Semester 2

Semester- 2

Missile and Launch Vehicles			
Course Code	MMAP201	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:00:00	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03 Hrs

Course Learning objectives:

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

Module-1 (8 hours)

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

Module-2(8 hours)

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

Liquid Propellant Rocket Motor Systems: Liquid propellants, types, composition, properties, performance. Propellant tanks, feed systems, pressurization, turbo-pumps, valves and feed lines, injectors, starting and ignition. Engine cooling, support structure. Control of engine starting and thrust build up, system calibration, integration and optimisation –

safety and environmental concerns. Description of the space shuttle main engine. Propellant slosh, propellant hammer, geysering effect in cryogenic rocket engines.

Module-3(8 hours)

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

Module-4(8 hours)

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

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

Module-5(8 hours)

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

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

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

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

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

Semester-End Examination:

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

Suggested Learning Resources:

Text books:

1. Rocket Propulsion Element', George P Sutton and Oscar Biblarz, John Wiley and Sons Inc,7th edition, 2010,ISBN-13: 978-8126525775.
2. 2. 'Missile Aerodynamics', Jack N Neilson, AIAA,1st edition, 1988,ISBN-13: 978-0962062902.

Reference books:

1. 'Missile Configuration Design', S SChin,.
2. Rocket Propulsion and Space-Flight Dynamics, Cornelisse, J.W., Schoyer H.F.R. and Wakker,. K.F., Pitman, 1979,ISBN-13: 978-0273011415
3. Rocket and Spacecraft propulsion, Turner, M.J.L., Springer,3rd edition,2010,ISBN-13: 978-3642088698.
4. Space Vehicle Dynamics, Ball, K.J., Osborne, G.F., Oxford University Press, 1967,ISBN-13: 978-0198561071
5. Materials for Missiles and Spacecraft, Parker, E.R., McGraw Hill, 1982.

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=lbuCMYy7AeI/
- https://www.youtube.com/watch?v=XDtqd0V9N30
- https://www.youtube.com/watch?v=Ry0tcLC5LJU
- https://www.youtube.com/watch?v=ZEZV8LwAWcc
- https://www.youtube.com/watch?v=K8cwhVTJbmg
- https://www.youtube.com/watch?v=9xHuVQASRLU
- https://www.youtube.com/watch?v=bT5_RdecM6g
- https://www.youtube.com/watch?v=qG1O5ViEHes&list=PLUeHTafWecAXDFDYEwunLL2V2kwqKzkvJ
- https://www.youtube.com/watch?v=6qEqXurSV1s
- https://www.youtube.com/watch?v=sKkzHrhoSSw
- https://www.youtube.com/watch?v=--mOplQkKR0

Skill Development Activities Suggested

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

Course outcome (Course Skill Set)

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

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

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research /investigation and development work to solve practical problems.	PO1
2	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program	PO3
3	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems	PO4
4	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.	PO5
5	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	PO7
6	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	PO8

Mapping of COS and Pos

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

Semester - 2

Aerodynamics			
Course Code	MMAP202	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:02:00	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 10-12 Lab slots	Total Marks	100
Credits	04	Exam Hours	03 Hrs

Course objectives:

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

MODULE-1 (10hours)

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

MODULE-2 (8 hours)

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

MODULE-3 (8 hours)

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

MODULE-4 (8 hours)

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

MODULE 5 (6 hours)

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

Linearized Supersonic Flow : Introduction , Derivation of the Linearized Supersonic,Pressure Coefficient Formula, Application to Supersonic Airfoils,Viscous Flow: Supersonic Airfoil Drag.

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

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

Assessment Details (both CIE and SEE)

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

CIE for the theory component of IPCC

1. Two Tests each of **25 Marks**
2. Two assignments each of **25 Marks/One Skill Development Activity of 50 marks**
3. Total Marks of two tests and two assignments/one Skill Development Activity added will be CIE for 60 marks, marks scored will be proportionally scaled down to **30 marks**.

