VISVESVARAYA TECHNOLOGICAL UNIVERSITY
BELAGAVI

Scheme of Teaching and Examinations and Syllabus

M.Tech AEROSPACE PROPULSION TECHNOLOGY (APT)

(Effective from Academic year 2020 - 21)

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examinations – 2020 - 21
M.Tech AEROSPACE PROPULSION TECHNOLOGY (APT)
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	Skill Development Activities (SDA)	Duration in hours	CIE Marks	SEE Marks	Total Marks	
1	PCC	20MAP11	Mathematical Modeling in Engineering.	03	--	02	03	40	60	100	4
2	PCC	20MAP12	Aerospace Propulsion	03	--	02	03	40	60	100	4
3	PCC	20MAP13	Finite Element Methods	03	--	02	03	40	60	100	4
4	PCC	20MAP14	Aerospace Materials and processes	03	--	02	03	40	60	100	4
5	PCC	20MAP15	Introduction to Space Technology	03	--	02	03	40	60	100	4
6	PCC	20MAPL16	Propulsion Lab	--	04	--	03	40	60	100	2
7	PCC	20RMI17	Research Methodology and IPR	02	--	--	03	40	60	100	2
			TOTAL	**17**	**04**	**10**	**21**	**280**	**420**	**700**	**24**

Note: PCC: Professional core.

Skill development activities:
Students and course instructor/s to involve either individually or in groups to interact together to enhance the learning and application skills.
The students should interact with industry (small, medium and large), understand their problems or foresee what can be undertaken for study in the form of research/ testing / projects, and for creative and innovative methods to solve the identified problem.
The students shall
(1) Gain confidence in modelling of systems and algorithms.
(2) Work on different software/s (tools) to Simulate, analyse and authenticate the output to interpret and conclude. Operate the simulated system under changed parameter conditions to study the system with respect to thermal study, transient and steady state operations, etc.
(3) Handle advanced instruments to enhance technical talent.
(4) Involve in case studies and field visits/ field work.
(5) Accustom with the use of standards/codes etc., to narrow the gap between academia and industry.
All activities should enhance student's abilities to employment and/or self-employment opportunities, management skills, Statistical analysis, fiscal expertise, etc.

Internship: All the students have to undergo mandatory internship of 6 weeks during the vacation of I and II semesters and /or II and III semesters. A University examination shall be conducted during III semester and the prescribed credit shall be counted for the same semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared as fail in internship course and have to complete the same during the subsequent University examination after satisfying the internship requirements.

Note: (i) Four credit courses are designed for 50 hours Teaching – Learning process.
(ii) Three credit courses are designed for 40 hours Teaching – Learning process.

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II SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week			Examination				Credits
				Theory	Practical/ seminar	Skill Development Activities (SDA)	Duration in hours	CIE Marks	SEE Marks	Total Marks	
1	PCC	20MAP21	Computational Fluid Dynamics	03	--	02	03	40	60	100	4
2	PCC	20MAP22	Fuels and Combustion	03	--	02	03	40	60	100	4
3	PCC	20MAP23	Heat Transfer in Propulsion Systems	03	--	02	03	40	60	100	4
4	PEC	20MAP24X	Professional elective 1	04	--	--	03	40	60	100	4
5	PEC	20MAP25X	Professional elective 2	04	--	--	03	40	60	100	4
6	PCC	20MAPL26	CFD Laboratory	--	04	--	03	40	60	100	2
7	PCC	20MAP27	Technical Seminar	--	02	--	--	100	--	100	2
TOTAL				**17**	**06**	**06**	**18**	**340**	**360**	**700**	**24**

Note: PCC: Professional core, PEC: Professional Elective.

Professional Elective 1		**Professional Elective 2**	
Course Code under 20MAP24X	**Course title**	**Course Code under 20MAP25X**	**Course title**
20MAP241	Fatigue and Fracture Mechanics	20MAP251	Ramjet and Scramjet
20MAP242	Engine Performance Control & Simulation	20MAP252	Mechanical Aspects of Rotating Machinery
20MAP243	Aerospace Structures	20MAP253	Advanced Composite Materials
20MAP244	Numerical methods in combustion	20MAP254	Introduction to reacting flows.

Note:

1. Technical Seminar: 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. Participation in the seminar by all postgraduate students of the same and other semesters of the programme shall be mandatory.

The CIE marks awarded for Technical Seminar, shall be based on the evaluation of Seminar Report, Presentation skill and Question and Answer session in the ratio 50:25:25.

2. Internship: All the students shall have to undergo mandatory internship of 6 weeks during the vacation of I and II semesters and /or II and III semesters. A University examination shall be conducted during III semester and the prescribed credit shall be counted in the same semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared as fail in internship course and have to complete the same during the subsequent University examination after satisfying the internship requirements.

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III SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week			Examination				Credits
				Theory	Practical/ Mini –Project/ Internship	Skill Development activities (SDA)	Duration in hours	CIE Marks	SEE Marks	Total Marks	
1	PCC	20MAP31	Aerospace Instrumentation and Control	03	--	02	03	40	60	100	4
2	PEC	20MAP32X	Professional elective 3	03	--	--	03	40	60	100	3
3	PEC	20MAP33X	Professional elective 4	03	--	--	03	40	60	100	3
4	Project	20MAP34	Project Work phase -1	--	02	--	--	100	--	100	2
5	PCC	20MAP35	Mini-Project	--	02	--	--	100	--	100	2
6	Internship	20MAPI36	Internship	(Completed during the intervening vacation of I and II semesters and /or II and III semesters.)			03	40	60	100	6
TOTAL				**09**	**04**	**02**	**12**	**360**	**240**	**600**	**20**

Note: PCC: Professional core, PEC: Professional Elective.

Professional elective 3		**Professional elective 4**	
Course Code under 20MAP32X	**Course title**	**Course Code under 20MAP33X**	**Course title**
20MAP321	Advanced Bearings and Rotor Dynamics	20MAP331	Missile and Launch Vehicles
20MAP322	Hypersonic Aerodynamics	20MAP332	Advanced Propulsion
20MAP323	Advanced Gas Turbines	20MAP333	Gas Turbine and Rocket Propulsion
20MAP324	Advanced materials for aerospace applications.	20MAP334	Introduction to Artificial intelligence and machine learning.

Note:

1. Project Phase-1: Students in consultation with the guide/co-guide if any, shall pursue literature survey and complete the preliminary requirements of selected Project work. Each student shall prepare relevant introductory project document, and present a seminar.

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 Question and Answer session in the ratio 50:25:25.

SEE (University examination) shall be as per the University norms.

2. Internship: Those, who have not pursued /completed the internship shall be declared as fail in 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.

