Course Title	SPACE FLIGHT MECHANICS	Semester	VI
Course Code	MVJ19AS61	CIE	50
Total No. of Contact Hours	50 L : T : P :: 3 :2 : 0	SEE	50
No. of Contact Hours/week	5	Total	100
Credits	4	Exam. Duration	3 Hrs.

The course objective is to:

1. Understand the basic concepts of space environment and its effects on space missions
2. Acquire knowledge of orbit mechanics and orbit maneuvers.
3. Gain knowledge of satellite injection and satellite attitude dynamics
4. Understand interplanetary trajectories and atmospheric re-entry problems.
5. Comprehend ballistic missile trajectory

Module 1	L1, L2	10 Hrs.

Space Environment: Flight & spacecraft technologies Difference between space and atmosphere, upper atmosphere. Peculiarities of space environment and its description, effect of space environment on materials of spacecraft structure and astronauts, manned space missions, effect on satellite lifetime. The solar system, reference frames and coordinate systems, terminology related to the celestial sphere and its associated concepts

Laboratory Sessions/ Experimental learning: Determination of satellite life time.

Applications: Spacecraft

Video link / Additional online information (related to module if any):

8. https://www.youtube.com/results?search_query=SPACE+FLIGHT+MECHANICS+NPTEL+
9. https://www.youtube.com/watch?v=V7IrDWYb-mM&list=PLbMVogVj5nJSiVuBHAyAKBtC7-E0hsApp

Module 2	L1,L2	10 Hrs.

Basic Concepts and the General N-Body of Orbit Mechanics, Orbit Maneuvers:Kepler's laws of planetary motion and proof of the laws, Newton's universal law of gravitation, the many body problem, Lagrange-Jacobi identity, the circular restricted three body problem, liberation points, the general N-body problem, two body problem, relations between position and time. Types of Orbits (LEO, MEO, Geosynchronous, and Geostationary, Polar orbits) 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

Laboratory Sessions/ Experimental learning: Perform Hohmann transfer orbit simulation.

Applications: Spacecraft

Video link / Additional online information (related to module if any):

1. https://onlinecourses.nptel.ac.in/noc19_ph15/preview
2. https://www.youtube.com/watch?v=SfgEQUbnHyw
3. https://www.youtube.com/watch?v=yD3_gZ_uXF4&t=67s

Module 3	L1,L2	10 Hrs.

Satellite Injection and Satellite Perturbations:General aspects of satellite injection, satellite orbit transfer, various cases, orbit deviations due to injection errors, special and general perturbations, Cowell's method and Encke's method, method of variations of orbital elements, general perturbations approach, Injection conditions - Flight dispersions, Burnout velocity.

Satellite Attitude Dynamics: Torque free axisymmetric rigid body, Attitude Control for Spinning Spacecraft, Attitude Control for Non-spinning Spacecraft, The Yo-Yo Mechanism, Gravity – Gradient Satellite, Dual Spin Spacecraft, Attitude Determination.

Laboratory Sessions/ Experimental learning:Perform Torque free axisymmetric rigid body satellite attitude simulation.

Applications:Orbital Mechanics

Video link / Additional online information (related to module if any):

7. https://www.youtube.com/results?search_query=Fundamentals+of+Orbit+Mechanics+NPTEL
8. https://www.youtube.com/watch?v=SNd5IrMjlC4&t=73s
9. https://www.youtube.com/watch?v=6r9jtEPppRY

Module 4	L1,L2	10 Hrs.

Interplanetary Trajectories:Two-dimensional interplanetary trajectories, fast interplanetary trajectories, three dimensional interplanetary trajectories, launch of interplanetary spacecraft, trajectory estimation about the target planet, concept of sphere of influence, Lambert's theorem. Gravity Turn Trajectories

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

Laboratory Sessions/ Experimental learning: Perform trajectory simulation for small atmospheric reentry module

Applications: Spacecraft(Reentry)

Video link / Additional online information (related to module if any):

3. https://www.youtube.com/results?search_query=Satellite+Attitude+Dynamics+nptel
4. https://www.youtube.com/watch?v=Q_P3S7t5lS4&list=PLbRMhDVUMngfOt5ATLzSIlqia0-IZbDI0

Module 5	L1,L2	10 Hrs.

Ballistic Missile Trajectories:Introduction to ballistic missile trajectories, boost phase, the ballistic phase, trajectory geometry, optimal flights, time of flight, re-entry phase, the position of impact point and calculation, influence coefficients. Sounding Rocket, Aerospace Plane

Laboratory Sessions/Experimental learning: Perform trajectory simulation for small atmospheric reentry module

Applications: **Missile Trajectories**

Video link / Additional online information (related to module if any):

3. https://www.youtube.com/results?search_query=Space+Mission+Operations+nptel
4. https://www.youtube.com/watch?v=V7IrDWYb-mM&list=PLbMVogVj5nJSiVuBHAyAKBtC7-E0hsApp

Course outcomes:

Upon completion of the course, students will be able to:

CO310.1	Apply the basic concepts of space environment
CO310.2	Apply the knowledge of orbital mechanics of satellite.
CO310.3	Analyse satellite injection and satellite dynamics
CO310.4	Determine inter-planetary trajectories and atmospheric re-entry problems
CO310.5	Evaluate ballistic missile trajectory

Reference Books:

1.	George P.Sutton and Oscar Biblarz , Rocket Propulsion Elements, 7th Edition,2010
2.	Thomson, Introduction to Space Dynamics, Dover publications, Revised edition, 2012
3.	Vande kamp.P, Elements of Astro mechanics, Pitman, 1979
4.	William Ewiesel, Space Flight Dynamics, Create space Independent Pub; 3rd edition (3 June 2010)

CIE Assessment:

CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests

- Quizzes/mini tests (4 marks)
- Mini Project / Case Studies (8 Marks)
- Activities/Experimentations related to courses (8 Marks)

SEE Assessment:
lxii. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.
lxiii. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.
lxiv. One question must be set from each unit. The duration of examination is 3 hours.

CO,PO Mapping														
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	2	2	0	1	1	2	3	1	1
CO2	3	3	1	3	1	2	2	1	2	0	1	3	1	1
CO3	3	3	2	3	2	2	0	0	2	0	0	3	1	1
CO4	3	3	2	2	3	2	0	0	1	0	0	2	1	1
CO5	3	2	2	2	2	3	3	2	3	3	3	3	1	1

High,3, Medium,2, Low,1

Course Title	FINITE ELEMENT METHODS	Semester	V
Course Code	MVJ19AS62	CIE	50
Total No. of Contact Hours	50 L : T : P :: 3 :2 : 0	SEE	50
No. of Contact Hours/week	5	Total	100
Credits	4	Exam. Duration	3 Hrs.

The course objective is to:

1. Understand the importance of discretization of domain using different finite elements.
2. Acquire the knowledge of different loading and boundary conditions.
3. Understand the governing methods of finite element analysis.
4. Comprehend the higher order discretization.
5. Gain the knowledge offield problems.

Module 1	L1,L2,L3	10 Hrs.

Introduction: Basic Concepts, Background Review: Introduction,Stresses and Equilibrium, Plane stress, Plane strain, Boundary Conditions, Strain-Displacement Relations, simple elements for the FEM, Potential Energy and Equilibrium, The Rayleigh-Ritz Method, Galerkin's Method, Saint Venant's Principle, Von Mises Stress,

Finite Element Modeling, node, element, Coordinates and Shape Functions, Element Stiffness Matrix and assembly, Properties of K, Use of local and natural coordinates, compatibility and convergence requirements of shape functions.

Laboratory Sessions/ Experimental learning:2D plane stress analysis using ANSYS

Applications:

1. Solving practical technical problems using scientific and mathematical tools,
2. Calculating the global stiffness matrix in the finite element method

Video link / Additional online information

10. https://nptel.ac.in/courses/112/104/112104193/
11. https://nptel.ac.in/courses/112/104/112104116/
12. https://ocw.mit.edu/courses/mechanical-engineering/2-092-finite-element-analysis-of-solids-and-fluids-i-fall-2009/study-materials/

Module 2	L1,L2,L3,	10 Hrs.

Analysis of bars, truss, frames and beams:

Construction of shape functions for bar element and beam element, Plane trusses, Three-Dimensional trusses, Three-dimensional Frames

Construction of shape functions for bar element and beam element, Bar elements, uniform bar elements, uniform section, mechanical and thermal loading, varying section, truss analysis, Frame element, Beam element, problems for various loadings and boundary

Laboratory Sessions/ Experimental learning:To determine maximum deflection and bending stress for given cantilever beam using ANSYS

Applications:

1. 2D and 3 D elements to apply boundary conditions,
2. The direct stiffness method to compute degrees of freedom at the element nodes.
3. To determine the value of state variable at any point of element based on values of state variable.