CIE for the practical component of IPCC

- On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The **15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.

- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for **10 marks**. Marks of all experiments' write-ups are added and scaled down to **15 marks**.
- The laboratory test at the end /after completion of all the experimentsshallbe conducted for **50 marks** and scaled down to **05 marks.**

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

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SEE for IPCC

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

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

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper shall include questions from the practical component).

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

Suggested Learning Resources:

Text books:

1. Fundamentals of Aerodynamics ,John D. Anderson, McGraw-Hill publication, 5th edition and 2010

2.Modern compressible flow, John D. Anderson , McGraw-Hill publication, 3rd edition and 2002

Reference books:

1. Aerodynamics for Engineering students, E L Houghton and P W Carpenter, Edward Arnold publication, 7th edition and 2016

2. Fundamentals of compressible flow , Yahya, S M.New Age International, 5th edition and 2016

3. Introduction to flight, John D. Anderson, McGraw-Hill publication, 6th Edition And 2008

Web links and Video Lectures (e-Resources):

- https://archive.nptel.ac.in/courses/101/106/101106033/
- https://archive.nptel.ac.in/courses/101/106/101106033/
- https://archive.nptel.ac.in/courses/101/104/101104018/
- https://www.digimat.in/nptel/courses/video/101101002/L42.htm

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

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

Course outcome (Course Skill Set)

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

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

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research /investigation and development work to solve practical problems.	PO1
2	An ability to write and present a substantial technical report/document.	PO2
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program	PO3
4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems	PO4
5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.	PO5
6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools	PO6
7	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	PO8

Mapping of COS and POs

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

Semester- 2

Introduction to Artificial intelligence and machine learning.			
Course Code	MMAP203	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:00:00	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03 Hrs

Course Learning objectives:

- Apply AI techniques to solve the given problems.
- Implement trivial AI techniques on relatively large system
- Explain uncertainty and Problem solving techniques.

Module-1 (8 Hours)

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

Module-2(8 Hours)

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(8 Hours)

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

Module-4(8 Hours)

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

Module-5(8 Hours)

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

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

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

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

Semester-End Examination:

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

Suggested Learning Resources:

Text books:

1. Machine Learning and Artificial Intelligence, Ameet V Joshi, Springer, 2019.
2. Artificial Intelligence and Machine Learning fundamentals, Zsolt Nagy, Packt Publishing, 2019

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

Web links and Video Lectures (e-Resources):

- https://onlinecourses.nptel.ac.in/noc22_cs56/preview/
- https://nptel.ac.in/courses/106106139/

Skill Development Activities Suggested

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

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Identify the AI based problems	L1,L2
CO2	Apply techniques to solve the AI problems	L3,L4
CO3	Define learning and explain various logic inference	L1,L3

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research /investigation and development work to solve practical problems.	PO1
2	An ability to write and present a substantial technical report/document.	PO2
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program	PO3
4	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools	PO6
5	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	PO7
6	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	PO8

Mapping of COS and POs

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

Semester- 2

AERO ENGINE TESTING AND PERFORMANCE EVALUATION			
Course Code	MMAP204	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:00:00	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03 Hrs

Course Learning objectives:

- Realize the basics on Engine Testing & Evaluation.
- Acquire the knowledge on thermodynamic testing on compressor, combustor, Turbine & nozzles.
- Gain knowledge on Engine performance & structural integrity test
- Apprehend the techniques of engine testing
- Recognize various test facilities & data acquisition techniques

Module-1 (6 Hours)

Introduction: Need For Gas Turbine Engine Testing And Evaluation, Philosophy Of Testing, Rationale of Testing. Types of tests: Proof of Concepts, Design Verification, Design Validation, and Formal Tests.