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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	
1	Project	20MAP41	Project work phase -2	--	04	03	40	60	100	20
			TOTAL	--	**04**	**03**	**40**	**60**	**100**	**20**

Note:

1. Project Phase-2:

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 -2, shall be based on the evaluation of Project Report subjected to plagiarism check, Project Presentation skill and Question and Answer session in the ratio 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.

M.TECH AERONAUTICAL ENGINEERING (MAE)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -I

MATHEMATICAL MODELING IN ENGINEERING

Course Code	20MAP11	CIE Marks	40
Teaching Hours/Week (L:T:P)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Model fitting

Introduction, Fitting models to data graphically - Analytic methods of model fitting - Chebyshev Approximation Criterion, Minimizing the Sum of the Absolute Deviations, Least-Squares Criterion, Relating the Criteria. Applying the least squares criterion- Fitting a Straight Line, Fitting a Power Curve, Transformed Least Squares Fit, Example: Vehicular stopping distance

Module-2

Modelling with a differential equations

Introduction- Population growth, Prescribing Drug Dosage, Breaking distance revisited. Graphical solutions of Autonomous differential equations, Example: Drawing a phase line and sketching solution curves, Numerical approximation methods - First-Order Initial Value Problems, Approximating Solutions to Initial Value Problems: Example 1: Using Euler's method, Example 2: A saving certificate revisited.

Module-3

Ordinary Differential Equations: Solving ODE"s using: Picard's method, Runge Kutta fourth order, Runge Kutta Fehlberg method, Stiffness of ODE using shooting method, Boundary value problems.

Module-4

Partial Differential Equations: Classification of second order Partial Differential Equations. Solution of One dimensional wave equation,(Schmidt`s explicit formula), One dimensional heat equation by Schmidt method, Crank- Nicholson method, and Du Fort-Frankel method.

Module-5

Sampling Theory: Testing of hypothesis using t and χ^2 test, Goodness of fit. F-test, Analysis of Variance: One – way with/without interactions, problems related to ANOVA, Design of experiments, RBD.

Course outcomes:

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

1. Acquire the idea of significant figures, types of errors during numerical computation.
2. Develop the mathematical models of thermal system using ODE's and PDE's.
3. Learn the deterministic approach for statistical problems by using probability distributions.
4. Demonstrate the validity of the hypothesis for the given sampling distribution using standard tests and understand the randomization on design of experiments.
5. Classify and analyze mathematical tools applied to thermal engineering study cases.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have 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.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year

1	A First course in Mathematical modeling	Frank.R.Giordano, Maurice.D.Weir, Willium.P.Fox	China machine press	2003
2	Numerical methods for Scientific and Engg computation	M K Jain, S.R.K Iyengar, R K. Jain	New Age International	2003
Reference Books				
1	Higher Engineering Mathematics	B.S. Grewal	Khanna Publishers	2017
2	Probability and Statistics for Engineers and Scientists	R.E, Walpole, R.H.Myres, S.L.Myres and Keying Ye	Pearson	2012
3	Probability and Statistics in Engineering	William W.H., Douglas C.M., David M.G.and Connie M.B	Wiley	2008
4	Advanced Engineering Mathematics	C. Ray Wylie and Louis C Barrett	McGraw-Hill	1995

M.TECH AEROSPACE PROPULSION TECHNOLOGY (MAP)
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SEMESTER -I

AEROSPACE PROPULSION

Course Code	**20MAP12**	CIE Marks	40
Teaching Hours/Week (L:T:P)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

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.

Module-2

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.

Module-3

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.

Module-4

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.

Module-5

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.

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

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

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have 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.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Aerospace Propulsion	Dennis G Shepherd	American Elsevier Publishing Co Inc NY.	1972
2	Aircraft power plants	Michael J Kroes and Thomas W Wild	Macmillan/McGraw Hill NY.	8th edition &2013
3	Rocket Propulsion Elements	George P Sutton and Donald M Ross	John Wiley & Sons NY.	1957
Reference Books				
1	Aircraft Gas Turbine Engine Technology	E. Irwin	Treager	3rd Edition, 1995
2	Mechanics & Thermodynamics of Propulsion	Hill, P.G. , Peterson, C.R. Addison	Wesley Longman INC	1999
3	Design of Liquid Propellant Rocket Engines	Huzel and Houng	NASA SP 125	1971.
4	Rocket Propulsion	Barrere et al	Elsevier Co.,	1960
5	Fundamental Aspects of Solid Propellant Rockets	Williams F A. et al	Agardograph, 116 Technivision	1970
6	Gas turbine engineering handbook	Meherwan P. Boyce	Gulf professional publisher, Elsevier	2006

M.TECH AEROSPACE PROPULSION TECHNOLOGY (MAP)
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SEMESTER -I

FINITE ELEMENT METHODS

Course Code	**20MAP13**	CIE Marks	40
Teaching Hours/Week (L:T:P)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Introduction to Finite Element Method, One-Dimensional Elements-Analysis of Bars: Introduction to FEM and fundamental principles, Engineering Analysis, Variational formulations, weighted residual methods. Basic Equations and Potential Energy Functional, 1-0 Bar Element, Strain matrix, Element equations, Stiffness matrix.

Module-2

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.

Module-3

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.

Module-4

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.

Module-5

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.

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

1. Apply FEA the one, two and three dimensional problems.
2. Simulate the real life problems of aero structure analysis using FEM.
3. Distinguish the use of different commercial FEM softwares for static and dynamic problems.

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have 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.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Finite Elements in engineering	Chandrupatla T. R.	PHI	2nd Edition 2007
2	Finite Elements Method in Engineering	Rao S. S	Elsevier	4th Edition 2006
Reference Books				
1	Finite Elements Analysis	Lakshminarayana H. V.	Universities Press,	2004
2	Textbook of Finite Element Analysis	P.Seshu	PHI	2004
3	Finite Element Method	J.N.Reddy	McGraw -Hill International Edition	3rd edition &2005
4	Finite Elements Procedures	Bathe K. J.	PHI	**2007**

M.TECH AEROSPACE PROPULSION TECHNOLOGY (MAP)
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SEMESTER -I

AEROSPACE MATERIALS AND PROCESSES

Course Code	**20MAP14**	CIE Marks	40
Teaching Hours/Week (L:T:P)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

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

Module-2

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.

Module-3

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.

Module-4

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.

Module-5

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.

