN9780486619804.

Weblinksand VideoLectures(e-Resources):

- https://onlinecourses.nptel.ac.in/noc22_ae09/preview

ActivityBasedLearning(SuggestedActivitiesinClass)/PracticalBasedlearning

- Exploration–gatheringknowledgeandattainingskillsthroughactiveinvestigation.
- Expression–encouragingstudentstoexpresstheirviewsthroughvisualpresentations.

Atthe endofthecoursethestudentwillbeableto:

Sl.No.	Description	BloomsLevel
CO1	Evaluatetypicalairfoilcharacteristicsand two-dimensionalflowsoverairfoil	L1,L2
CO2	Computeandanalysetheincompressibleflowoverfinitewings	
	L4CO3	
	Applyfinitewingtheoryanddesignhighlift systemsfromtheaerodynamicsviewpoint L3	

ProgramOutcomeofthiscourse:

PO's	ProgramOutcome
PO1	Anabilitytoindependentlycarry outresearch/investigationanddevelopmentworktosolvepracticalproblems.
PO2	Anabilitytowriteandpresentasubstantialtechnicalreport/document.
PO3	Studentsshouldbeabletodemonstratea degreeofmasteryover theareaasperthespecializationoftheprogram.The masteryshouldbeatalevel higherthantherequirementsintheappropriatebachelorprogram
PO4	Acquiretechnicalcompetence,comprehensiveknowledgeandunderstandingthemethodologiesandtechnologies associatedwithAerospaceEngineering.Applyknowledgetoidentify,formulateandanalysecomplexengineeringproblems
PO5	Havinganabilitytoapplyknowledgeofscience,mathematics,engineering&technologyfordevelopmentofAerospace Propulsiontechnologies.
PO6	Acquiretheskillsforusesofcontemporarytechniques,resources andmodern engineeringandITtools
PO7	Functioneffectivelyasanindividual,andasamemberorleaderin diverseteams,andinmultidisciplinarysettings.
PO8	Apply ethicalprinciplesandcommittoprofessionalethicsand responsibilitiesandnormsoftheengineeringpractice
PO8	Apply ethicalprinciplesandcommittoprofessionalethicsandresponsibilitiesandnormsoftheengineeringpractice

COsandPOsMapping :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	1	2	1	1	1	2	2	3
CO2	1	1	1	1	2	3	3	3
CO3	1	1	1	1	1	2	2	2

PROJECT WORK PHASE – 1			
Course Code	**22MAP34**	CIE Marks	100
Number of contact Hours/Week	**0-6-0**	SEE Marks	**--**
Credits	**03**	Exam Hours	**--**

Course objectives:

- Support independentlearning.
- Guidetoselectand utilizeadequateinformationfromvaried resources maintaining ethics.
- Guide to organize the work in the appropriate mannerand present information (acknowledging the sources)clearly.
- Develop interactive, communication, organisation,time management, and presentation skills.
- Impart flexibility andadaptability.
- Inspire independent and teamworking.
- Expand intellectual capacity, credibility, judgement,intuition.
- Adhere to punctuality, setting and meetingdeadlines.
- Instil responsibilities to oneself andothers.
- Train students to present the topic of project work in a seminarwithoutanyfear,faceaudienceconfidently,enhance communication skill, involve in group discussion to present and exchange ideas.

Project Phase-1: The project work shall be carried out individually. However, in case a disciplinary or interdisciplinary project requires more participants, then a group consisting of not more than three shall be permitted.
Students in consultation with the guide/co-guide (if any) in disciplinary project or guides/co-guides (if any) of all departments in case of multidisciplinary projects, shall pursue a literature survey and complete the preliminary requirements of the selected Project work. Each student shall prepare a relevant introductory project document, and present a seminar.

Course Outcomes:
At the end of the course the student will be able to:

- Demonstrateasoundtechnicalknowledgeoftheirselected project topic.
- Undertake problem identification, formulation, andsolution.
- Design engineering solutions to complex problems utilisinga systemsapproach.
- Communicate with engineers and the community at largein written an oralforms.
- Demonstrate the knowledge, skills and attitudes ofa professionalengineer.

Continuous Internal Evaluation

- CIE marks shall be awarded by a committee comprising of HoD as Chairman, all Guide/s and co-guide/s (if any) and a senior faculty of the concerned departments. The CIE marks awarded for project work phase -1, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question-and-Answer session in the ratio of **50:25:25**.
- There will be **no SEE**.