Module-2(10 Hours)

Aero Thermodynamic Tests:
Compressor: Compressor scaling parameter Groups, Compressor MAP. Inlet distortions. Surge margin stack up. Testing and Performance Evaluation, Test rig.
Combustor: Combustor MAP, Pressure loss, combustion light up test. Testing and Performance Evaluation.
Turbines: Turbine MAP. Turbine Testing And Performance Evaluation. Component model scaling.
Inlet duct & nozzles: Ram pressure recovery of inlet duct. Propelling nozzles, after burner, maximum mass flow conditions. Testing and Performance Evaluation.

Module-3(12 Hours)

Engine performance. Design & off-design Performance. Transient performance. Qualitative characteristics quantities. Transient working lines. Starring process & Wind milling of Engines. Thrust engine start envelope.
Calculations for design and off-design performance from given test data – (case study for a Jet Engine).
Qualification Tests: Tests used to evaluate a design. Environment ingestion capability. Preliminary flight rating tests, Qualification testing, acceptance tests, Reliability figure of merit. Structural integrity tests: DesignVerification Tests, Durability And Life Assessment Tests, Reliability Tests, Failure Simulation Tests, Functional and operatability Tests.

Module-4(6 Hours)

Types of engine tests: normally aspirated testing, ram air testing, altitude testing, flying test bed, mission oriented tests, open air test bed, ground testing of engine installed in aircraft, flight testing. Test procedure: test schedule preparation, test log sheets, test documents.

Module-5(6 Hours)

Test cell: Air breathing engine test facility. Direct connect altitude cell, propulsion wind tunnels. Types of engine test beds. Factors for design of engine test beds. Altitude test facility. Steps in test bed cross calibration. Engine testing with simulated inlet distortions. Surge test. Cell Calibration and Correction. Performance Reduction Methodology.
Instrumentation, Data Acquisition: Measurement of Thrust, Pressure, Temperature, Vibration, etc. Accuracy And Uncertainty In Measurements. Experimental Stress Analysis.

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

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

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

Semester-End Examination:

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

Suggested Learning Resources:

Text books:

1. Gas Turbine Performance -P.P Walsh and P. Peletcher, Blackwell Science, 1998, ISBN 0632047843.
2. Experimental methods for Engineers - J P Holman, Tata McGraw –Hill Publication Co. Ltd.,2007

Reference books:

1. Advance Aero-Engine Testing, AGARD-59 Publication
2. An inventory of Aeronautical Ground Research Facilities -NASA CR-1875,
3. Military Specifications: Engine, Aircraft, Turbo Jet &Turbofan; General Specification for Advance Aero Enginetesting - MIL –5007 E, 15th Oct 1973.

Web links and Video Lectures (e-Resources):

- https://www.sto.nato.int/publications/AGARD/AGARD-AR-245/AGARD-AR-245.pdf

Skill Development Activities Suggested

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

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Understand the basic required for engine testing & evaluation	L1, l2
CO2	Apply the thermodynamic tests on different parts of the engine	L3, L4
CO3	Analyse the Engine performance & structural integrity test	L3, L4
CO4	Apprehend the techniques of engine testing	L2
CO5	Recognize various test facilities & data acquisition techniques	L2, L3

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research /investigation and development work to solve practical problems.	PO1
2	An ability to write and present a substantial technical report/document.	PO2
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program	PO3
4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems	PO4
5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.	PO5

Mapping of COS and POs

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

Semester- 2

Computational Fluid Dynamics			
Course Code	MMAP205	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02:00:02	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03 Hrs

Course Learning objectives:

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

Module-1 (8 Hours)

Introduction: CFD ideas to understand, CFD Application, Governing Equations (no derivation) of flow; continuity, momentum, energy. Conservative &Non-conservative forms of equations, Integral vs Differential Forms of Equations. Form of Equations particularly suitable for CFD work. Shock capturing, Shock fitting, Physical Boundary conditions.