Course outcomes:

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

1. Identify different materials for Gas Turbine Engines.
2. Distinguish alloys of Titanium, Nickel, Composite materials and their manufacturing processes.
3. Use casting and forging technology for Gas turbine components.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have 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.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Development of Gas Turbine Materials	G. W. Meetham	Applied Science Publications, London	1981
2	Metal Matrix Composites	K. U. Krainer	Wiley-VCH, Verlag GmbH & Co	2006
3	Fundamentals of Modern Manufacturing: Materials, Processes, and Systems	Mikell P. Groover	Wiley	2nd Edition 2005
Reference Books				
1	Materials for High Temperature Engineering Applications	G. W. Meetham and M. H. Van de Voorde	Springer	2006
2	Mechanical Metallurgy	George E. Dieter,	McGraw-Hill	1988
3	Materials Science and Engineering: an Introduction	William D. Callister	John Wiley and sons	6th edition 2005
4	Manufacturing Engineering and Technology	Serope Kalpakjian, Steven R Schmid	Pearson Education	2003

M.TECH AEROSPACE PROPULSION TECHNOLOGY (MAP)
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SEMESTER -I

INTRODUCTION TO SPACE TECHNOLOGY

Course Code	**20MAP15**	CIE Marks	40
Teaching Hours/Week (L:T:P)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

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.

Module-2

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

Module-3

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.

Module-4

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.

Module-5

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

Course outcomes:

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

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

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have 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.

Textbook/ Textbooks				
Sl No	**Title of the book**	**Name of the Author/s**	**Publisher Name**	**Edition and year**
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

M.TECH AEROSPACE PROPULSION TECHNOLOGY (MAP)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -I

PROPULSION LAB

Course Code	**20MAPL16**	CIE Marks	40
Teaching Hours/Week (L:T:P)	0:0:4	SEE Marks	60
Credits	02	Exam Hours	03

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
4	Measurement of Burning Velocity of a Premixed Flame
5	Determination of heat of combustion of aviation fuels
6	Fuel - injection characteristics (spray cone geometry; spray speed etc. for various types of injectors)
7	Measurement of static overall pressure rise & rotor static pressure rise & fan overall efficiency through axial flow fan unit
8	Effect of inlet flow distortion on measurement of static overall pressure rise & rotor static pressure rise & fan overall efficiency through axial flow fan unit .
9	Investigation of relationship between flame speed and air-fuel ratio for a slow burning gaseous fuel.
10	Construction of flame stability diagram through flame lift up and flame fall back
11	Measurement of static overall pressure rise & rotor static pressure rise & fan overall efficiency through counter rotating axial flow fan unit
12	Effect of inlet flow distortion on measurement of static overall pressure rise & rotor static pressure rise & fan overall efficiency through contra rotating axial flow fan unit .

Course outcomes:

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

1. Demonstrate various experimental facilities
2. Explain the use of different sensors and measurement techniques
3. Perform the test, acquire the data and analyse and document

M.TECH AEROSPACE PROPULSION TECHNOLOGY (MAP)
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SEMESTER -I

RESEARCH METHODOLOGY AND IPR

Course Code	20RMI17	CIE Marks	40
Teaching Hours/Week (L:T:P)	2:0:0	SEE Marks	60
Credits	02	Exam Hours	03

Module-1

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.

Module-2

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.

Module-3

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 Technics, 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.

Module-4

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.

Module-5

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 onBiological 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.

Course outcomes:

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

- Discuss research methodology and the technique of defining a research problem
- Explain the functions of the literature review in research, carrying out a literature search, developing theoretical and conceptual frameworks and writing a review.
- Explain various research designs, sampling designs, measurement and scaling techniques and also different methods of data collections.
- Explain several parametric tests of hypotheses, Chi-square test, art of interpretation and writing research reports
- Discuss various forms of the intellectual property, its relevance and business impact in the changing global business environment and leading International Instruments concerning IPR.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
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	3rd Edition, 2011
3	Study Material (For the topic Intellectual Property under module 5)	Professional Programme Intellectual Property Rights, Law and Practice, The Institute of Company Secretaries of India, Statutory Body Under an Act of Parliament, September 2013.		
Reference Books				
1	Research Methods: the concise knowledge base	Trochim	Atomic Dog Publishing	2005
2	Conducting Research Literature Reviews: From the Internet to Paper	Fink A	Sage Publications	2009

*** END ***

M.TECH AEROSPACE PROPULSION TECHNOLOGY (MAP)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -II

COMPUTATIONAL FLUID DYNAMICS

Course Code	**20MAP21**	CIE Marks	40
Teaching Hours/Week (L:T:P)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

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 andits 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.

Module-2

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**.**

Module-3

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)

Module-4

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.

Module-5

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.

Course outcomes:

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

1. Develop grids around given shapes and transform the physical domain in to computational domain
2. Develop adaptive structured and unstructured grids
3. Apply knowledge to solve CFD problems through finite difference and finite volume

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have 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.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Computational Fluid Dynamics, The Basics with Applications	John D Anderson Jr.	McGraw Hill International Edn	2nd edition &1995
2	Computational Fluid Dynamics	T J Chung	Cambridge University Press	2nd edition &2008
Reference Books				
1	Computational Fluid Dynamics - An Introduction	F. Wendt (Editor)	Springer – Verlag, Berlin	3rd edition &2009.
2	Numerical Computation of Internal and External Flows, Vols. I and II	Charles Hirsch	John Wiley & Sons, New York	1st edition &1988.
3	Computational Fluid Dynamics- A Practical Approach	JiyuanTu, Guan HengYeoh, and Chaoqun Liu	Elsevier Inc	2008

M.TECH AEROSPACE PROPULSION TECHNOLOGY (MAP)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -II

FUELS AND COMBUSTION

Course Code	**20MAP22**	CIE Marks	40
Teaching Hours/Week (L:T:P)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

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.

Module-2

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).

Module-3

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 Vapour and Air.

Module-4

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, Evaporation-Controlled Systems, Reaction- and Evaporation-Controlled Systems.

Module-5

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.

Course outcomes:

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

1. Distinguish fuels their properties their treatment for aerospace applications.
2. Use the knowledge on fundamentals of combustion.
3. Apply the combustion flame characterization, combustion performance, fuel stabilization and classification.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have 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.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
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
3	Fuels & Combustion	Samir Sarkar	Orient Long man	1996
Reference Books				
1	Coal, Coke and Coal Chemicals	Wilson, P.J. and J.H. Wells	McGraw-Hill, New York,	1960.
2	Liquid Fuels	Williams, D.A. and G. James	London Pergamon, London	1963
3	Gas Engineers Handbook	C George Segeler	Industrial Press, New York,	1966

M.TECH AEROSPACE PROPULSION TECHNOLOGY (MAP)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -II

HEAT TRANSFER IN PROPULSION SYSTEMS

Course Code	**20MAP23**	CIE Marks	40
Teaching Hours/Week (L:T:P)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Fundamentals: Conduction, Convection, Radiation, Concept of boundary layers - velocity / thermal. Need for turbine blade cooling, turbine cooling technology, turbine heat transfer and cooling issues.

Turbine-Stage Heat Transfer: Introduction, Real engine turbine stage, simulated turbine stage, time-resolved heat-transfer measurement on a rotor blade. Cascade blade heat transfer. Airfoil end wall heat transfer. Turbine rotor blade tip heat transfer. Leading edge region heat transfer. Flat surface heat transfer.