Video link / Additional online information

1. https://nptel.ac.in/courses/112/104/112104193/
2. https://nptel.ac.in/courses/112/104/112104116/
3. https://ocw.mit.edu/courses/mechanical-engineering/2-092-finite-element-analysis-of-solids-and-fluids-i-fall-2009/study-materials/

Module 3	L1,L2,L3	10 Hrs.

Analysis of Two and Three dimensional Elements: Shape functions of Triangular, Rectangular and Quadrilateral elements, different types of higher order elements, constant and linear strain triangular elements, stiffness matrix Four-Noded Tetrahedral Element (TET 4), Eight-Noded Hexahedral Element (HEXA 8), Tetrahedral elements, Hexahedral elements: Serendipity family, Hexahedral elements: Lagrange family. Numerical

Laboratory Sessions/ Experimental learning:Analysis of CST Element by using ANSYS

Applications:

To approximate the *shape* of the object and to compute the displacement of points inside the boundary of the object

Video link / Additional online information:

10. https://nptel.ac.in/courses/112/104/112104193/
11. https://nptel.ac.in/courses/112/104/112104116/
12. https://ocw.mit.edu/courses/mechanical-engineering/2-092-finite-element-analysis-of-solids-and-fluids-i-fall-2009/study-materials/

Module 4	L1,L2,L3	10 Hrs.

Theory of Isoparametric Elements and Axisymmetric: Isoparametric, sub parametric and super-parametric elements, characteristics of Isoparametric quadrilateral elements, structure of

computer program for FEM analysis, description of different modules, pre and post processing, Axisymmetric formulation finite element modeling of triangular and quadrilateral element. Numerical

Laboratory Sessions/ Experimental learning:Analysis of Long Cylinder (Axiymmetric Problem) using Quadrilateral Elements in ANSYS

Applications:

1. To create shape functions that would ensure the compatibility of the displacement between neighbouringelements while maintaining the requirements for shape functions
2. Higher-order approximation of the unknown function over a bounding surface described by non-planar elements.

Video link / Additional online information:

5. https://nptel.ac.in/courses/112/104/112104193/
6. https://nptel.ac.in/courses/112/104/112104116/
7. https://ocw.mit.edu/courses/mechanical-engineering/2-092-finite-element-analysis-of-solids-and-fluids-i-fall-2009/study-materials/

Module 5	**L1,L2,L3**	10 Hrs.

Field Problems: Heat transfer problems, Steady state fin problems, 1D heat conduction governing equation, Derivation of element matrices for two dimensional problems, Dynamic consideration-Formulation-Hamilton's principle, Element mass matrices. Numerical

Laboratory Sessions/ Experimental learning:Performing Heat Transfer Analysis Using ANSYS

Applications:

1. Problem involving heat flow
2. Structural dynamics

Video link / Additional online information:

5. https://nptel.ac.in/courses/112/104/112104193/
6. https://nptel.ac.in/courses/112/104/112104116/
7. https://ocw.mit.edu/courses/mechanical-engineering/2-092-finite-element-analysis-of-solids-and-fluids-i-fall-2009/study-materials/

Course outcomes:

Upon completion of the course, students will be able to:

CO311.1	Apply discretization technique for domain using different finite elements
CO311.2	Evaluate the effects of different loading and boundary conditions
CO311.3	Analyse the governing equations of finite element analysis

CO311.4	Formulating mathematical model using higher order element type
CO311.5	Analyseheat flow problem by considering dynamic consideration

Reference Books:	
1.	Chandru Patla T. R, PHI Finite Elements in engineering, , 3rd edition, 2002
2.	Bhavi Katti, Finite element Analysis, New Age International, 3rd edition,2015
3.	Zienkiewicz. O.C, The Finite Element Method, Elsevier, 7th edition,2013
4.	C.S. Krishnamurthy, Finite Element analysis - Theory and Programming, Tata McGraw Hill Co. Ltd, New Delhi, 2nd edition,2011
5.	Rao S. S, Elsevier, Finite Elements Method in Engineering, 5th edition, 2008

CIE Assessment:

CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests

- Quizzes/mini tests (4 marks)
- Mini Project / Case Studies (8 Marks)
- Activities/Experimentations related to courses (8 Marks)

SEE Assessment:

lxv. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.

lxvi. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.

lxvii. One question must be set from each unit. The duration of examination is 3 hours.

CO,PO Mapping														
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1	2	1	1	1	2	2	1	2	1	1
CO2	3	3	2	2	2	1	1	1	2	2	1	2	1	1

CO3	3	3	2	2	2	1	1	1	2	2	1	2	1	1
CO4	3	3	3	2	2	1	1	1	2	2	1	2	1	1
CO5	3	3	2	2	2	1	1	1	2	2	1	2	1	1

High,3, Medium,2, Low,1

Course Title	COMPUTATIONAL FLUID DYNAMICS	Semester	VI
Course Code	MVJ19AS631	CIE	50
Total No. of Contact Hours	40 L: T : P :: 3 :1 : 0	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3hrs

The Course objective is to:

1. Gain knowledge of CFD ideas, and Flow Equations
2. Learn the Mathematical behaviour of PDEs vis a vis nature of flow
3. Know the discretisation techniques in finite difference
4. Understand grid generation and adaptive grids
5. Acquire knowledge to solve CFD problems through finite volume technique

Module-1	L2,L3	8 Hrs.

Introduction: CFD ideas to understand, CFD Application, Need for high speed Parallel Computing, Substantial derivative, Divergence of velocity. Flow models, Continuity Equation, Momentum Equation, and Energy Equations in various forms. Physical Boundary conditions. Conservative & Non-conservative forms of equations, Integral vrs Differential Forms of Equations. Form of Equations particularly suitable for CFD work. Shock capturing, Shock fitting.

Laboratory Sessions/ Experimental learning: Ansys Lab

Applications:Flow Analysis

Nptel Video: CFD by Prof. S Chakraborty IIT Kharagpur

Module-2	L3,L4	8 Hrs.

Mathematical Behaviour of Partial Differential Equations: Classification of partial differential equations – Cramer Rule, Eigenvalue method. Hyperbolic, parabolic, and elliptic form of equations. Mixed type of equations. Classification of governing equations for one-dimensional compressible inviscid flow.

Impact of classification on physical and computational fluid dynamics. Case studies-steady inviscid supersonic flow, unsteady inviscid flow, steady boundary layer flow, unsteady thermal conduction, and steady subsonic inviscid flow.

Laboratory Sessions/ Experimental learning: Ansys Lab

Applications: Flow analysis

Nptel Video: CFD by Prof. S Chakraborty IIT Kharagpur

Module-3	L3,L4	8 Hrs.
DiscretisationTechniquesDiscretization: Essence of discretization- Finite difference method, and difference equations. Explicit and Implicit approach. Errors and stability analysis. Time marching and Space marching. Reflection Boundary condition. Relaxation technique; successive over relaxation/ successive under relaxation. Alternating Direction Implicit (ADI) Method. Upwind and Mid-point leap frog schemes.Numerical and artificial viscosity. **Laboratory Sessions/ Experimental learning**: Ansys Lab **Applications**: Finite Difference Techniques for flow analysis **Video link / Additional online information (related to module if any)**: Nptel Video: CFD by Prof. S Chakraborty IIT Kharagpur		

Module-4	L3,L4	8 Hrs.
Grid generation &Adaptive Grid Methods: Need for grid generation and Body-fitted coordinate system. Structured grids-essential feature. Structured grids generation techniques-algebraic and numerical methods. Unstructured grid generation Techniques-Delaunay-Voronoi diagram, advancing front method, multi-block grid generation, Grid quality, adaptive grids. Adaptive Structured Grid Generation, Unstructured adaptive grid Methods. **Transformation**: Matrices &Jacobian of transformation. Transformation of Equation from physical plane into computational Plane-examples. **Laboratory Sessions/ Experimental learning**: Ansys Lab **Applications**: Grid formulation and transformation of planes **Video link / Additional online information (related to module if any)**: **Nptel Video**: CFD by Prof. S Chakraborty IIT Kharagpur		

Module-5	L3,L4	8 Hrs.
Finite Volume Techniques and some Applications: Spatial discretisation:-Cell Centred Formulation and Cell vertex Formulation (overlapping control volume, duel control volume). Temporal discretisation: - Explicit time-stepping and Implicit time- stepping, time step calculation **Applications**: Aspects of numerical dissipation & dispersion. Approximate factorization, Flux Vector splitting. Diffusion problem. Heat through conduction and radiation. Up winding technique. Post-processing and visualization, contour plots, vector plots etc.		