Mathematical Behaviour of Partial Differential Equations and Discretization: Classification of partial differential equations and its Impact on computational fluid dynamics; case studies. Essence of discritization, order of accuracy and consistency of numerical schemes, Lax's Theorem, convergence, Reflection Boundary condition.

Module-2(8 Hours)

Mathematical Behavior of Partial Differential Equations and Discretization: Higher order Difference quotients. Explicit & Implicit Schemes. Error and analysis of stability, Error Propagation. Stability properties of Explicit & Implicit schemes.

Solution Methods of Finite Difference Equations: Time & Space Marching. Alternating Direction Implicit (ADI) Schemes. Relaxation scheme, Jacobi and Gauss-Seidel techniques, SLOR technique. Lax-Wendroff first order scheme, Lax-Wendroff with artificial viscosity, upwind scheme, midpoint leap frog method.

Module-3(8 Hours)

Grid Generation: Structured Grid Generation: Algebraic Methods, PDE mapping methods, use of grid control functions, Surface grid generation, Multi Block Structured grid generation, overlapping and Chimera grids. Unstructured Grid Generation: Delaunay-Voronoi Method, advancing front methods (AFM Modified for Quadrilaterals, iterative paving method, Quad tree&Octree method)

Module-4(8 Hours)

Adaptive Grid Methods: Multi Block Adaptive Structured Grid Generation, Unstructured adaptive Methods. Mesh refinement methods, and Mesh enrichment method. Unstructured Finite Difference mesh refinement. **Approximate Transformation & Computing Techniques:** Matrices &Jacobian. Generic form of governing Flow Equations with strong conservative form in transformed space. Transformation of Equation from physical plane into computational Plane -examples. Control function methods. Variation Methods. Domain decomposition. Parallel Processing.

Module-5(8 Hours)

Finite Volume Techniques: Finite volume Discritisation-Cell Centered Formulation. High resolution finite volume upwind scheme Runge-Kutta stepping, Multi-Step Integration scheme. Cell vertex Formulation. Numerical Dispersion.

CFD Application to Some Problems: Aspects of numerical dissipation & dispersion. Approximate factorization, Flux Vector splitting. Application to Turbulence-Models. Large eddy simulation, Direct Numerical Solution. Post-processing and visualization, contour plots, vector plots etc, Familiarization

with CFD softwares and solvers.

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

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

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

Semester-End Examination:

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

Suggested Learning Resources:

Text books:

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

Reference books:

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

Web links and Video Lectures (e-Resources):

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

Skill Development Activities Suggested

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

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Develop grids around given shapes and transform the physical domain in to computational domain	L1,L2,L4
CO2	Develop adaptive structured and unstructured grids	L3,L4
CO3	Apply knowledge to solve CFD problems through finite difference and finite volume techniques and Analyse	L5

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research /investigation and development work to solve practical problems.	PO1
2	An ability to write and present a substantial technical report/document.	PO2
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program	PO3
4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems	PO4
5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.	PO5
6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools	PO6
7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	PO7
8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	PO8

Mapping of COS and POs

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

Semester- 2

Ramjet and Scramjet			
Course Code	MMAP216A	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:00:00	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03 Hrs

Course Learning objectives:

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

Module-1 (8 hours)

Introduction, Background Description, Fundamentals of Propulsion, Motivation to Study Ramjet and Scramjet, Thrust, Modes of Thrust Generation, Hypersonic Air breathing propulsion Ramjet. Basics of compressible one dimensional flows, Compressibility of Fluid, Mach number, T-S diagram of Compressible flow, Types of Ramjet Engines, Analysis of Ramjet Engines, performance, Thrust Equation.

Module-2(8 hours)

The ramjet engine, concept and performance. Different kinds of ramjets: the ram-rocket, the scramjet, Ram jet engine components like inlet, combustion chamber, nozzle, fuel control system and their design. Influence of component performance on the ram jet engine. Supersonic intakes, internal compression intake, Normal shock diffuser, converging diverging diffuser, external compression intakes, flow distortion, mixed compression intake, axisymmetric intake.