Module-2

Turbine Film Cooling: Fundamentals of film cooling. Film cooling on rotating turbine blades. Film cooling on cascade vane simulations, Film cooling on cascade blade simulations, Film cooling on airfoil end walls. Turbine blade tip film cooling. Leading edge region film cooling. Flat surface film cooling. Film cooling effectiveness. Discharge coefficient of turbine cooling holes. Film cooling effect on aerodynamic losses.

Jet Impingement Cooling: Heat transfer enhancement by a single jet, Impingement heat transfer in the mid-chord region by jet array, Impingement cooling of leading edge.

Module-3

Rib Turbulated Cooling: Effect of rib layouts and flow parameters on ribbed channel heat transfer, heat transfer coefficient and friction factor correlation, high performance ribs, effect of surface heating conditions, nonrectangular cross section channels, effect of high blockage ratio ribs, effect of rib profile effect of number of ribbed walls, effect of a 180^{o} sharp turn, detailed heat transfer coefficient measurements in ribbed channel, effect of film cooling hole on ribbed channel heat transfer.

Module-4

Pin Fin Cooling: Flow and heat transfer analysis with single pin, pin array and correlation, effect of pin shape on heat transfer, effect of nonuniform array and flow convergence, effect of skewed pin array, partial pin arrangements, effect of turning flow, pin fin cooling with ejection, effect of missing pin on heat transfer coefficient.

Temperature Measurement Techniques: Infrared thermography, Thermocouples, Heat flux gauges, Liquid crystal thermography, Temperature sensitive paints. Engine Temperature and Health Monitoring- Thermal barrier coatings, Engine temperature monitoring, Engine safety and health monitoring.

Module-5

Compound and new cooling techniques: Impingement on ribbed walls, impingement on pinned and dimpled walls, combined effect of ribbed wall with grooves, combined effect of ribbed walls with pins and impingement inlet conditions, combined effect of swirl flow and ribs, impingement heat transfer with perforated baffles, combined effect of swirl and impingement. Concept of heat pipe for turbine cooling, new cooling concepts.

Course outcomes:

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

1. Apply fundamentals of heat transfer in aero engines.
2. Distinguish turbine film cooling, jet impingement cooling.
3. Apply cooling and their techniques (such as Rib turbulated cooling, pin fin cooling and temperature measurement techniques)

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have 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.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Gas Turbine Heat Transfer and Cooling	Technology Je Chin Han, Sandip Dutta & Srinath V Ekkad.	Taylor and Francis New York	2000
2	Heat Transfer	JP Holman	McGraw – Hill Book Company	1996
Reference Books				
1	Gas Turbine Handbook	Anthony Giampaolo	Fairmont Pr	1997
2	Engine health monitoring as applied to gas turbine engines	NAL, Bangalore		1983
3	Measurement techniques in heat transfer	Eckert, E R G and Goldstein R J Ed	Washington: Hemisphere Pub. Corp.	

M.TECH AEROSPACE PROPULSION TECHNOLOGY (APT)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -II

FATIGUE AND FRACTURE MECHANICS

Course Code	**20MAP241**	CIE Marks	40
Teaching Hours/Week (L:T:P)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

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.

Module-2

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.

Module-3

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.

Module-4

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.

Module-5

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.

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

1. Apply principles of fracture mechanics
2. Solve problems related to plastic fracture mechanics
3. Model Computational fracture mechanics

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have 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.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Introduction to Fracture Mechanics	Karen Helen	McGraw Hill	2000.
2	Fracture of Engineering Brittle Materials	Jayatilake	Applied Science, London	2001
Reference Books				
1	Fracture Mechanics Application	T. L. Anderson	CRC press	1998
2	Elementary Engineering Fracture of Mechanics	David Broek, ArtinusNijhoff, London	Springer	1999

M.TECH AEROSPACE PROPULSION TECHNOLOGY (APT)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -II

ENGINE PERFORMANCE, CONTROL AND SIMULATION

Course Code	**20MAP242**	CIE Marks	40
Teaching Hours/Week (L:T:P)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

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.

Module-2

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.

Module-3

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

Module-4

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

Module-5

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.

Course outcomes:

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

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

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have 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.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
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	1st edition &1984
Reference Books				
1	Aircraft Engine Design	Jack. D. Mattingly, William H. Heiser, David.T.Pratt	AIAA Education Series	3rd edition & 2017
2	Jet Propulsion	Nicholas Cumpsty	Cambridge University Press	1997
3	Aircraft Propulsion	Saeed Farokhi	John Wiley & Sons, Inc	2nd edition 2014
4	Aircraft Propulsion and Gas Turbine Engines	Ahmed F. E1-Sayed	CRC Press, Taylor and Francis Group	2nd edition &2017
5	Gas Turbine Performance	Philip P. Walsh and Paul Fletcher	Blackwell Science Ltd, Blackwell Publishing company	1998
6	Systems of Commercial Turbo Fan Engines-An Introduction to System Functions,	Andreas Linke-Diesinger	Springer Publications	2008

M.TECH AEROSPACE PROPULSION TECHNOLOGY (APT)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -II

AEROSPACE STRUCTURES

Course Code	**20MAP243**	CIE Marks	40
Teaching Hours/Week (L:T:P)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

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

Module-2

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.

Module-3

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.

Module-4

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

Module-5

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

Course outcomes:

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

1. Identify the problems of aero structures.
2. Evaluate the importance of theories on sections of aero structures.
3. Analyze the aircraft structures.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have 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.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
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
3	Mechanics of Composite Materials	Autar K. Kaw	CRC Press LLC	1997
Reference Books				
1	Aircraft Structures	Peery, D.J. and Azar, J.J	McGraw-Hill, New York	2nd Edition 1993
2	Theory and Analysis of Flight structures	Rivello, R.M	McGraw-Hill, N.Y	1993
3	Analysis and Performance of fiber composites	B.D. Agarwal and L.J. Broutman	John-Wiley and Sons	1990

M.TECH AEROSPACE PROPULSION TECHNOLOGY (APT)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -II

NUMERICAL METHODS IN COMBUSTION

Course Code	**20MAP244**	CIE Marks	40
Teaching Hours/Week (L:T:P)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

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.

Module-2

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.

Module-3

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.

Module-4

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.

Module-5

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.

Course outcomes:

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

1. Solve laminar premixed and diffusiom flame problems in combustion
2. Distinguish different types of turbulent flames numerically
3. Appreciate the reactive and non-reactive combustion through numerial methods

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have 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.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
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

M.TECH AEROSPACE PROPULSION TECHNOLOGY (APT)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -II

RAMJET AND SCRAMJET

Course Code	**20MAP251**	CIE Marks	40
Teaching Hours/Week (L:T:P)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

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.