Laboratory Sessions/ Experimental learning: Ansys Lab **Applications**: Flow analysis through Finite Volume Technique **Video link / Additional online information (related to module if any)**: **Nptel Video**: CFD by Prof. S Chakraborty IIT Kharagpur

Course outcomes:	
CO403.1.1	Apply knowledge of CFD ideas, and Flow Equations
CO403.1.2	Assimilate Mathematical behaviour of PDEs vis a vis nature of flow
CO403.1.3	Utilise finite difference techniques.
CO403.1.4	Generate &Utilise grids
CO403.1.5	Apply finite volume techniques

Reference Books:	
1.	F. Wendt (Editor), Computational Fluid Dynamics - An Introduction, Springer – Verlag, Berlin; 1992.
2.	Charles Hirsch, Numerical Computation of Internal and External Flows, Vols. I and II. John Wiley & Sons, New York; 1988.
3	Fletcher, C.A.J, Computational Techniques for Fluid Dynamics, Springer, Berlin,2nd edition, 2002,ISBN-13: 978-3540543046
4	Tapan K. Sengupta, Fundamentals of CFD, Universities Press, 2004.

CIE Assessment:
CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests - Quizzes/mini tests (4 marks) - Mini Project / Case Studies (8 Marks) - Activities/Experimentations related to courses (8 Marks)
SEE Assessment:
lxviii. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.

lxix. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.

lxx. One question must be set from each unit. The duration of examination is 3 hours.

CO-PO-PSO Mapping														
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	1	-	-	1	1	1	1	1	-	1
CO2	3	3	2	2	1	-	-	1	1	1	1	1	-	1
CO3	3	3	2	2	1	-	-	1	1	1	1	1	-	1
CO4	3	3	2	2	1	-	-	1	1	1	1	1	-	1
CO5	3	3	2	2	1	-	-	1	1	1	1	1	3	3

High-3, Medium-2, Low-1

Course Title	EXPERIMENTAL STRESS ANALYSIS	Semester	VI
Course Code	MVJ19AS632/AE632	CIE	50
Total No. of Contact Hours	40 L: T : P :: 3 :1 : 0	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3 Hrs.

The course objective is to:

1.Understand electrical strain gauges and their characteristics

2. Comprehend the stress strainof mechanical systems using electrical resistance strain gauges.

3. Gain knowledge of the photo elastic method to study and characterize the elastic behaviour of solid bodies.

4. Acquire knowledge of stress strain behaviour of solid bodies using methods of coating.

5. Gain knowledge of the Moire`s methods and analysis

Module 1	L1,L2	8 Hrs.

Introduction: Definition of terms, Calibration, Standards, Dimension and units generalized measurement system. Basic concepts in dynamic measurements, system response, distortion, impedance matching, Analysis of experimental data, cause and types of experimental errors. General consideration in data analysis.

Electrical Resistance: Strain Gages: Strain sensitivity in metallic alloys, Gage construction, Adhesives and mounting techniques, Gage sensitivity and gage factor, Performance' Characteristics, Environmental effects, Strain Gage circuits. Potentiometer, Wheatstone's bridges, Constant current circuits.

Laboratory Sessions/ Experimental learning:

Strain sensitivity in metallic alloys, Wheatstone's bridges

Applications:

Usage of Strain gage, Identifying Errors during calibration

Video link / Additional online information (related to module if any):

13. https://www.youtube.com/watch?v=tkOGqG1Wj8g

Module 2	L1,L2,L3,	8 Hrs.

Strain Analysis Methods: Two element, three element rectangular and delta rosettes, Correction for transverse strain effects, Stress gage, Plane shear gage, Stress intensity factor gage.

Force, Torque and strain measurements: Mass balance measurement, Elastic element for force measurements, torque measurement. **Laboratory Sessions/ Experimental learning:** Force measurements, torque measurement. **Applications:** Methods to find measuring parameters **Video link / Additional online information (related to module if any):** 4. https://www.youtube.com/watch?v=ydyVsVk96z8		
Module 3	**L1,L2,L3**	8 Hrs.
Two Dimensional Photoelasticity: Nature of light, Wave theory of light - optical interference, Stress optic law –effect of stressed model in plane and circular polariscopes, Isoclinics&Isochromatics, Fringe order determination Fringe multiplication techniques, Calibration photo elastic model materials Separation methods: Shear difference method, Analytical separation methods, Model to prototype scaling, Materials for 2D photoelasticity. **Three Dimensional Photo elasticity:** Stress freezing method, Scattered light photoelasticity, Scattered light as an interior analyzer and polarizer, Scattered light polariscope and stress data Analyses. **Digital Photoelasticity:** Introduction, Full field Displacement, Strain displacement data, Advanced Video Extensometer, Dic application and advantages. **Laboratory Sessions/ Experimental learning:** optical interference **Applications: Understanding** stress variation under loading **Video link / Additional online information (related to module if any):** 13. https://www.youtube.com/watch?v=5tKPLfZ9JVQ		
Module 4	**L1,L2,L3**	8 Hrs.
Photo elastic (Birefringent) Coatings: Birefringence coating stresses, Effects of coating thickness: Reinforcing effects, Poission's, Stress separation techniques: Oblique incidence, Strip coatings **Laboratory Sessions/ Experimental learning:** Scattered light polariscope and stress data Analyses. **Applications:** Identifying Stress **Video link / Additional online information (related to module if any):** 8. https://www.youtube.com/watch?v=bkYqqJa5P8w		
Module 5	**L1,L2**	8 Hrs.

Brittle Coatings: Coatings stresses, Crack patterns, Refrigeration techniques, Load relaxation techniques, Crack detection methods, Types of brittle coatings, Calibration of coating. Advantages and brittle coating applications.

Moire Methods: Moire fringes produced by mechanical interference. Geometrical approach, (Shearing interferometry, Digital image correlation ,Specal Method, correction factor, calibration tecniques) Displacement field approach to Moire fringe analysis, 0ut of plane displacement measurements, out of plane slope measurements. Applications and advantages

Laboratory Sessions/ Experimental learning:

Moire fringe analysis

Applications: Understanding holographic technique

Video link / Additional online information (related to module if any):

8. https://www.youtube.com/watch?v=UW5bcsax78I
9. https://www.youtube.com/watch?v=jHb-PM5qH7s&list=PL16JJHgYPkvMyabXO3RVs0YoqwSdMo4YT (NPTEL course)

Course outcomes:

Upon completion of the course, students will be able to:

CO312.2.1	Analyse electrical strain gaugesand their characteristics.
CO312.2.2	Evaluate stress strain of mechanical systems using electrical resistance strain gauges.
CO312.2.3	Analyse the elastic behavior of solid bodies using photo elastic methods
CO312.2.4	Illustrate tress strain measurements using method of coatings.
CO312.2.5	Analyse moire methods and their applications

Reference Books:

1.	Srinath L.S Experimental stress Analysis, tata Mc Graw Hill, 1st edition 1971
2.	Sadhu Singh,Experimental Stress Analysis., Khanna publisher. 1st edition 1981
3.	Dally and Riley,Experimental Stress Analysis, McGraw Hill. 1st edition 1991
4.	Holman, Experimental Methods for Engineers, Tata McGraw-Hill Companies, 7th Edition, New York, 2007.

CIE Assessment:

CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests

- Quizzes/mini tests (4 marks)
- Mini Project / Case Studies (8 Marks)
- Activities/Experimentations related to courses (8 Marks)

SEE Assessment:

lxxi. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.

lxxii. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.

lxxiii. One question must be set from each unit. The duration of examination is 3 hours.

CO,PO Mapping														
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	2	1	0	0	0	0	2	2	2	1	1
CO2	3	3	2	3	3	2	0	0	0	1	2	2	1	1
CO3	3	3	2	3	3	1	0	0	0	1	2	2	1	1
CO4	3	3	2	3	3	2	0	0	0	2	1	2	1	1
CO5	3	3	2	2	3	1	0	0	0	2	2	2	1	1

High,3, Medium,2, Low,1

Course Title	FUELS & COMBUSTION	Semester	VI
Course Code	MVJ19AS633	CIE	50
Total No. of Contact Hours	40 L: T : P :: 3 :1 : 0	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3 Hrs.

The course objective is to:

1. Comprehend the basic properties of fuel.
2. Acquire knowledge of alternative fuels and treatment.
3. Understand the concept of combustion sustainability in gas turbines.
4. Understand the combustion fundamentals and performance.
5. Acquire knowledge of combustion performance.

Module 1	L1,L2	8 Hrs.

Fuel Properties: Fuel Properties and Aircraft Fuel Specifications, Relative Density, API Gravity, Molecular Mass, Distillation Range, Vapour 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.