Module-3(8 hours)

Ramjet Operating principle – Sub critical, critical and supercritical operation – Combustion in ramjet engine – Ramjet performance – Sample ramjet design calculations – Introduction to scramjet – Preliminary concepts in supersonic combustion – Integral ram- rocket- Numerical problems.
Types of Scramjet Engines, Analysis of Scramjet Engines, performance, Thrust Equation, Problem, TS Diagram, Loss coefficient, Combustion Chamber, Types of Injection.

Module-4(8 hours)

Scramjet Propulsion: Practical Progress, Heat addition in duct with Area variations, Isolators, Aerothermodynamics of dual mode combustion system, Real H-K diagram, Interoperation of Experimental Data, Fuel-air mixing processes, Measures of local goodness of mixing, Mixing in a Turbulent shear layer

Module-5(8 hours)

Hypersonic Air breathing Engine Performance Analysis, Thermodynamics Closed Cycle Analysis ,Maximum Allowable Compression Temperature, First Law Analysis Results, Stream Thrust Analysis, Compression Components, Influence of Boundary Layer Friction, Burner Entry Pressure, Leading-Edge Oblique Shock Wave geometry

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

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

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

Semester-End Examination:

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

Suggested Learning Resources:

Text books:

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

Reference books:

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

Web links and Video Lectures (e-Resources):

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

Skill Development Activities Suggested

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

Course outcome (Course Skill Set)

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

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

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research /investigation and development work to solve practical problems.	PO1
2	An ability to write and present a substantial technical report/document.	PO2
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program	PO3
4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems	PO4
5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.	PO5
6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools	PO6
7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	PO7
8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	PO8

Mapping of COS and POs

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

Semester- 2

Introduction to Reacting flows			
Course Code	MMAP216B	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:00:00	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03 Hrs

Course Learning objectives:

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

Module-1 (8 hours)

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

Module-2(8 hours)

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

Module-3(8 hours)

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

Module-4(8 hours)

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

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 Non ideal-Flow Reactors.

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

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

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

Semester-End Examination:

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

Suggested Learning Resources:

Text books:

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

Reference books:

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

Web links and Video Lectures (e-Resources):

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

Skill Development Activities Suggested

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

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Analyze the transport processes.	L1
CO2	Apply constitutive laws for engineering applications	L2
CO3	Describe momentum transport mechanisms, rates, and coefficients in a flow.	L3
CO4	Understand energy transport mechanisms, rates, and coefficients in a flow.	L4,L5
CO5	Explain mass transport mechanisms, rates, and coefficients	L5

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research /investigation and development work to solve practical problems.	PO1
2	An ability to write and present a substantial technical report/document.	PO2
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program	PO3
4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems	PO4
5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.	PO5
6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools	PO6
7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	PO7
8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	PO8

Mapping of COS and POs

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

Semester- 2

Advanced Gas Turbines			
Course Code	MMAP216C	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:00:00	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03 Hrs

Course Learning objectives:

- Understand jet propulsion cycles and thermodynamics of each component of a turbine engine
- Know the materials for various components and the manufacturing techniques of various parts
- Gain knowledge on the performance of compressors and turbines

Module-1 (8 hours)

Jet propulsion cycles and analysis: Introduction, Prime movers, simple gas turbine, energy equation, Dimensional analysis of rotating machine, Ram jet engine, pulse jet engine, turboprop engine, turbojet engine, thrust and thrust equation, specific thrust of turbojet engine, efficiencies, parameters affecting performance, thrust augmentation, problems

Module-2(8 hours)

Ideal cycles and their analysis: Introduction, assumptions, Brayton Cycle, reheat cycle, reheat and regenerator, inter cooled cycle with heat exchanger, inter cooled and reheat cycle, comparison of varies cycles, Ericsson cycle, compressor and turbine efficiency, performance of actual cycle.