INTERNSHIP			
Course Code	**22MAPI36**	CIE Marks	50
Number of contact Hours/Week	**6 Weeks**	SEE Marks	50
Credits	**06**	Exam Hours	03

Course Objectives:

Internship/Professional practice provide students the opportunity of hands-on experience that include personal training, time and stress management, interactive skills, presentations, budgeting, marketing, liability andrisk management, paperwork, equipment ordering, maintenance, responding to emergencies etc.

The objectives arefurther,

- To put theory intopractice.
- To expand thinking and broaden the knowledge and skills acquired through course work in the field.
- To relate to, interact with, and learn from current professionals in the field.
- To gain a greater understanding of the duties and responsibilities of a professional.
- To understand and adhere to professional standards in the field.
- To gain insight to professional communication including meetings, memos, reading, writing, public speaking, research, client interaction, input of ideas, and confidentiality.
- To identify personal strengths and weaknesses.
- To develop the initiative and motivation to be a self-starter and work independently.

Internship: Students under the guidance of internal guide/s and external guide shall take part in all the activities regularly to acquire as much knowledge as possible without causing any inconvenience at the place ofinternship.

Each student, is required to

- Present the seminar on the internship orally and/orthrough power pointslides.
- Answer the queries and involve indebate/discussion.
- Submit the report duly certified by the externalguide.
- The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident.

Course outcomes:

At the end of the course the student will be able to:

- Gain practical experience within industry in which theinternship isdone.
- Acquire knowledge of the industry in which the internshipis done.
- Apply knowledge and skills learned to classroomwork.
- Develop a greater understanding about career optionswhile more clearly defining personal careergoals.
- Experience the activities and functions ofprofessionals.
- Develop and refine oral and writtencommunication skills.
- Identifyareasforfutureknowledgeandskilldevelopment.
- Expand intellectual capacity, credibility, judgment,intuition.
- Acquire the knowledge of administration, marketing,finance and economics.

Continuous Internal Evaluation

CIE marks for the Internship report, presentation and question and answer session shall be awarded in the ratio of 50:25:25 for the **total CIE of 50 marks** bythe committee constituted for the purpose by the Head of the Department. Thecommitteeshallconsistofthreefacultyfromthedepartmentwith committee comprising of HoD as Chairman, all Guide/s and co-guide/s (if any) and a senior faculty of the concerned departments.

Semester End Examination

SEE marks for the internship report (30 marks), seminar (20 marks) and question and answer session (10 marks) shall be awarded in the ratio of 50:25:25 for the **total SEE of 50 marks** (based on the quality of report and presentation skill, participation in the question and answer session) by the examiners appointed by the University.

IV SEMESTER			
PROJECT WORK PHASE -2			
Course Code	**22MAP41**	CIE Marks	100
Number of contact Hours/Week	**8 Hours/Week**	SEE Marks	100
Credits	**18**	Exam Hours	03

Course Objectives:

- To support independentlearning.
- To guide to select and utilize adequate informationfrom varied resources maintaining ethics.
- To guide to organize the work in the appropriate mannerand present information (acknowledging the sources)clearly.
- To develop interactive, communication, organisation,time management, and presentationskills.
- To impart flexibility andadaptability.
- To inspire independent and teamworking.
- To expand intellectual capacity, credibility,judgement, intuition.
- To adhere to punctuality, setting and meetingdeadlines.
- To instill responsibilities to oneself andothers.
- To train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

Project Work Phase - II: Students in consultation with the guide/co-guide (if any) in disciplinary project or guides/co-guides (if any) of all departments in case of multidisciplinary projects, shall continue to work of Project Work phase -1to complete the Project work. Each student / batch of students shall prepare project document, and present a seminar.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, all Guide/s and co-guide/s (if any) and a senior faculty of the concerned departments. The CIE marks awarded for project work phase -2, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question-and-Answer session in the ratio of 50:25:25.

SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check, shall be as per the University norms.

Course Outcomes:

At the end of the course the student will be able to:

- Present the project and be able to defendit.
- Make links across different areas of knowledge and to generate, develop and evaluate ideas and information so as to apply these skills to the projecttask.
- Habituated to critical thinking and use problem solvingskills
- Communicate effectively and to present ideas clearly and coherently in both the written and oralforms.
- Work in a team to achieve commongoal.
- Learn on their own, reflect on their learning and take appropriate actions to improve it.