Semester: III		
TRASNFORMS & STATISTICAL METHODS		
Course Code:	**MVJ21MAE31/ MAS31/MME31**	**CIE Marks:100**
Credits: L:T:P:S: 3:2:0:0		**SEE Marks: 100**
Hours: 40L+26T		**SEE Duration: 3 Hrs**
Course Learning Objectives: The students will be able to		
1	Comprehend and use of analytical and numerical methods in different engineering fields.	
2	Apprehend and apply Fourier Series.	
3	Realize and use of Fourier transforms.	
4	Realize and use of Z-Transforms.	
5	Use of statistical methods in curve fitting applications.	

UNIT-I	
Laplace Transform: Definition and Laplace transforms of elementary functions. Laplace transforms of Periodic functions and unit-step function and problems. **Inverse Laplace Transform:** Definition and problems, Convolution theorem to find the inverse Laplace transforms and problems. **Applications**: Solution of linear differential equations using Laplace transforms. **Web Link and Video Lectures:** https://www.youtube.com/watch?v=8oE1shAX96U https://www.intmath.com/laplace-transformation/7-inverse-laplace-transform.php	**10 Hrs**
UNIT-II	
Fourier series: Recapitulation of Series, Continuous and Discontinuous functions, Periodic functions, Dirichlet's conditions, Fourier series of periodic functions of period	**10 Hrs**

2π and arbitrary period $2l$, Half-range Fourier sine and cosine series, Practical Harmonic Analysis and Problems. **Web Link and Video Lectures:** https://www.youtube.com/watch?v=Sq2FhCxcyI8 https://www.youtube.com/watch?v=4N-IwHUCFa0	
UNIT-III	
Fourier transforms: Infinite Fourier transform, Infinite Fourier sine and cosine transforms, Inverse Fourier transforms, Inverse Fourier sine and cosine transforms, Convolution theorem. **Web Link and Video Lectures:** https://www.youtube.com/watch?v=spUNpyF58BY https://www.youtube.com/watch?v=6spPyJH6dkQ	**10 Hrs**
UNIT-IV	
Z-Transforms: Z-transform: Difference equations, basic definition, z-transform -definition, Standard z-transforms, Damping rule, Shifting rule, Initial value and final value theorems (without proof) and problems, Inverse Z-transform. **Applications**: Application of Z- transforms to solve difference equations. **Web Link and Video Lectures:** http://www.eas.uccs.edu/~mwickert/ece2610/lecture_notes/ece2610_chap7.pdf https://electricalbaba.com/final-value-theorem-and-its-application/	**10 Hrs**
UNIT-V	
Curve Fitting: Curve fitting by the method of least squares. Fitting of the curves of the form $y = ax + b$, $y = ax^2 + bx + c$, $y = ae^{bx}$. **Statistical Methods:** Introduction, Correlation and coefficient of correlation, Regression, lines of regression and problems. **Web Link and Video Lectures:** https://mathbits.com/MathBits/TISection/Statistics2/correlation.htm https://www.youtube.com/watch?v=xTpHD5WLuoA	**10 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1	Use Laplace transform and inverse transforms techniques in solving differential equations.
CO2	Demonstrate Fourier Transform as a tool for solving Integral equations.
CO3	Demonstrate Fourier Transform as a tool for solving Integral equations.
CO4	Apply Z Transform to solve Difference Equation.Use Method of Least Square for appropriate Curves.
CO5	Fit a suitable curve by the method of least squares and determine the lines of regression for a set of statistical data.

Reference Books	
1.	Prof G.B.Gururajachar "Engineering Mathematics-III , Academic Excellent series Publications, 2016-17
2.	B.S. Grewal, "Higher Engineering Mathematics" Khanna Publishers, 43rd Edition, 2013
3.	Erwin Kreyszig, "Advanced Engineering Mathematics", Wiley-India publishers, 10thedition,2014.
4.	Ramana B. V., "Higher Engineering Mathematics", Tata McGraw-Hill, 2006.
5.	Bali N. P. & Manish Goyal, "A text book of Engineering Mathematics", Laxmi Publications, 8th Edition.

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

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

High-3, Medium-2, Low-1

Semester: III		
THERMODYNAMICS		
Course Code:	**MVJ21AS32/ MVJ21AE32**	**CIE Marks:100**
Credits: L:T:P:S: 3:2:0:0		**SEE Marks: 100**
Hours: 40L+26T		**SEE Duration: 3 Hrs**
Course Learning Objectives: The students will be able to		
1	Understand various concepts and definitions of thermodynamics.	
2	Comprehend the I-law of thermodynamics.	