Module-3(8 hours)

Centrifugal and axial flow compressors: Essential parts of centrifugal and axial flow compressors, principles of operation, blade shape and velocity triangles, performance characteristics, surging and chocking, degree of reaction, compressor stage efficiency, and mechanical loses, problems.

Module-4(8 hours)

Impulse and reaction turbine: single impulse stage and reaction stage, velocity triangles of a single stage machines, expression for work output, blade and stage efficiencies, velocity and pressure compounding, multi stage reaction turbines, performance graphs, losses and efficiencies.

Module-5 (8 hsours)

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

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

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

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

Semester-End Examination:

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

Suggested Learning Resources:

Text books:

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

Reference books:

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

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=V6aU907cxkM
- https://www.youtube.com/watch?v=Q9SIHFTJbVI
- https://www.youtube.com/watch?v=PmQxK9PcImE
- https://www.youtube.com/watch?v=3bhoVSI6VoI
- https://www.youtube.com/watch?v=TZiUuC5mrV
- https://www.youtube.com/watch?v=cgbhui1Jwiw
- https://www.youtube.com/watch?v=knnNYBZbjPw
- https://www.youtube.com/watch?v=1zHSK-Nlaz0

Skill Development Activities Suggested

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

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	To understand the construction and working principles, material selection of gas turbine and to make the differences between impulse and reaction turbines.	**L1,L2**
CO2	Model jet propulsion cycles	**L2, L3**
CO3	Solve problems related to performance of compressors and turbines	**L4,L5**

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research /investigation and development work to solve practical problems.	PO1
2	An ability to write and present a substantial technical report/document.	PO2
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program	PO3
4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems	PO4
5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.	PO5
6	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	PO8

Mapping of COS and POs

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

Semester- 2

Aerospace Structures			
Course Code	MMAP216D	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:00:00	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03 Hrs

Course Learning objectives:

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

Module-1 (8 hours)

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

Module-2(8 hours)

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

Module-3(8 hours)

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

Module-4(8 hours)

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

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

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

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

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

Semester-End Examination:

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

Suggested Learning Resources:

Text books:

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

Reference books:

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

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=JltYcdVvzXE
- https://www.youtube.com/watch?v=LKqfhyomVfc
- https://www.youtube.com/watch?v=Zn6ic1yczT8
- https://www.youtube.com/watch?v=0nkbs_V2MD8
- https://www.youtube.com/watch?v=EIBeShVFPp8
- https://www.youtube.com/watch?v=eXdWs7xPM4Q
- https://www.youtube.com/watch?v=tl8SWNcAiPw.
- https://www.youtube.com/watch?v=3ovJEGcpbns.

Skill Development Activities Suggested

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

Course outcome (Course Skill Set)

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

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

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research /investigation and development work to solve practical problems.	**PO1**
2	An ability to write and present a substantial technical report/document.	**PO2**
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program	**PO3**
4	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with Aerospace Engineering. Apply knowledge to identify, formulate and analyse complex engineering problems	**PO4**
5	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of Aerospace Propulsion technologies.	**PO5**
6	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools	**PO6**
7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	**PO7**
8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	**PO8**

Mapping of COS and POs

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

Semester- 2

Aircraft Systems and Instrumentation (OFFLINE)			
Course Code	MMAP258A	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1:0:0	SEE Marks	50
Total Hours of Pedagogy	15 Hrs	Total Marks	100
Credits	01	Exam Hours	1 Hour
Examination type (SEE)	**MCQ**		

Course objectives:

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

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Teaching in the classroom through Chalk, Talk and ICT
2. Assignment of Home/fieldwork on real-life problem
3. Adoption of Project-based/Activity Based learning
4. Practising the foundational knowledge.

Module-1 (03 Hours)

Airplane Control Systems: Conventional Systems, power-assisted and fully powered systems, Power actuated systems, Modern control systems, Digital fly-by-wire systems, Fly by light, Autopilot systems.