Module-2

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, axi-symmetric intake.

Module-3

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

Module-4

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

Module-5

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

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

1. Use the basics of ramjet and scramjet engines.
2. Apply principles of operation and engine performance.
3. Distinguish different progresses in ramjet and scramjet propulsions

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have 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.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Hypersonic airbreathing propulsion	William H. Heiser, David T. Pratt	AIAA	1994
2	Scramjet Propulsion, Progress in Astronautics and Aeronautics	ET Curran and S N B Murthy	AIAA	2001
Reference Books				
1	Ramjet Technology	EA Bunt and others	US Defence	

M.TECH AEROSPACE PROPULSION TECHNOLOGY (APT)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -II

MECHANICAL ASPECTS OF ROTATING MACHINERY

Course Code	**20MAP252**	CIE Marks	40
Teaching Hours/Week (L:T:P)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Introduction: Definition of a rotating machinery, parts of a rotating machinery w.r.t 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.

Module-2

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.

Module-3

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

Module-4

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.

Module-5

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

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

1. Distinguish the basics of concept and different kind of loads in rotating components of systems.
2. Apply knowledge systems in use.
3. Appreciate different systems and do optimization of their designs.

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have 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.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Mechanical Vibration	W.T. Thomson	Prentice- Hall	5th Edition 1997.
2	Rotor dynamics 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

M.TECH AEROSPACE PROPULSION TECHNOLOGY (APT)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -II

ADVANCED COMPOSITES MATERIALS

Course Code	**20MAP253**	CIE Marks	40
Teaching Hours/Week (L:T:P)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

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.

Module-2

Macro & Micro behavior of a lamina: Stress strain relationship for an orthotropic Lamina- Restriction on elastic constants-Strengths 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.

Module-3

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, nano composites.

Module-4

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.

Module-5

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.

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

1. Use the science of composite materials and micro and macro behaviour of a lamina.
2. Distinguish and apply the composite materials for thermal, electrical/electro-magnetic applications.
3. Apply composites for thermoelectric, dielectric and smart structure applications.

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have 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.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
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	ASTM STP Publication,	1996
2	Composite materials-Properties as Influenced by Phase geometry	Nielson	Springer-Verlag Berlin Heidelberg	2005

M.TECH AEROSPACE PROPULSION TECHNOLOGY (APT)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -II

Introduction to reacting flows

Course Code	20MAP254	CIE Marks	40
Teaching Hours/Week (L:T:P)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

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.

Module-2

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

Module-3

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

Module-4

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.

Module-5

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 Nonideal-Flow Reactors.

Course outcomes:

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

1. Analyze the transport processes.
2. Apply constitutive laws for engineering applications
3. Describe momentum transport mechanisms, rates, and coefficients in a flow.
4. Understand energy transport mechanisms, rates, and coefficients in a flow.
5. Explain mass transport mechanisms, rates, and coefficients

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have 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.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Transport Processes in Chemically Reacting Flow Systems	Daniel E. Rosner	Dover Publ, Inc. USA.	2000
2				
Reference Books				
1	Multiphase Flow and Transport Process in Subsurface	Rainer Helmig	Springer Publ Inc., Germany.	1997.
2				
3				

M.TECH AEROSPACE PROPULSION TECHNOLOGY (APT)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -II

CFD LABORATORY

Course Code	20MAPL26	CIE Marks	40
Teaching Hours/Week (L:T:P)	0:0:4	SEE Marks	60
Credits	02	Exam Hours	03

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.
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.
11	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:

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

1. Solve different flows such as laminar and turbulent flows.
2. Compute flow using commercially available softwares.
3. Conduct CFD experiments and compare the results from computations.

M.TECH AEROSPACE PROPULSION TECHNOLOGY (APT)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -II

TECHHNICAL SEMINAR

Course Code	20MAP27	CIE Marks	100
Number of contact Hours/week (L:T:P)	0:0:2	SEE Marks	--
Credits	02	Exam Hours	--

Course objectives:

The objective of the seminar is to inculcate self-learning, face audience confidently, enhance communication skill, involve in group discussion and present and exchange ideas.

Each student, under the guidance of a Faculty, is required to

- Choose, preferably through peer reviewed journals, a recent topic of his/her interest relevant to the Course of Specialization.
- Carryout literature survey, organize the Course topics in a systematic order.
- Prepare the report with own sentences.
- Type the matter to acquaint with the use of Micro-soft equation and drawing tools or any such facilities.
- Present the seminar topic orally and/or through power point slides.
- Answer the queries and involve in debate/discussion.
- Submit two copies of the typed report with a list of references.

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.

The CIE marks for the seminar shall be awarded (based on the relevance of the topic, presentation skill,

Marks distribution for CIE of the course 20MAP27seminar:

Seminar Report: 30 marks
Presentation skill:50 marks
Question and Answer:20 marks

*** END ***

M.TECH AEROSPACE PROPULSION TECHNOLOGY (APT)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -III

AEROSPACE INSTRUMENTATION AND CONTROLS

Course Code	**20MAP31**	CIE Marks	40
Teaching Hours/Week (L:T:P)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

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

Module-2

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.

Module-3

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.

Module-4

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 controllability, definition of state controllability, alternate tests on controllability, Definition of observability, alternate tests on observability, relationship among controllability, observability and transfer functions.

Module-5

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.

Course outcomes:

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

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

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have 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.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Instrumentation, Measurement and Analysis	Nakra and Chaudhry, B C Nakra K KChaudhry	Tata McGraw-Hill Companies, Inc, New York	Seventh Edition 2006
2	Mechanical measurements	R. S. Sirohi, H. C. Radha Krishna	NewAge International Pvt. Ltd., New Delhi	2004
3	Automatic Control Systems	B.C. Kuo	Prentice Hall Inc	9th edition &2014
4	Modern Control Engineering	K. Ogata	Prentice Hall Inc.	5th edition &2010
Reference Books				
1	Introduction to Measurements and Instrumentation‖	Arun K. Ghosh	Prentice-Hall of India	2nd Edition 2007
2	Automatic Control Systems	Harrison & Bollinger	International Text Book Company	1969
3	Automatic Control Engineering	Francis H. Raven	McGraw- Hill International	2nd edition &1955

M.TECH AEROSPACE PROPULSION TECHNOLOGY (APT)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -III

ADVANCED BEARINGS AND ROTOR DYNAMICS

Course Code	**20MAP321**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

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.

Module-2

Fundamentals of rotor dynamics: Objective of Rotor dynamic Analysis, Concept of rigid and flexural critical speeds and mode shapes, 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

Module-3

Concepts 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.

Module-4

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.

Module-5

Case Studies: 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.