3	Comprehend the II-law of thermodynamics
4	Acquire the knowledge of Pure Substances & Ideal Gases
5	Acquire the knowledge of various types of gas cycles.

UNIT-I	
Fundamental Concepts & Definitions: Thermodynamics definition and scope, Microscopic and Macroscopic approaches. Some practical applications of engineering thermodynamic Systems, Characteristics of system boundary and control surface, examples. Thermodynamic properties; definition and Modules, intensive and extensive properties. Thermodynamic state, state point, state diagram, path and process, quasi-static process, cyclic and non-cyclic; processes; Thermodynamic equilibrium; definition, mechanical equilibrium; diathermic wall, thermal equilibrium, chemical equilibrium. Zeroth law of thermodynamics, Temperature; concepts, scales, fixed points and measurements. **Work and Heat:** Mechanics-definition of work and its limitations. Thermodynamic definition of work; examples, sign convention. Displacement work; as a part of a system boundary, as a whole of a system boundary, expressions for displacement work in various processes through p-v diagrams. Shaft work; Electrical work. Other types of work Laboratory Sessions / Experimental learning: To determine the unknown area of a given drawing using planimeter Applications: 1.For temperature measurements 2.To obtain displacement work Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101/104/101104067/	**10 Hrs**
UNIT-II	
First Law of Thermodynamics: Joules experiments, equivalence of heat and work. Statement of the First law of thermodynamics, extension of the First law to non - cyclic processes, energy, energy as a property, modes of energy, pure substance; definition, two-property rule, Specific heat at constant volume, enthalpy, specific heat at constant pressure. Extension of the First law to control volume; steady state-steady flow energy equation, important	**10 Hrs**

applications, analysis of unsteady processes such as film and evacuation of vessels with and without heat transfer Laboratory Sessions/ Experimental learning: https://www.youtube.com/watch?v=suuTC9uGLrIhttps://www.youtube.com/watch?v=7bJywbP7ZIU Applications: 1.Conservation of energy principle to Heat and Thermodynamic processes 2.Compressors, Blowers, Steam or Gas Turbines, IC engines Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101/104/101104067/	
UNIT-III	
Second Law of Thermodynamics: Devices converting heat to work; (a) in a thermodynamic cycle, (b) in a mechanical cycle. Thermal reservoir. Direct heat engine; schematic representation and efficiency. Devices converting work to heat in a thermodynamic cycle; reversed heat engine, schematic representation, coefficients of performance. Kelvin - Planck statement of the Second law of Thermodynamics; PMM I and PMM II, Clausius statement of Second law of Thermodynamics, Equivalence of the two statements; Reversible and Irreversible processes; factors that make a process irreversible, reversible heat engines, Carnot cycle, Carnot principles. **Entropy:** Clasius inequality; Statement, proof, application to a reversible cycle. Entropy; definition, a property, change of entropy, principle of increase in entropy, entropy as a quantitative test for irreversibility, calculation of entropy using Tds relations, entropy as a coordinate. Available and unavailable energy. Laboratory Sessions/ Experimental learning: https://www.youtube.com/watch?v=7OJG-ZHrbD8https://www.youtube.com/watch?v=7bJywbP7ZIUhttps://www.youtube.com/watch?v=2vHLJjlinjw Applications: 1. All types of heat engine cycles including Otto, Diesel, etc 2. Refrigerators and heat pumps based on the Reversed Carnot Cycle	**10 Hrs**

3. Mixing of two fluids, heat transfer through a finite temperature difference Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101/104/101104067/	
UNIT-IV	
Pure Substances & Ideal Gases: Mixture of ideal gases and real gases, ideal gas equation, compressibility factor use of charts. P-T and P-V diagrams, triple point and critical points. Sub-cooled liquid, Saturated liquid, mixture of saturated liquid and vapour, saturated vapour and superheated vapour states of pure substance with water as example. Enthalpy of change of phase (Latent heat). Dryness fraction (quality), T-S and HS diagrams, representation of various processes on these diagrams. **Thermodynamic relations:** Maxwell`s equations, Tds relations, ratio of heat capacities, evaluation of thermodynamic properties from an equation of state Laboratory Sessions/ Experimental learning: https://www.youtube.com/watch?v=Juz9pVVsmQQhttps://www.youtube.com/watch?v=L1AHGHRvv9s Applications: Working fluids and its properties, in power plants for power generations. Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101/104/101104067/	**10 Hrs**
UNIT-V	
Gas Cycles: Efficiency of air standard cycles, Carnot, Otto, Diesel cycles, P-V & T-S diagram, calculation of efficiency, Numerical **vapour power cycle:** Carnot vapour power cycle, simple Rankine cycle, Analysis and performance of Rankine Cycle, Ideal and practical regenerative Rankine cycles – Reheat and Regenerative Cycles, Binary vapour cycle. Laboratory Sessions/ Experimental learning: To determine the unknown area of a given drawing using planimeter to calculate the thermal efficiency of Petrol cycle. To calculate the thermal efficiency of Diesel cycle. Applications:	**10 Hrs**