Laboratory Sessions/ Experimental learning: Aircraft propulsion lab

Applications: Rockets engines, Gas turbine engines

Video link / Additional online information (related to module if any):

1. https://nptel.ac.in/courses/112/106/112106299/

Module 2	L1,L2	8 Hrs.

Fuel Treatment: Introduction, Production of Liquid Fuels, Removal of Sulphur Compounds, Contaminants, Asphaltenes, Gum, Sediment, Ash, Water, Sodium, Vanadium, Additives, Gum Prevention.

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)

Laboratory Sessions/ Experimental learning: Aircraft propulsion lab

Applications: Rockets engines, Gas turbine engines

Video link / Additional online information (related to module if any):

5. https://nptel.ac.in/courses/112/107/112107291/

Module 3	L1,L2	8 Hrs.

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

Laboratory Sessions/ Experimental learning: Aircraft propulsion lab

Applications: Rockets engines, Gas turbine engines

Video link / Additional online information (related to module if any):

1. https://nptel.ac.in/courses/121/106/121106014/

Module 4	L1,L2,L3	8 Hrs.

Combustion Fundamentals: Deflagration, Detonation, Classification of Flames, Flammability Limits, Weak Mixtures, Rich Mixtures, Laminar Premixed Flames, laminar and turbulent flame burning velocity, Factors Influencing Laminar Flame Speed, Equivalence Ratio, Initial Température, Pressure, Laminar Diffusion Flames, TurbulentPremixed Flames, Flame Propagation in Heterogeneous Mixtures of Fuel Drops, Fuel Vapour and Air. Combustion flame characterization: Droplet and Spray Evaporation, Evaporation Constant, Convective Effects, Effective Evaporation Constant, Spray Evaporation, Spontaneous Ignition, Flashback, Stoichiometry.

Laboratory Sessions/ Experimental learning: Aircraft propulsion lab

Applications: Rockets engines, Gas turbine engines

Video link / Additional online information (related to module if any):

1. https://nptel.ac.in/courses/101/108/101108068/

Module 5	L1,L2,L3	8 Hrs.

Combustion Performance: Combustion Efficiency, The Combustion Process, Reaction-Controlled Systems, Mixing-Controlled Systems, Evaporation-Controlled Systems, Reaction- and Evaporation- Controlled Systems. 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, Aircraft Gas Turbine Fuels, Engine Fuel System.

Laboratory Sessions/ Experimental learning: Aircraft propulsion lab

Applications: Rockets engines, Gas turbine engines

Video link / Additional online information (related to module if any):	
10. https://nptel.ac.in/courses/101/108/101108068/	
Course outcomes:	
Upon completion of the course, students will be able to:	
CO312.3.1	Summarize the fuel properties.
CO312.3.2	Analyse the fuel treatment process.
CO312.3.3	Apply the concept of combustion sustainability in gas turbines
CO312.3.4	Explain the combustion fundamentals
CO312.3.5	Compute the combustion performance.

Reference Books:	
1.	Arthur H. Lefebvre & Dilip R. Ballal, Gas Turbine Combustion, CRC Press, 3rd Edition,2010
2.	Minkoff, G.J., and C.F.H. Tipper, Chemistry of Combustion Reaction, London Butterworth, 1962.
3.	Samir Sarkar, Fuels & Combustion, Orient Long man 1996.
4.	Wilson, P.J. and J.H. Wells, Coal, Coke and Coal Chemicals, McGraw-Hill, 1960.

CIE Assessment:
CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests - Quizzes/mini tests (4 marks) - Mini Project / Case Studies (8 Marks) - Activities/Experimentations related to courses (8 Marks)
SEE Assessment:
lxxiv. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus. lxxv. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions. lxxvi. One question must be set from each unit. The duration of examination is 3 hours.

CO, PO Mapping														
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	0	0	0	0	0	0	1	1	1	1
CO2	3	3	2	3	0	0	0	0	0	0	1	2	1	1
CO3	3	3	3	3	0	0	0	0	0	0	0	2	1	1
CO4	3	3	2	3	0	0	0	0	0	0	1	1	1	1
CO5	3	2	2	2	0	0	0	0	0	0	1	1	1	1

High,3, Medium,2, Low,1

Course Title	ATMOSPHERIC FLIGHT MECHANICS	Semester	VI
Course Code	MVJ19AS641	CIE	50
Total No. of Contact Hours	40 L: T : P :: 3 :1 : 0	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3 Hrs.

The course objective is to:

1. Understand the Flight environment and Longitudinal Stick Fixed Stability
2. Understand the static longitudinal stability with Control stick free conditions
3. Acquire the knowledge of Static Directional and Lateral stability &control
4. Gain the knowledge of equations of motions and Stability derivatives.
5. Learn the Dynamic Stability of Aircraft.

Module 1	L1,L2	8 Hrs.

Flight Environment, Flight Forces and Steady Flight Performance

The atmosphere as flight environment. The International Standard Atmosphere Model. The Force and Moment Systems of an Aircraft. Steady state performance.

Static Longitudinal Stability and Control (Stick Fixed)

Degree of freedom of rigid bodies in space. Static Longitudinal stability - Stick fixed. Effects of fuselage and nacelle - Influence of CG location - Power effects - Stick fixed neutral point. Longitudinal control, Elevator power, Elevator angle versus equilibrium lift coefficient

Laboratory Sessions/ Experimental learning:

Effect of Static margin on Longitudinal Stability of Aircraft- Flight Simulation Lab

Applications:

Determine the Longitudinal stability of Aircraft with Stick fixed

Video link / Additional online information (related to module if any):

14. NPTEL- Aircraft Stability & Control

https://nptel.ac.in/courses/101/104/101104062/

2. MIT open course ware- Aircraft Stability & Control

https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-333-aircraft-stability-and-control-fall-2004/

Module 2	L1,L2,L3,	8 Hrs.

Static Longitudinal Stability and Control-Stick free

Introduction, Hinge moment parameters, Control surface floating characteristics and aerodynamic balance, Estimation of hinge moment parameters, Thetrim tabs, Stick-free Neutral point, Stick force gradient in unaccelerated flight, Restriction on aft C.G.

Laboratory Sessions/ Experimental learning:

Calculate the variation of Trim Tabs during Stick free Neutral point condition

Applications:

Determine the Longitudinal stability of Aircraft with controls free

Video link / Additional online information (related to module if any):

1. NPTEL- Aircraft Stability & Control

https://nptel.ac.in/courses/101/104/101104062/

2. MIT open course ware- Aircraft Stability & Control

https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-333-aircraft-stability-and-control-fall-2004/

Module 3	L1,L2	8 Hrs.

Static Directional and Lateral Stability and Control

Static directional stability rudder fixed, Contribution of airframe components, Directional control. Rudder power, Stick-free directional stability, Requirements for directional control, Rudder lock, Dorsal fin. One engineinoperative condition. Weather cocking effect.

Static lateral stability. Estimation of dihedral effect. Effect of wing sweep, flaps, and power. Lateral control, Estimation of lateral control power, Aileron control forces, Balancing the aileron. Coupling between rolling and yawing moments. Adverse yaw effects. Aileron reversal.

Laboratory Sessions/ Experimental learning:

Effect of aileron input in lateral and directional motion of Aircraft

Applications:

Effect of Directional and Lateral stability on Aircraft

Video link / Additional online information (related to module if any):

1. NPTEL- Aircraft Stability & Control

https://nptel.ac.in/courses/101/104/101104062/

2. MIT open course ware- Aircraft Stability & Control

https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-333-aircraft-stability-and-control-fall-2004/

Module 4	L1,L2,L3	8 Hrs.

Equations of Motions (EOMs)

Derivation of rigid body equations of motion, Orientation, and position of the airplane, gravitational and thrust Forces, Small disturbance theory. Aerodynamic force and moment representation, Derivatives due to change in forward speed, Derivatives due to the pitching velocity, Derivatives due to the time rate of change of angle of Attack, Derivatives due to rolling rate, Derivatives due to yawing rate.

Laboratory Sessions/ Experimental learning:

Estimate the effect of stability derivatives on aircraft due to changes in forward speed, change in angle of attack, change in roll rate and yaw rate

Applications:

Stability derivative estimation for a stable aircraft

Video link / Additional online information (related to module if any):

1. NPTEL- Aircraft Stability & Control

https://nptel.ac.in/courses/101/104/101104062/

2. MIT open course ware- Aircraft Stability & Control

\https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-333-aircraft-stability-and-control-fall-2004/

Module 5	L1,L2, L3	8 Hrs.

Dynamic Stability

Dynamic longitudinal stability. Types of modes of motion: phugoid motion, short period motion. Routh's stability criteria. Factors affecting period and damping of oscillations. Dynamic Directional and lateral stability. Response to aileron step-function, side-slip excursion. Dutch roll and Spiral instability. Auto- rotation and spin. Stability derivatives for directional and lateral dynamics.