Course outcomes:
At the end of the course the student will be able to:
1. Apply the fundamentals of bearings and rotor dynamics
2. Distinguish vibration related phenomenon in bearings and their challenges
3. Apply bearing materials, sensors and measurements

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have 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.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Rotor dynamics	JS Rao	New Age International Publishers	3rd edition &2018

2	Machinery Vibration and rotor Dynamics	John Vance, Fouad Zeidan and Brian Murphy	John Wiley & Sons	1st edition &2010
Reference Books				
1	Rotor Dynamics	Agnieszka Muszyńska	CRC Press	1st edition &2005
2	Rotor Dynamics of Turbo machinery	John M. Vance	John Wiley & Sons	1st edition &1988
3				

M.TECH AEROSPACE PROPULSION TECHNOLOGY (APT)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -III

HYPERSONIC AERODYNAMICS

Course Code	**20MAP322**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

General Considerations. Characteristics General features of hypersonic flow field. Assumptions underlying inviscid hypersonic theory. Normal shock waves, oblique & curved shocks. Mach number independence principles. General strip theory.
Small Disturbance Theory. Introduction to basic equations. Hypersonic Similitude, United supersonic-hypersonic similitude. Slender – body strip theory.

Module-2

Small Disturbance Theory. Slightly blunted slender bodies, large incidence & correlation of Similitude. Unsteady flow theory. Non equilibrium effects.

Newtonian Theory. Two-dimensional axis symmetric bodies, simple shapes & free layers. Optimum shapes, shock layer structure.

Module-3

Newtonian Theory. Shock layer structure with cross flow. Conical flow, bodies of revolution at small incidences.
Theory of Thin Shock Layers. Basic concepts, successive approximation schemes. Constant stream tube-area approximation. Two-dimensional axis symmetric blunt faced bodies.

Module-4

Viscous Flows. Hypersonic Viscous effects, Boundary Layer equations. Similar laminar boundary layer solutions. Local similarity concept. Viscous interactions - flow models and interaction parameters. Weak pressure interaction. Strong pressure interaction. General features of rarified gas flows.

Module-5

Hypersonic Testing. Hypersonic Scaling, high enthalpy & high speed, types of hypersonic facilities. Shock tunnels & expansion tubes. Features of Hypersonic wind tunnel design. Instrumentation to hypersonic vehicle testing. Test model similarity laws.

Course outcomes:
At the end of the course the student will be able to:
1. Apply knowledge of oblique and curved shock waves and shock wave structure
2. Solve problems related to hypersonic viscous effects
3. Model hypersonic wind tunnel testing

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have 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.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Hypersonic Inviscid Flows	Wallace D Hayes &	Dover Publication	2004
2	Hypersonic Flow Theory	Wallace Hayes	Academic Press Inc	1959
Reference Books				
1	Hypersonic and High Temperature Gas Dynamics	John D Anderson Jr	AIAA	2000
2	Advanced Hypersonic Test Facilities	Frank K.Lu and Dart E. Marran	AIAA	2002
3	Introduction to Hypersonic Flow	Cherynl C.G.	Academic Press	1961

M.TECH AEROSPACE PROPULSION TECHNOLOGY (APT)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -III

ADVANCED GAS TURBINES

Course Code	**20MAP323**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

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

Module-2

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.

Module-3

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

Module-4

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.

Module-5

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

Course outcomes:
At the end of the course the student will be able to:
1. Model jet propulsion cycles
2. Select the materials for various components and involve in manufacturing of various parts
3. Solve problems related to performance of compressors and turbines

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have 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.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Gas turbines	V Ganesan	Tata McGraw-Hill Publishing company limited	3rd edition &2017
2	Gas turbine theory	H.I.H Saravanamuttoo, G.F.C. Rogers and H. Cohen PV Straznicky	Pearson Education Canada	7th edition &2017
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	1972
3	Aircraft Gas Turbine Engine	E. Irwin Treager		3rd Edition

M.TECH AEROSPACE PROPULSION TECHNOLOGY (APT)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -III

ADVANCED MATERIALS FOR AEROSPACE APPLICATIONS

Course Code	**20MAP324**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Introduction:

Mechanical Behaviors and their Origins-Atomic packing and bonding of condensed matters-Elasticity-Anelasticity-Plasticity and Creep. Aerospace Materials: Design, Fabrication, and Characterization-Grains and interfaces/interphases-Metal alloys-Polymers and composites.

Module-2

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.

Module-3

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.

Module-4

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..

Module-5

Advanced Materials: Engineering in Multiple Scales-Case studies: nano-engineered materials, bio-inspired materials, metamaterials -Existing challenges: scalable manufacturing, certification, unknowns.

Course outcomes:

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

1. Identify the types of materials for aerospace applications.
2. Select the materials for various components and involve in manufacturing of various parts
3. Use the smart and intelligent materials to solve problems related to aerospace vehicle design.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have 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.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
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
3.	Materials for Missiles and Spacecraft	E.R. Parker	McGraw Hill	1978
Reference Books				
1	Ceramics: Mechanical Properties, Failure Behaviors, Materials Selection.	Munz and Fett	Springer	1999
2	Principle of Polymer Systems	Rodriguez, Cohen, Ober, and Archer	CRC Press	2003
3	Fracture Mechanics: Fundamentals	Anderson	CRC Press	1994

M.TECH AEROSPACE PROPULSION TECHNOLOGY (APT)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -III

MISSILES AND LAUNCH VEHICLES

Course Code	**20MAP331**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

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.

Module-2

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)theArienne 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 spaceshuttle main engine. Propellant slosh, propellant hammer, geysering effect in cryogenic rocket engines.

Module-3

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.

Module-4

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

Module-5

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 for thermal protection and for pressure vessels.

Course outcomes:

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

1. Identify the types of space launch vehicles and missiles.
2. Distinguish the solid and liquid propellant motors.
3. Classify different types of materials used for rockets and missiles.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have 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.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Rocket Propulsion Element	George P Sutton and Oscar Biblarz	John Wiley and Sons Inc	7th edition,2010
2	Missile Aerodynamics	Jack N Neilson	AIAA	1st edition, 1988
Reference Books				
1	Missile Configuration Design'	SS Chin		1st edition &1961
2	Rocket Propulsion and Space-Flight Dynamics	Cornelisse, J.W., Schoyer H.F.R. and Wakker,. K.F	Pitman	1979
3	Rocket and Spacecraft propulsion	Turner, M.J.L	Springer	3rd edition,2010
4	Space Vehicle Dynamics	Ball, K.J., Osborne, G.F.,	Oxford University Press	1967
5	Materials for Missiles and Spacecraft	Parker, E.R	McGraw Hill	1982

M.TECH AEROSPACE PROPULSION TECHNOLOGY (APT)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -III

ADVANCED PROPULSION SYSTEMS

Course Code	**20MAP332**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Advanced Cryogenic & LOX-HC Engines - Introduction to cryogenics and its applications, Properties of Cryogenic fluids, Engine cycles, system level analysis, testing, thrust chamber, turbo pumps, cryotanks. HC Engines. Engines for booster and upper stages. LOX Kerosene & LOX-Methane engines. Liquid Oxygen and Hydrocarbon, liquid rocket engine (LRE) for application as main engines & booster stages of Launchers- Different LRE cycles.