IC engines, Gas turbine engines etc.. Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101/104/101104067/	

Course Outcomes: After completing the course, the students will be able to	
CO1	Apply the concepts of thermodynamics in various engineering problems.
CO2	Differentiate thermodynamic work and heat and apply I law of thermodynamics to different process
CO3	Differentiate thermodynamic work and heat and apply II law of thermodynamics to different process
CO4	Apply the concepts of Pure Substances & Ideal Gases
CO5	Apply the principles of various gas cycles

Reference Books	
1.	A Venkatesh, Basic Engineering Thermodynamics, Universities Press, India, 2007, ISBN 13: 9788173715877
2.	P K Nag, Basic and Applied Thermodynamics, 2nd Ed., Tata McGraw Hill Pub. 2002, ISBN 13: 9780070151314
3.	YunusA.Cenegal and Michael A.Boles, Thermodynamics: An Engineering Approach, TataMcGraw Hill publications, 2002, ISBN 13: 9780071072540
4.	J.B.Jones and G.A.Hawkins, Engineering Thermodynamics, Wiley 1986, ISBN 13: 9780471812029

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The

three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

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

High-3, Medium-2, Low-1

Semester: III		
ELEMENTS OF AEROSPACE TECHNOLOGY		
Course Code:	**MVJ21AS33**	**CIE Marks:100**
Credits: L:T:P:S: 3:0:0:0		**SEE Marks: 100**
Hours: 40L		**SEE Duration: 3 Hrs**

Course Learning Objectives: The students will be able to	
1	Understand basic principles of Aircraft and the history of space vehicles.
2	Acquire the basic principles of flight.
3	Learn the basic principle of Aircraft & Rocket propulsion.
4	Understand the Aircraft Structures and Materials.
5	Acquire the basics of Aircraft Instruments & systems.

UNIT-I	
Introduction to Aircrafts: History of aviation, International Standard atmosphere, Atmosphere and its properties, Temperature, pressure and altitude relationships, Classification of aircrafts, V/STOL machines. 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: Ornithopter modelling, Paper plane. Applications: Environmental conditions Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101101079/	**8 Hrs**
UNIT-II	
Basic principles of flight: Significance of speed of sound, Propagation of sound, Mach number, subsonic, transonic, supersonic, hypersonic flows, Bernoulli's theorem, Aerodynamic forces and moments on an Airfoil, Lift and drag components, lift curve, drag curve, types of drag, factors affecting lift and drag; Centre of pressure and its significance, Aerodynamic centre, Aspect ratio, Airfoil nomenclature, Basic characteristics of airfoils, NACA nomenclature, Simple problems on lift and drag.	**8 Hrs**

Laboratory Sessions/ Experimental learning: Aerodynamics lab Applications: Aircraft Flow dynamics Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101104061/https://nptel.ac.in/courses/101101079/	
UNIT-III	
Aircraft Propulsion: Introduction, Classification, Piston Engine & its application, Brayton cycle, Principle of operation of Turboprop, turbojet and turbofan engines, Introduction to ramjets and scramjets; performance characteristics. **Rocket Propulsion:** Principles of operation of rocket, Classification of Rockets, Types of rockets and typical applications, Introduction to Space Exploration. Laboratory Sessions/ Experimental learning: Propulsion lab Applications: Aircraft engines Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101101079/	**8 Hrs**
UNIT-IV	
Aircraft and Spacecraft - Structures and Materials: Introduction- General types of construction, Monocoque, Semi-Monocoque and Geodesic structures. Typical wing and fuselage structure; Metallic and non-metallic materials for aircraft application. Use of aluminum alloy, titanium, stainless steel and composite materials. Materials selection for spacecraft application. Laboratory Sessions/ Experimental learning: Structures lab Applications: Material & Structural Dynamics of Aircraft Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101101079/	**8 Hrs**
UNIT-V	
Instrument: Instrument Displays, Introduction to Navigation Instruments, Basic Air data systems & Probes, Mach meter, Air speed indicator, Vertical speed indicator, Altimeter, Gyro based instruments, Introduction to spacecraft instruments. Inertial & GPS based sensors. **Systems:** Introduction to Hydraulic and pneumatic systems, Air Conditioning	**8 Hrs**

and Cockpit pressurization system, Generation and distribution of Electricity on board the airplane, Aircraft Fuel System, Fire Protection, Ice and Rain Protection System Laboratory Sessions/ Experimental learning: Instrumentation lab. Applications: Aircraft Instruments. Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101101079/	