Laboratory Sessions/ Experimental learning:

Determine short period and phugoid oscillations for a given Quartic equation

Applications:

Determine relative stability of an Aircraft

Video link / Additional online information (related to module if any):

1. NPTEL- Aircraft Stability & Control

https://nptel.ac.in/courses/101/104/101104062/

2. MIT open course ware- Aircraft Stability & Control

https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-333-aircraft-stability-and-control-fall-2004/

Course outcomes:

Upon completion of the course, students will be able to:

CO313.1.1	Describe the Flight environment and explain the concept of stick fixed static stability.
CO313.1.2	Compare the longitudinal stability for stick fixed &stick free case.
CO313.1.3	Analyse Static Directional and Lateral static stability
CO313.1.4	Evaluation of various flying modes.
CO313.1.5	Analyse the dynamic stability of Aircraft

Reference Books:	
1.	Nelson, R.C. Flight Stability and Automatic Control, McGraw-Hill Book Co., 2007.
2.	Perkins, C.D., and Hage, R.E., Airplane Performance stability and Control, John Wiley Son Inc, New York, 1988
3.	Bernard Etkin, Dynamics of Flight Stability and Control, John Wiley & Sons, Second Edition, 1982
4.	Bandu N. Pamadi, Performance, Stability, Dynamics, and Control of Airplanes, AIAA 2nd Edition Series, 2004

CIE Assessment:

CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests

- Quizzes/mini tests (4 marks)
- Mini Project / Case Studies (8 Marks)
- Activities/Experimentations related to courses (8 Marks)

SEE Assessment:

lxxvii. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.

lxxviii. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.

lxxix. One question must be set from each unit. The duration of examination is 3 hours.

CO-PO-PSO Mapping		

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	1	-	-	1	1	1	1	1	-	1
CO2	3	3	2	2	1	-	-	1	1	1	1	1	-	1
CO3	3	3	2	2	1	-	-	1	1	1	1	1	-	1
CO4	3	3	2	2	1	-	-	1	1	1	1	1	-	1
CO5	3	3	2	2	1	-	-	1	1	1	1	1	3	3

High,3, Medium,2, Low,1

Course Title	FATIGUE AND FRACTURE MECHANICS	Semester	VI
Course Code	MVJ19AS642	CIE	50
Total No. of Contact Hours	40 L: T : P :: 3 :1 : 0	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3 Hrs.

The course objective is to:

1. Understand the basics of fatigue of structures.
2. Understand the Statistical Aspects of Fatigue Behaviour
3. Acquire knowledge of Physical Aspects of Fatigue
4. Understand concepts of equations of Fracture Mechanics
5. Comprehend the various Fatigue Design and Testing Procedures.

Module 1	L1,L2	8 Hrs.

Fatigue of Structures: S.N. curves, Endurance limit, Effect of mean stress, Goodman, Gerber and Soderberg relations and diagrams, Notches and stress concentrations, Neuber's stress concentration factors, plastic stress concentration factors – Notched S-N curves.Plane stress and plane strain concepts, Dugdale approach

Laboratory Sessions/ Experimental learning:

Effect of Stress concentration factors and SNcurves plot in strength of materials lab

Applications:

Determine the Endurance limit and Stress concentration factors

Video link / Additional online information (related to module if any):

NPTEL-

1. https://nptel.ac.in/courses/112/106/112106065/
2. https://www.youtube.com/watch?v=o-6V_JoRX1g

Module 2	L1, L2	8 Hrs.

Statistical Aspects of Fatigue Behaviour: Low cycle and high cycle fatigue, Coffin-Manson's relation, Transition life, Cyclic Strain hardening and softening, Analysis of load histories, Cycle counting techniques, Cumulative damage, Miner's theory, Fatigue loading, Various stages of crack propagation

Laboratory Sessions/ Experimental learning:

Experimental verification of the components can be done for Low cycle and high cycle fatigue

Applications: Determine the cumulative damage of the material **Video link / Additional online information (related to module if any):** 1.NPTEL- https://nptel.ac.in/courses/112/106/112106065/		
Module 3	**L1, L2**	8 Hrs.
Physical Aspects of Fatigue: Phase in fatigue life, Crack initiation, Crack growth, Final fracture, Dislocations, Fatigue fracture surfaces. Crack opening displacement, crack tip opening displacement. **Laboratory Sessions/ Experimental learning:** To determine the crack initiation and crack growth of the given material using equipment setup. **Applications:** To determine the COD and CTOD values of the given material **Video link / Additional online information (related to module if any):** 1.NPTEL- https://nptel.ac.in/courses/112/106/112106065/		
Module 4	**L1, L2**	8 Hrs.
Fracture Mechanics: Strength of cracked bodies, potential energy and surface energy, Griffith's theory, Irwin – Orwin extension of Griffith's theory to ductile materials, Stress analysis of cracked bodies, Effect of thickness on fracture toughness, Stress intensity factors for typical geometries, Linear elastic fracture mechanics. **Laboratory Sessions/ Experimental learning:** Estimate the effect of stress intensity factors and effect of thickness on fracture toughness. **Applications:** To find out the stress analysis of the cracked bodies **Video link / Additional online information (related to module if any):** 1.NPTEL- https://nptel.ac.in/courses/112/106/112106065/		
Module 5	**L1, L2**	8 Hrs.
Fatigue Design and Testing: Safe life and fail safe design philosophies, Importance of Fracture Mechanics in aerospace structure, Application composite materials and structures. **Laboratory Sessions/ Experimental learning:** Determine short period and phugoid oscillations for a given Quadratic equation **Applications:** Determine the relative stability of an Aircraft **Video link / Additional online information (related to module if any):** 1.NPTEL- https://nptel.ac.in/courses/112/106/112106065/		
Course outcomes:		

Upon completion of the course, students will be able to:	
CO313.2.1	Apply the concept of Fatigue analysis of the structures
CO313.2.2	Compare the low cycle fatigue and high cycle fatigue and strain hardening and softening
CO313.2.3	Investigate the reasons for crack initiation, growth, and fracture and for COD and CTOD
CO313.2.4	Evaluate Fracture Toughness
CO313.2.5	Analyse Design for Fatigue

Reference Books:	
1.	D. Brock, Elementary Engineering Fracture Mechanics,Noordhoff International Publishing Co.,London, 1994
2.	J.F. Knott, Fundamentals of Fracture Mechanics, Butterworth & Co., Publishers Ltd., London,1983.
3.	W. Barrois and L. Ripley, Fatigue of Aircraft Structures, Pergamon Press, Oxford, 1983
4.	C.G.Sih, Mechanics of Fracture, Vol.1 Sijthoff and Noordhoff International Publishing Co., Netherland, 1989.

CIE Assessment:
CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests - Quizzes/mini tests (4 marks) - Mini Project / Case Studies (8 Marks) - Activities/Experimentations related to courses (8 Marks)
SEE Assessment:
lxxx. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.

lxxxi. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.

lxxxii. One question must be set from each unit. The duration of examination is 3 hours.

CO,PO Mapping														
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	2	2	1	1	1	1	1	1	1	1
CO2	3	3	3	3	2	2	1	1	1	1	1	1	1	1
CO3	3	3	3	3	2	2	1	1	1	1	1	1	1	1
CO4	3	3	3	3	2	2	1	1	1	1	1	1	1	1
CO5	3	3	3	3	2	2	1	1	1	1	1	1	1	1

High,3, Medium,2, Low,

Course Title	MISSILES AND LAUNCH VEHICLES	Semester	VI
Course Code	MVJ19AS643	CIE	50
Total No. of Contact Hours	40 L: T : P :: 3 :1 : 0	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3 Hrs.

Course objective is to:

This course will enable students to

1. Understand the types of Space Launch vehicles and Missiles.
2. Study the components and working solid rocket motors
3. Acquire knowledge of components and working of liquid rocket motors
4. Understand Trajectory monitoring and control.
5. Acquire the knowledge on rocket materials and testing.

Module 1	L1,L2,L3	8 Hrs.

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.

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.

Laboratory Sessions/ Experimental learning:

Calculate the ballistic missile trajectories.

Applications:

Designing missiles, rockets, spacecraft, launching of satellites.

Video link / Additional online information (related to module if any):

15. https://nptel.ac.in/courses/101/104/101104078/
16. https://www.youtube.com/watch?v=cTq5UaAxp2I
17. https://design.mst.edu/designteams/rocket-design/

Module 2	L1,L2,L3,	8 Hrs.

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

Laboratory Sessions/ Experimental learning:

To calculate thrust profile for different solid grain structures.