Module-2 (03 Hours)

Aircraft Systems: Hydraulic systems, Study of typical workable system, components, Pneumatic systems, Advantages, Working principles, Typical Air pressure system, Brake system, Typical Pneumatic power system, Components, Landing Gear systems, Classification.

Module-3(03 Hours)

Auxiliary System: Basic Air cycle systems, Vapour Cycle systems, Evaporative air cycle systems, Fire protection systems, de-icing and anti-icing systems.

Module-4(03 Hours)

Aircraft Instruments: Flight Instruments, Gyroscope, Accelerometers, Airspeed Indicators, TAS, EAS, Mach Meters, Altimeters, Principles and operation, Study of various types of engine instruments, Tachometers, Temperature gauges, Pressure gauges, Operation and Principles.

Module-5 (03 Hours)

Navigation Systems: VOR, ADF, Inertial Navigation Systems, Instrument Landing Systems, Doppler Navigation Systems, GPS, GAGAN, NavIC,

Course outcome (Course Skill Set)

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

1. Distinguish the conventional and modern control systems.
2. Classify the aircraft systems and instruments.
3. Categorize different types of navigation systems for aircraft guidance.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous internal Examination (CIE)

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examinations (SEE)

SEE paper shall be set for 50 questions, each of the 01 marks. The pattern of the question paper is MCQ (multiple choice questions). The time allotted for SEE is **01 hour.** The student has to secure a minimum of 35% of the maximum marks meant for SEE.

Suggested Learning Resources:

Text Books

1. Ian Moir and Allan Sea bridge, 'Aircraft Systems: Mechanical, Electrical and Avionics-Subsystem Integration', Wiley India Pvt Ltd, 3rd edition, 2012, ISBN-13: 978-8126535217.
2. Pallet, E.H.J., "Aircraft Instruments and Integrated Systems", Longman Scientific and Technical, 1996.
3. R.P.G. Collinson.,"Introduction to Avionics Systems", Springer,3rd edition, 2011, ISBN-13: 978-9400707078.

Reference Books

1. Lalit Gupta and OP. Sharma, 'Aircraft Systems (Fundamentals of Flight Vol. IV)', HimalayanBooks;2006.
2. Treager. S, "Gas Turbine Technology", McGraw-Hill, 3rd edition,2013, ISBN-13: 978-1259064876.
3. R.W. Sloley and W.H. Coulthard, 'The aircraft Engineers Handbook, No 4, Instruments', 6thEdition, 2005, ISBN-13: 978-8175980518.
4. SR. Majumdar,'Pneumatic Systems', Tata McGraw Hill Publishing Co,1st Edition, 2001, ISBN-13: 978-0074602317.
5. William A Neese, 'Aircraft Hydraulic Systems', Himalayan Books, 2007.
6. Middleton,D.H.,Ed.,"AvionicsSystems,LongmanScientificandTechnical",LongmanGroup UKLtd.,England,1989, ISBN-13: 978-0582018815.

Web links and Video Lectures (e-Resources):

- .https://nptel.ac.in/courses/101104071

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

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

Computational Fluid Dynamics Laboratory			
Course Code	MMAPL207	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	01:02:00	SEE Marks	50
Credits	02	Exam Hours	03 Hrs

Course objectives:

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

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

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

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation (CIE):

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

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

- Each experiment to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- **Total marks scored by the students are scaled down to 30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 01 tests for 100 marks, test shall be conducted after the 14th week of the semester.
- In test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- **The test marksis scaled down to 20 marks** (40% of the maximum marks).

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

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

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

All laboratory experiments are to be included for practical examination.

(Rubrics) Breakup of marks and the instructions printed on the cover page of the answer

script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.

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

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

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

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

The duration of SEE is 03 hours

Suggested Learning Resources:

- Computational Fluid Dynamics lab Manual