Module-2

Green Propellants Propellant-less Propulsion. Environmental effects of space propellants (toxicity, pollution, performance aspects). Liquid bio-propellant (H2-O2, N2O4-, etc.) for main engines. Solid propellant (NH4ClO4) for the booster. Momentum exchange tether, electro-dynamic tether, Solar thermal propulsion for upper stages, solar sails, magnetic sails. Beamed energy -Earth to Orbit Propulsion.

Module-3

Miniaturised Propulsion & Electrical Propulsion Systems. Classification of mission requirement. Micro-propulsion technologies; solid micro thruster, micro bi-propellant thruster, cold gas thruster, Integration aspects in micro-spacecraft. Electrical Propulsion Systems. State-of-the-art in electrical propulsion system, high-power gridded ion thruster (GIT), high – power Hall Effect thruster (HET), high- power applied-field magneto plasma dynamic thruster (MPDT), and double stage HET. Micro Ion thruster, Microchip laser thruster. Colloid thruster. Fundamentals of ion propulsion
body design considerations.

Module-4

Nuclear Propulsion. Nuclear rocket engine design and performance, nuclear rocket reactors, nuclear rocket nozzles, nuclear rocket engine control, radioisotope propulsion, basic thrusters configuration, thrusters technology, heat source development, nozzle development, nozzle performance of radio isotope propulsion systems. Testing of Nuclear rocket engines

Module-5

Other Advance Propulsion Technologies. Super Conductivity-Property of material-super conductivity state, conduction, electrons propagation. Effect of temperature on material conductivity. Type-I and type-II materials.
Chemical propellant system - advanced propellants, high energy density matter (HEDM), alternative design-pulse detonation rocket.
Laser Propulsion System- General Concept. Laser accelerated Plasma Propellant. Test Techniques and safety for Advance Propulsion Technologies.

Course outcomes:
At the end of the course the student will be able to:
1. Other Advance Propulsion Technologies. Super Conductivity-Property of material-super conductivity state, conduction, electrons propagation. Effect of temperature on material conductivity. Type-I and type-II materials.
2. Chemical propellant system - advanced propellants, high energy density matter (HEDM), alternative design-pulse detonation rocket.
3. Laser Propulsion System- General Concept. Laser accelerated Plasma Propellant. Test Techniques and safety for Advance Propulsion Technologies.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have 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.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Advance Propulsion Systems & Technologies: Today to 2020	Claudio Bruno, and Antonio Accettura	AIAA	2008
2	Rocket Propulsion Elements	G P Sutton	John Wiley & Sons Inc., New York	1998
Reference Books				
1	Advanced Space Propellant Systems	Martin Tajmar	Springer	2003
2	Hypersonic Airbreathing Propulsion	William H. Heiser and David T. Pratt	AIAA Education Series,	2001
3	Spacecraft Systems Engineering	Fortescue and Stark	Wiley	4th 2011

M.TECH AEROSPACE PROPULSION TECHNOLOGY (APT)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -III

GAS TURBINES AND ROCKET PROPULSION

Course Code	**20MAP333**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Categories of propulsion system, air breathing engines, non-air breathing engines, thrust of turbojet, turbofan, ramjet and rockets, Performance parameters of propulsion systems

Module-2

Gas turbine components, flow through gas turbine components like inlets, compressor, combustor, turbine and nozzles, Gas turbine component characteristics, propeller, propeller performance.

Module-3

Gas turbine engine basic cycle, ideal and real cycle, T-S diagram, turbo jet, turbofan and turboprop engines, turbofan with mixed and un mixed jets, Concept of spooling, Engine rating, concept of flat rating Thrust and SFC variation with flight Mach number and altitude, Commercial gas turbine engines.

Single and two spool engine matching, matching of turbojet and turbo fan engines, Design point optimization of gas turbine engine, Engine sizing, Installed performance and uninstalled performance, Gas turbine engine evaluation in test beds

Module-4

Velocity increment and mass ratio, burnout velocity and distance, specific impulse, trajectory and gravity turn, coasting height, multi staging, satellite and escape velocity.

Aero-thermo chemistry, Chemical rockets, internal ballistics of solid propellant rockets, performance parameters, Liquid propellant rockets, components and its performance, propellant-general, liquid and solid propellant.

Module-5

Hybrid rockets, status and development of chemical rockets, Electro thermal rocket engines, performance parameters, propellants, resistance heating, arc heating, electrode less discharge, Electromagnetic propulsion, principle of operation, pulse plasma accelerators, travelling wave accelerators, propellants, performance of E-M accelerators. Ion Propulsion, Performance parameters, efficiency of ions, acceleration of the beam, beam neutralization, optimum specific impulse, acceleration –deceleration system, heavy ion.

Course outcomes:

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

1. Use the fundamentals of gas turbines and rocket propulsion.
2. Apply the basic cycles and theory of propulsion.
3. Distinguish types of propulsion and types of rocket fuels.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have 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.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Rocket Propulsion Elements	Sutton, G.P.,	John Wiley & sons	5th Edition,
2	Aerospace Propulsion	D.G.Shepherd	American Elsevier Publishing Company, Inc.	1972
3	Elements of Gas Turbine Propulsion	Jack D. Mattingly	Tata McGraw-Hill Publishing Company	1996.
Reference Books				
1	Aircraft Engine Design	Jack. D. Mattingly,	AIAA Education	3rd edition
2	Aerothermodynamics of Gas Turbine and Rocket Propulsion	Gordon C. Oates	AIAA Education Series	1st edition &1984
3	Fundamentals of Gas Turbines	William W. Bathe,	John Wiley and Sons	
4	Gas Turbine Theory	HIH Sarvanamuttoo, GFC Rogers, H.Cohen	Pearson Education, Asia	5th Edition,
5	Mechanics & Thermodynamics of Propulsion	Hill, P.G and Peterson, CR	Addition-Wesley Longman INC	1999.

M.TECH AEROSPACE PROPULSION TECHNOLOGY (APT)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -III

Introduction to Artificial intelligence and machine learning

Course Code	20MAP334	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Introduction to Data Science and AI & ML, Data Science, AI & ML, Essential Concepts in AI and ML Data Understanding, Representation and Visualisation

Module-2

Machine Learning: Linear Methods, Linear Regression, Multiple Linear Regression, Non-Linear Regression, Clustering, Forecasting models, Perceptron and Neural Network, Decision Trees, Support Vector Machines.