Applications:

Selection of solid propellant based on the mission requirement, grain configuration and resulting different thrust profile, design important systems of rockets and missiles.

Video link / Additional online information (related to module if any):

6. https://www.youtube.com/watch?v=irpJBnu5Y2I
7. https://www.youtube.com/watch?v=6B-8l-mWTUU
8. https://www.grc.nasa.gov/www/k-12/rocket/rktengine.html

Module 3	L1,L2,L3	8 Hrs.

Liquid Propellant Rocket Engine 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.

Laboratory Sessions/ Experimental learning:

To study the burning velocity of premixed flames at various air/fuel ratio.

Applications:

Selection of liquid propellant based on the mission requirement, specific impulse resulting from different fuel and oxidizer combination, design of pump or pressure feed system for propellant transfer from tanks to combustion chamber.

Video link / Additional online information (related to module if any):

https://www.youtube.com/watch?v=atdkmxC75Cs

https://www.youtube.com/watch?v=yt6nnz-kuaU

https://www.hq.nasa.gov/pao/History/SP-4209/ch3-4.htm

Module 4	L1,L2,L3	8 Hrs.

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.

Trajectory Monitoring and control: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, Rocket Dispersion. Missile Autopilot, proportional navigation guidance, command guidance.

Laboratory Sessions/ Experimental learning:

Role of multi staging in performance of launch vehicles.

Applications:

Planning and designing of flight path and trajectories for rockets and missiles. Directional change control using thrust vectoring.

Video link / Additional online information (related to module if any):

9. https://www.youtube.com/watch?v=L0SbCVyLNP8
10. https://www.youtube.com/watch?v=L0SbCVyLNP8
11. https://bps.space/tvc

Module 5	L1,L2	8 Hrs.

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. Descriptions 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, re-entry body design consideration, requirements of materials for thermal protection and for pressure vessels.

Laboratory Sessions/ Experimental learning:

Reentry vehicles: Sphere v/s Blunt bodies drag estimation.

Applications:

Selection of right materials depending on the mission requirement. Designing of a failsafe testing rocket system. Design of Rockets and Missiles, aerodynamic controls, reentry body design configurations.

Video link / Additional online information (related to module if any):

11. https://nptel.ac.in/courses/101/104/101104078/
12. https://nptel.ac.in/content/storage2/101/104/101104078/MP4/mod11lec53.mp4
13. https://www.sciencebuddies.org/science-fair-projects/project-ideas/Phys_p008/physics/model-rocket-propulsion#background

Course outcomes:

Upon completion of the course, students will be able to:

CO313.3.1	Apply knowledge gained in identifying the types of space launch vehicles and missiles.
CO313.3.2	Evaluate solid propellant motors.
CO313.3.3	Analyse liquid propellant engines.
CO313.3.4	Predict the trajectory of rocket and estimate error in dispersion.
CO313.3.5	Select material for application and analyse rocket testing.

Reference Books:	
1.	George P Sutton and Oscar Biblarz, Rocket Propulsion Element, John Wiley and Sons Inc, 7th edition, 2010.
2.	Cornelisse, J.W., Schoyer, Rocket Propulsion and Space Flight Dynamics, H.F.R. and Wakker,. K.F, Pitman, 1979.
3.	Ball, K.J., Osborne, G.F, Space Vehicle Dynamics, Oxford University Press, 1967
4.	Parker, E.R, Materials for Missiles and Spacecraft, McGraw Hill, 1982.

CIE Assessment:

CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests

- Quizzes/mini tests (4 marks)
- Mini Project / Case Studies (8 Marks)
- Activities/Experimentations related to courses (8 Marks)

SEE Assessment:

lxxxiii. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.

lxxxiv. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.

lxxxv. One question must be set from each unit. The duration of examination is 3 hours.

CO, PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	0	0	0	0	0	0	0	0	1	1	0

CO2	3	2	1	0	0	1	1	0	0	0	0	1	1	0
CO3	3	2	1	0	0	1	1	0	0	0	0	1	1	0
CO4	3	2	1	0	0	0	0	0	0	0	0	1	1	0
CO5	3	2	1	0	0	1	1	0	0	0	0	1	1	0

High,3, Medium,2, Low,1

Course Title	INTRODUCTION TO SPACECRAFT AND SATELLITE TECHNOLOGIES.	Semester	VI
Course Code	MVJ19AS651	CIE	50
Total No. of Contact Hours	40 L: T : P :: 3 :1 : 0	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3 Hrs.

The course objective is to:

1. Gain basic knowledge of developments in history of spacecraft flight
2. Understand the basic rocket propulsion fundamentals
3. Learn the spacecraft basic structure and materials used.
4. Understand the satellite mission and configuration
5. Acquire knowledge of satellite attitude and orbit control

Module 1	L1,L2	8 Hrs..

Introduction to Space Flight: History of Space Flight & spacecraft technologies Difference between space and atmosphere, upper atmosphere, Introduction to basic orbital mechanics, types of Orbits (LEO, MEO, Geosynchronous and Geostationary, Polar orbits), Kepler's Laws of planetary motion.

Laboratory Sessions/ Experimental learning: aerospace simulation lab

Applications: Spacecraft technologies

Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101101079/

Module 2	L1,L2	8 Hrs.

Rocket Propulsion Fundamentals

Classification of rockets-principle of rocket propulsion-analysis of ideal chemical rocket, The chemical rocket, solid propellant rockets- grain configuration, liquid propellant rockets, hybrid rockets, cryogenic rockets nuclear propulsion, electro dynamic propulsion, photon propulsion, propulsive efficiency

Laboratory Sessions/ Experimental learning:

1.Make Sugar rocket by using potassium nitrate (small size)

Applications: Rockets and missile manufacturing industries

Video link / Additional online information (related to module if any):

1. https://nptel.ac.in/courses/101/104/101104078/
2. https://nptel.ac.in/courses/101/104/101104019/
3. https://nptel.ac.in/courses/101106033/

Module 3	L1,L2	8 Hrs.

Spacecraft - Structures and Materials:

Loads experienced by spacecraft. Introduction- General types of construction, Monocoque, Semi-Monocoque and Geodesic structures. Typical spacecraft structure; Metallic and non-metallic materials for spacecraft application. Use of aluminium alloy, titanium, stainless steel and composite materials. Materials selection for spacecraft application.

Laboratory Sessions/ Experimental learning: Structures lab

Applications: Material & Structures of spacecraft

Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101101079/

Module 4	L1,L2	8 Hrs.

Satellite Mission and Configuration: Mission overview, requirements for different missions, space environment, spacecraft configuration, spacecraft bus, payloads, requirements and constraints, initial configuration decisions and trade-offs, spacecraft configuration process, broad design of spacecraft bus, subsystem layout, and types of satellites, constellations and applications.

Laboratory Sessions/ Experimental learning: Spacecraft Simulation Lab

Applications: Spacecraft mission analysis and overview of configuration process.

Video link / Additional online information (related to module if any):

4. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-885j-aircraft-systems-engineering-fall-2005/video-lectures/lecture-1/
5. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-885j-aircraft-systems-engineering-fall-2005/video-lectures/lecture-2/

Module 5	L1,L2	8 Hrs.

Attitude and Orbit Control System: Coordinate systems, Requirements of attitude and orbit control systems (AOCS), Environment effects, Attitude stabilization, Attitude sensors and actuators,

Laboratory Sessions/ Experimental learning:Aerospace simulation lab

Applications: Place a satellite into orbit and bring the deviated satellite back into its correct orbit

Video link / Additional online information (related to module if any):

3. https://www.youtube.com/watch?v=lsclmlNrpKM
4. https://www.youtube.com/watch?v=3BmWIc88im0

Course outcomes:

Upon completion of the course, students will be able to:

CO314.1.1	Explain developments in history of spacecraft flight
CO314.1.2	Analyse the basic rocket propulsion
CO314.1.3	Explain the spacecraft basic structure and materials used
CO314.1.4	Identify satellite mission and configuration
CO314.1.5	Analyse satellite attitude and orbit control

Reference Books:

1.	E. Stuhlinger and G. Mesmer. Space Science and Engineering. 1st Edition, McGraw-Hill, New York (1965).
2.	Megson, T.H.G., "*Aircraft Structures for Engineering Students*", Edward Arnold, 6th Edition 2017, Elsevier Aerospace Engineering series, ISBN-13: 978-0081009147, ISBN10: 9780081009147.
3.	Sutton G.P., "Rocket Propulsion Elements", John Wiley, New York, 9th edition,2016,ISBN: 9781118753910
4.	Marcel J.S., Spacecraft Dynamics and control, Cambridge University Press, UK, 2000

CIE Assessment:

CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests

- Quizzes/mini tests (4 marks)
- Mini Project / Case Studies (8 Marks)
- Activities/Experimentations related to courses (8 Marks)

SEE Assessment:

lxxxvi. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.

lxxxvii. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.

lxxxviii. One question must be set from each unit. The duration of examination is 3 hours.

CO,PO Mapping														
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1	1	1	1	1	1	1	1	1	1	1
CO2	2	2	1	1	1	1	1	1	1	1	1	1	1	1
CO3	2	2	1	1	1	1	1	1	1	1	1	1	1	1
CO4	2	2	1	1	1	1	1	1	1	1	1	1	1	1
CO5	2	2	1	1	1	1	1	1	1	1	1	1	1	1

High,3, Medium,2, Low,1

Course Title	ASTROPHYSICS & SPACE ENVIRONMENT	Semester	VI
Course Code	MVJ19AS652	CIE	50
Total No. of Contact Hours	40 L: T : P :: 3 :1 : 0	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3 Hrs.

Course objective is to:

- Understand the basics of Astrophysics
- Acquire basic knowledge of Stellar Atmosphere.
- Acquire knowledge of types of Astrophysics and related instrumentations
- Acquire knowledge of the sun and solar system.
- Learn the Space Environment

Module 1	L1,L2	10Hrs.

Introduction: Overview of major contents of universe, Black body radiation, specific intensity, flux density,l uminosity, Basics of radiative transfer (Emission/absorption coefficients, source functions), Magnitudes, distance modulus, Colour index, Extinction, Colour temperature, effective temperature, Brightness temperature, bolometric magnitude/luminosity, Excitation temperature, kinetic temperature, Utility of stellar spectrum.

Laboratory Sessions/ Experimental learning:

1.Lower Solar atmosphere- Waves & transients

Applications:

1.Theoretical models of astrophysical objects like Neutron Stars,

2.White Dwarfs, and Black Holes

Video link / Additional online information (related to module if any):

18. https://www.youtube.com/watch?v=MTY1Kje0yLg
19. https://www.youtube.com/watch?v=pj9cNnT7PJs
20. https://www.youtube.com/watch?v=itdYS9XF4a0

Module 2	L1,L2	8 Hrs.

Basic knowledge of stellar atmospheres:Binaries, variable stars, clusters, open and globular clusters, Laws of planetary motion, Motions and Distances of Stars, Statistical and moving cluster parallax, Velocity

Dispersion, Compact objects (BH-systems, Accretion rate/efficiency, Eddington luminosity), Shape, size andcontents of our galaxy, Normal and active galaxies, High energy physics

(introduction to X-ray and Gamma ray radiation processes), Newtonian cosmology, microwave background, early universe.

Laboratory Sessions/ Experimental learning:

1.Solar Terrestrial studies & Radio astronomy

Applications:

1.Use the distance of the particle and the brightness of its signal to determine the size and mass of the particle in Space.

Video link / Additional online information (related to module if any):

9. https://www.youtube.com/watch?v=DJWtZFooKaE

Module 3	L1,L2, L3	8 Hrs.

Astrophysics:

Radio astronomy, optical astronomy, infra-red astronomy, ultra violet, x-ray and r-ray astronomy using space telescopes.

Instrumentation aspects-sky mappers, spectrograph, observatories etc.

Laboratory Sessions/ Experimental learning:

1. observatories

Applications:

1. Understanding of formation of universe

Video link / Additional online information (related to module if any):

1. https://www.youtube.com/watch?v=H6Er2TN5EKs

Module 4	L1,L2,L3	8 Hrs.

Sun & Solar System: The sun, helioseismology, convection, solar magnetism: flux tubes, sun spots, dynamo, solar cycle, chromosphere, corona, solar wind, physical processes in the solar system; dynamics of the solar system; physics of planetary atmospheres; individual planets; comets, asteroids, and other constituents of the solar system; extra-solar planets; formation of the solar system, stars, and planets.

Laboratory Sessions/ Experimental learning:

1.Solar Interior Dynamics & Helioseismology,

2.Solar Magnetic fields & radiative transfer

Applications:

1. Observations of the Sun & predict the eruptions and periods with particular intensive radiation.

Video link / Additional online information (related to module if any):

1.https://www.youtube.com/watch?v=2HoTK_Gqi2Q

2. https://www.youtube.com/watch?v=PHsQ0J5tpCM		
Module 5	**L1,L2**	8 Hrs.
Space Environment: Introduction, Vacuum Environments and its effect, Neutral environment and its effects, Plasma environment, Radiation Environment and its effects, Debris Environment and its effects. **Laboratory Sessions/ Experimental learning:** 1. Study of the chemical & dynamical history of Milky way galaxy **Applications:** 1. Measurements and modulations of the space environment and their consequences. **Video link / Additional online information (related to module if any):** 14. https://www.youtube.com/watch?v=LIqPxnoprqY 15. https://www.youtube.com/watch?v=w_PWL0oZzOc 16. https://www.youtube.com/watch?v=Eb8c_302lxs		

Course outcomes: Upon completion of the course, students will be able to:	
CO314.2.1	Apply the basics of astrophysics
CO314.2.2	Evaluate thebasic knowledge on Stellar atmospheres & their properties.
CO314.2.3	Analyse Astrophysics with related instrumentations
CO314.2.4	Interpret the Solar system
CO314.2.5	Evaluate the space environment

Reference Books:	
1.	Sakurai, JJ., Advanced Quantum Mechanics, Pearson Education India, 1st edition,2002
2.	Stix, The Sun: An Introduction, M, Springer, Reprinted edition,2012
3.	Alan C. Tribble, The Space Environment, Princeton University Press, Revised edition,2003
17.	Shu, F, The Physical Universe, University of California, 1981

CIE Assessment:

CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests - Quizzes/mini tests (4 marks) - Mini Project / Case Studies (8 Marks) - Activities/Experimentations related to courses (8 Marks)
SEE Assessment:
lxxxix. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus. xc. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions. xci. One question must be set from each unit. The duration of examination is 3 hours.

CO-PO-PSO Mapping														
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	1	-	-	1	1	1	1	1	-	1
CO2	3	3	2	2	1	-	-	1	1	1	1	1	-	1
CO3	3	3	2	2	1	-	-	1	1	1	1	1	-	1
CO4	3	3	2	2	1	-	-	1	1	1	1	1	-	1
CO5	3	3	2	2	1	-	-	1	1	1	1	1	3	3

High,3, Medium,2, Low,1

Course Title	AEROSPACE SYSTEMS	Semester	VI
Course Code	MVJ19AS653	CIE	50
Total No. of Contact Hours	40 L: T : P :: 3 :1 : 0	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3 Hrs.

The course objective is to:

- Understand the satellite mission and the space environment
- Gain knowledge of the Attitude and Orbit Control Systems of spacecraft
- Gain the knowledge of power generation andEnergy storage systems for spacecraft
- Learn the various power converters and power distribution systems
- Understand the spacecraft propulsion system and thermal control systems

Module 1	L1,L2,	8 Hrs.

Satellite Mission and Configuration: Mission overview, requirements for different missions, space environment, spacecraft configuration, spacecraft bus, payloads, requirements and constraints, initial configuration decisions and trade-offs, spacecraft configuration process, broad design of spacecraft bus, subsystem layout, and types of satellites, constellations and applications.

Laboratory Sessions/ Experimental learning:Computer Simulation Lab

Applications: Spacecraft mission analysis and overview of the design process.

Video link / Additional online information (related to module if any):

6. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-885j-aircraft-systems-engineering-fall-2005/video-lectures/lecture-1/
7. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-885j-aircraft-systems-engineering-fall-2005/video-lectures/lecture-2/

Module 2	L1,L2,L3,	8 Hrs.

Attitude and Orbit Control System: Coordinate systems, Requirements of attitude and orbit control systems (AOCS), Environment effects, Attitude stabilization, Attitude sensors and actuators, Design of control algorithms.

Laboratory Sessions/ Experimental learning:Computer simulation lab

Applications: Place a satellite into orbit and bring the deviated satellite back into its correct orbit

Video link / Additional online information (related to module if any):

5. https://www.youtube.com/watch?v=lsclmlNrpKM
6. https://www.youtube.com/watch?v=3BmWIc88im0

Module 3	L1,L2,L3	8 Hrs.

Power Generation and Energy Storage System: Power Generation: Study of solar spectrum, Solar cells, Solar panel design and testing, Effects of the solar cells and panels (IR, UV, Particles).

Energy Storage Technology: Types of batteries (primary & secondary batteries), Electrical circuit model, Performance characteristics of batteries, Applications of batteries in launch vehicles and satellites, Fuel cell, Polymer electrolyte membrane fuel cell, Regenerative fuel cell, Flywheel energy storage system.