Module-3

Probabilistic Models, Dynamic programming and Reinforcement Programming, Evolutionary Algorithms, Time Series Models, Deep Learning, Emerging Trends in ML, Unsupervised Learning

Module-4

Foundations for AI, AI Basics , AI Classification, Supervised Learning, Feature Engineering Regression, Model Selection, Model Performance , Ranking

Module-5

Introduction to ML with R and using Python, Python and R for Artificial Intelligence, Machine Learning, and Data Science, AI/ML in aerospace industry

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

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have 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.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Machine Learning and Artificial Intelligence	Ameet V Joshi	Springer	2019
2	Artificial Intelligence and Machine Learning fundamentals	Zsolt Nagy	Packt Publishing	2018
Reference Books				
1	Artificial Intelligence and Machine Learning	Vinod Chandra SS	PHI Learning	2014

2	Basics of Artificial Intelligence and Machine Learning	DheerajMehrotra	Notion Press	2019
3				

M.TECH AEROSPACE PROPULSION TECHNOLOGY (APT)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -III

PROJECT WORK PHASE – 1

Course Code	20MAP34	CIE Marks	100
Number of contact Hours/Week (L:T:P)	0:0:2	SEE Marks	--
Credits	02	Exam Hours	--

Course objectives:

- Support independent learning.
- Guide to select and utilize adequate information from varied resources maintaining ethics.
- Guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- Develop interactive, communication, organisation, time management, and presentation skills.
- Impart flexibility and adaptability.
- Inspire independent and team working.
- Expand intellectual capacity, credibility, judgement, intuition.
- Adhere to punctuality, setting and meeting deadlines.
- Instil responsibilities to oneself and others.
- 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 Phase-1 Students in consultation with the guide/s shall carry out literature survey/ visit industries to finalize the topic of the Project. Subsequently, the students shall collect the material required for the selected project, prepare synopsis and narrate the methodology to carry out the project work.

Seminar: Each student, under the guidance of a Faculty, is required to

- Present the seminar on the selected project orally and/or through power point slides.
- Answer the queries and involve in debate/discussion.
- Submit two copies of the typed report with a list of references.

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.

Revised Bloom's Taxonomy Level	L_3 – Applying, L_4 – Analysing, L_5 – Evaluating, L_6 – Creating.

Course outcomes:

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

- Demonstrate a sound technical knowledge of their selected project topic.
- Undertake problem identification, formulation and solution.
- Design engineering solutions to complex problems utilising a systems approach.
- Communicate with engineers and the community at large in written an oral forms.
- Demonstrate the knowledge, skills and attitudes of a professional engineer.

Continuous Internal Evaluation

CIE marks for the project report (50 marks), seminar (30 marks) and question and answer (20 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session by the student) by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculty from the department with the senior most acting as the Chairperson.

M.TECH AEROSPACE PROPULSION TECHNOLOGY (APT)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -III

MINI PROJECT

Course Code	20MAP35	CIE Marks	40
Number of contact Hours/Week (L:T:P)	(0:0:2)	SEE Marks	60
Credits	02	Exam Hours/Batch	03

Course objectives:

- To support independent learning and innovative attitude.
- To guide to select and utilize adequate information from varied resources upholding ethics.
- To guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- To develop interactive, communication, organisation, time management, and presentation skills.
- To impart flexibility and adaptability.
- To inspire independent and team working.
- To expand intellectual capacity, credibility, judgement, intuition.
- To adhere to punctuality, setting and meeting deadlines.
- To instil responsibilities to oneself and others.
- 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: Each student of the project batch shall involve in carrying out the project work jointly in constant consultation with internal guide, co-guide, and external guide and prepare the project report as per the norms avoiding plagiarism.

Course outcomes:

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

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

CIE procedure for Mini - Project:

The CIE marks awarded for Mini - Project, shall be based on the evaluation of Mini - Project Report, Project Presentation skill and Question and Answer session in the ratio 50:25:25.The marks awarded for Mini - Project report shall be the same for all the batch mates.

Semester End Examination

SEE marks for the mini-project shall be awarded based on the evaluation of Mini-Project Report, Presentation skill and Question and Answer session in the ratio 50:25:25 by the examiners appointed by the University.

M.TECH AEROSPACE PROPULSION TECHNOLOGY (APT)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -III

INTERNSHIP / PROFESSIONAL PRACTICE

Course Code	20MAPI36	CIE Marks	40
Number of contact Hours/Week	0:0:2	SEE Marks	60
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 and risk management, paperwork, equipment ordering, maintenance, responding to emergencies etc. The objective are further,

- To put theory into practice.
- 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.

Internship/Professional practice: 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 of internship.
Seminar: Each student, is required to

- Present the seminar on the internship orally and/or through power point slides.
- Answer the queries and involve in debate/discussion.
- Submit the report duly certified by the external guide.
- 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 the internship is done.
- Acquire knowledge of the industry in which the internship is done.
- Apply knowledge and skills learned to classroom work.
- Develop a greater understanding about career options while more clearly defining personal career goals.
- Experience the activities and functions of professionals.
- Develop and refine oral and written communication skills.
- Identify areas for future knowledge and skill development.

Continuous Internal Evaluation
CIE marks for the Internship/Professional practice report (20 marks), seminar (10 marks) and question and answer session (10 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session by the student) by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculty from the department with the senior most acting as the Chairperson.

Semester End Examination

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

M.TECH AEROSPACE PROPULSION TECHNOLOGY (APT)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)
SEMESTER -IV

PROJECT WORK PHASE -2

Course Code	20MAP41	CIE Marks	40
Number of contact Hours/Week(L:T:P)	0:0:4	SEE Marks	60
Credits	20	Exam Hours	03

Course objectives:

- To support independent learning.
- To guide to select and utilize adequate information from varied resources maintaining ethics.
- To guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- To develop interactive, communication, organisation, time management, and presentation skills.
- To impart flexibility and adaptability.
- To inspire independent and team working.
- To expand intellectual capacity, credibility, judgement, intuition.
- To adhere to punctuality, setting and meeting deadlines.
- To instil responsibilities to oneself and others.
- 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: Each student of the project batch shall involve in carrying out the project work jointly in constant consultation with internal guide, co-guide, and external guide and prepare the project report as per the norms avoiding plagiarism.

Course outcomes:

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

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

Continuous Internal Evaluation:

Project Report: 20 marks. The basis for awarding the marks shall be the involvement of the student in the project and in the preparation of project report. To be awarded by the internal guide in consultation with external guide if any.

Project Presentation: 10 marks.

The Project Presentation marks of the Project Work Phase -II shall be awarded by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculty from the department with the senior most acting as the Chairperson.

Question and Answer: 10 marks.

The student shall be evaluated based on the ability in the Question and Answer session for 10 marks.

Semester End Examination

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