Laboratory Sessions/ Experimental learning:

Applications: Extracting the energy from the sun or from the onboard batteries for power of the spacecraft

Video link / Additional online information (related to module if any):

14. https://www.youtube.com/watch?v=mz_7UF4KQpk

Module 4	L1,L2,L3	8 Hrs.

Power Converter, control and distribution system:

Basic Convertors: (DC to DC converters, Buck, Boost, Buck-boost converter, Derived converters: Fly back converter, Transformer coupled forward converter, Push-pull converter, CUKs convertor, Resonant converter, Voltage and current regulators

Power Control and Distribution: Solar array regulators, Battery changing schemes, Protection schemes, Distribution, Harness, Thermal design, EMI/EMC/ESD/Grounding schemes for various types of circuits and systems.

Laboratory Sessions/ Experimental learning: Electrical Lab

Applications: Power supply and distribute the required amount of power for the various systems of the space vehicles.

Video link / Additional online information (related to module if any):

1. https://www.youtube.com/watch?v=wkQww6pHFrI

Module 5	L1,L2	8 Hrs.

Propulsion Systems and Thermal Control Systems: Systems Trade-off, Mono-propellant systems, Bi-propellant system, Thermal consideration, System integration design factors, Pre-flight test requirements, Systems reliability.

Orbital environments, Average temperature in space, Transient temperature evaluation, Thermal control techniques, Temperature calculation for a spacecraft, Thermal design and analysis program structure, Thermal design verification, Active thermal control techniques.

Telemetry Systems, Base band telemetry system, Modulation, TT & CRF system, Telecommand and Ground control systems

Laboratory Sessions/ Experimental Learning: Propulsion Lab

Applications: Launch of spacecraft and satellites in orbit.

Video link / Additional online information (related to module if any):

1. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-885j-aircraft-systems-engineering-fall-2005/video-lectures/lecture-5/
2. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-885j-aircraft-systems-engineering-fall-2005/video-lectures/lecture-6/

Course outcomes:

Upon completion of the course, students will be able to:

CO314.3.1	Identify the spacecraft mission requirement and environment
CO314.3.2	Illustrate the requirements of Attitude and Orbit control system.
CO314.3.3	Analysethe power generation and storage systems for Spacecraft
CO314.3.4	Describepower regularization and its design concepts.
CO314.3.5	Analyze the spacecraft propulsion system, thermal control, and telemetry systems.

Reference Books:

1.	Peter F. Spacecraft Systems Engineering, 4th edition, published by Wiley-Blackwell England, 2003
2.	Patel M. R., Spacecraft Power Systems, 1st edition, published by CRC Press Boca Raton, 2005
3.	Wilbur L.P. and Joseph A.S., Satellite Communication Systems Engineering, published by Prentice Hall, New Jersey, USA, 1986
4.	Marcel J.S., Spacecraft Dynamics and control, Cambridge University Press, UK, 2000

CIE Assessment:

CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests

- Quizzes/mini tests (4 marks)

- Mini Project / Case Studies (8 Marks)
- Activities/Experimentations related to courses (8 Marks)

SEE Assessment:

xcii. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.

xciii. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.

xciv. One question must be set from each unit. The duration of examination is 3 hours.

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	-	-	-	-	-	-	-	-	-	2	1
CO2	3	3	1	-	2	1	-	-	-	-	-	-	3	1
CO3	3	1	-	-	2	-	-	-	-	-	-	-	2	2
CO4	3	2	1	-	-	-	-	-	-	-	-	-	3	1
CO5	3	2	-	-	2	-	1	-	-	-	-	-	3	1

High,3, Medium,2, Low,1

Course Title	AEROSPACE STRUCTURES AND VIBRATION LAB	Semester	VI
Course Code	MVJ19ASL66	CIE	50
Total No. of Contact Hours	40	SEE	50
No. of Contact Hours/week	03	Total	100
Credits	02	Exam. Duration	3 Hours

Course objective is to:

- Learn about the simply supported beam, cantilever beam.
- Understand the Maxwell's theorem an d Poisson ratio.
- Acquire the knowledge about buckling load, shear failure and shear centre

Sl No	Experiment Name	RBT Level	Hours
1	Deflection of a Simply Supported Beam	L1,L2,L3	03
2	Deflection of a Cantilever Beam	L1,L2,L3	03
3	Beam with Combined Loading by using Superposition Theorem	L1,L2,L3	03
4	Verification of Maxwell's Reciprocal Theorem for Beam with a) Constant cross section b) Varying Cross section	L1,L2,L3	03
5	Determination of Young's Modulus and Poisson Ratio using Strain Gages.	L1,L2,L3	03
6	Buckling Load of Slender Eccentric Columns and Construction of South Well Plot	L1,L2,L3	03
7	Shear Failure of Bolted and Riveted Joint	L1,L2,L3	03
8	Bending Modulus of Sandwich Beam	L1,L2,L3	03
9	Determine the Index Factor `K` in a Tensile Field of Wagner Beam	L1,L2,L3	03
10	Tensile, Compressive and Flexural Testing of a Composite Material Plate	L1,L2,L3	03
11	Determination of Natural Frequency and Mode Shapes of a Cantilever Beam for the FollowingCases	L1,L2,L3	03

	a) Constant cross section b) Varying cross section		
12	Determination of Shear Centre for Following Cases Through Deflection a) Close section–Symmetrical bending b) Open section–Unsymmetrical bending	L1,L2,L3	03
13	Determination of Shear flow for Following Cases a) Close section–Symmetrical bending b) Open section–Unsymmetrical bending	L1,L2,L3	03
14	Determining of Shear Centre Through Shear Flow Measurement for Following Cases a) Close section–Symmetrical bending b) Open section–Unsymmetrical bending	L1,L2,L3	03

Course outcomes:	
CO1	Compute the deflection of simply supported beam and cantilever beam.
CO2	Verify the Maxwell's theorem.
CO3	Determine the buckling load ,shear failure and shear centre.

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	1	1	1	1
CO2	3	3	3	3	3	1	1	1	1	1	1	1
CO3	3	3	3	3	3	1	1	1	1	1	1	1

High-3, Medium-2, Low-1

Course Title	DESIGN,MODELING AND ANALYSIS LAB	Semester	VI
Course Code	MVJ19ASL67	CIE	50
Total No. of Contact Hours	40	SEE	50
No. of Contact Hours/week	03	Total	100
Credits	02	Exam. Duration	3 Hours

Course objective is to:

- Understand the procedure to draw the geometric models of symmetric, cambered aerofoil, nozzle, wing and other structures.
- Acquire the knowledge of types of meshing.
- Understand the basics of flow and stress analysis.

Sl No	Experiment Name	RBT Level	Hours
1	Modeling of Symmetric Aerofoil Geometry, And Generation of Body Fitting Mesh.	L1,L2,L3	03
2	Modeling of Cambered Aerofoil Geometry, And Generation of Body Fitting Mesh.	L1,L2,L3	03
3	Modeling of 2 D Incompressible and Inviscid Flow over an Aerofoil. Computations and Analysis for Velocity Vectors and Pressures Distributions.	L1,L2,L3	03
4	Modeling of 2-D Incompressible and Viscous Flow over an Aerofoil. Computations and Analysis for Velocity Vectors and Pressures Distributions.	L1,L2,L3	03
5	Geometric Modeling and Mesh Generation of 2-D Convergent Divergent Nozzle and Analyses of Flow for Adiabatic Conditions.	L1,L2,L3	03
6	Grid generation on fore portion of a space craft model.	L1,L2,L3	03
7	Thermal Analysisof 2-D pipe for conduction and convection heat transfer	L1,L2,L3	03

8	Structural Modeling and stress analysis of tapered I-section spar	L1,L2,L3	03
9	Fatigue analysis on aircraft wing spar	L1,L2,L3	03
10	Stress analysis under defined load conditions on a spar of 3D wing.	L1,L2,L3	03
11	Stress analysis under defined load conditions in a bulkhead.	L1,L2,L3	03
12	Estimation of stresses in a plate of varying stiffness under bending and torsion.	L1,L2,L3	03
13	Free and forced vibration analysis of a cantilever beam.	L1,L2,L3	03
14	Stress analysis on a flat plate with and without hole	L1,L2,L3	03

Course outcomes:	
CO1	Draw the geometric models of symmetric, cambered aerofoil, nozzle, wing and other structures.
CO2	Apply different types of meshing.
CO3	Perform the flow and stress analysis.

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	1	1	1	1
CO2	3	3	3	3	3	1	1	1	1	1	1	1
CO3	3	3	3	3	3	1	1	1	1	1	1	1

High-3, Medium-2, Low-1