Course Outcomes: After completing the course, the students will be able to	
CO1	Differentiate the different concepts of aircrafts and spacecraft's in flight.
CO2	Describe the Principle of aviation and space flight.
CO3	Explain the Fundamentals of Rocket Propulsion and Aircraft Propulsion.
CO4	Apply the concepts of aircraft materials and structures.
CO5	Appreciate the complexities involved during development of flight vehicles systems.

Reference Books	
1.	John D. Anderson, "Introduction to Flight", McGraw-Hill Education, 8th edition, 2015, ISBN: 978-0078027673.
2.	Lalit Gupta and O P Sharma, Fundamentals of Flight Vol-I to Vol-IV, Himalayan Books. 2006, ISBN: 9788170020752
3.	Ian Moir, Allan Seabridge, "Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration", John Wiley & Sons, 3rd edition, 2011, ISBN: 9781119965206
4.	Sutton G.P., "Rocket Propulsion Elements", John Wiley, New York, 9th edition,2016,ISBN: 9781118753910

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The

number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

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

High-3, Medium-2, Low-1

Semester: III

MECHANICS OF MATERIALS + MATERIAL TESTING LAB (Theory and Practice)		
Course Code:	**MVJ21AS34/ MVJ21AE34**	**CIE Marks:50+50**
Credits: L:T:P: 3:0:2		**SEE Marks: 50 +50**
Hours:40 L+ 26 P		**SEE Duration: 03+03 Hours**

Course Learning Objectives: The students will be able to	
1	Comprehend the basic concepts of strength of materials.
2	Acquire the knowledge of stresses due to bending
3	Understand the different failure in materials
4	Understand the relations among materials and their properties.
5	Acquire the practical knowledge of metallographic testing of engineering materials.

UNIT-I	
Basics of linear elasticity: The concept of stress& strain, state of stress & Strain at a point, Equilibrium equations, The state of plane stress and plane strain. Compatibility equations, Constitutive Laws (Hooke's Law), Stressstrain curves for brittle and ductile materials, Allowable stress, Material selection for structural performance. **Simple & Compound Stresses:** Extension / Shortening of a bar, bars with cross sections varying in steps, bars with continuously varying cross sections. Elongation due to self-weight. Volumetric strain, expression for volumetric strain, elastic constants, simple shear stress, shear strain, temperature stresses, Introduction to Plane stress, stresses on inclined sections, principal stresses & strains, Analytical & graphical method (Mohr's Circle) to find principal stresses & strains. Laboratory Sessions/ Experimental learning: UTM in Material Testing Lab Applications: Testing of Mild steel components, Bricks Video link / Additional online information (related to module if any): Prof.Dr.Suraj Prakash Harsha,Indian Institute of Technology, Roorkee. Lecture – 12 for Ductile and Brittle Materials	**10 Hrs**

UNIT-II	
Bending Moment and Shear Force in Beams: Introduction, Types of beams, loads and reactions, shear forces and bending moments, rate of loading, sign conventions, relationship between shear force and bending moments. Shear force and bending moment diagrams for different beams subjected to concentrated loads, uniformly distributed load, (UDL) uniformly varying load (UVL) and couple for different types of beams. **Euler-Bernoulli beam theory:** The Euler-Bernoulli assumptions, Implications of the Euler-Bernoulli assumptions, the Euler-Bernoulli Beam theory derivation, Bending stress equation, Moment carrying capacity of a section. Shearing stresses in beams, shear stress across rectangular, circular, symmetrical I and T sections (Only Numerical). Laboratory Sessions/ Experimental learning: Different load conditions can be practiced in Structures Lab Applications: Civil Construction with Symmetrical I & T sections Video link / Additional online information (related to module if any): Prof: S .K.Bhattacharya, IIT, Kharagpur, Lecture no 24. Bending of Beams- III	**10 Hrs**
UNIT-III	
Deflection of Beams: Introduction, Differential equation for deflection. Equations for deflection, slope and bending moment. Double integration method for cantilever and simply supported beams for point load, UDL, UVL and Couple. Macaulay's method. **Torsion of Circular Shafts and Elastic Stability of Columns:** Introduction. Pure torsion, assumptions, derivation of torsional equations, polar modulus, torsional rigidity / stiffness of shafts. Power transmitted by solid and hollow circular shafts. Laboratory Sessions/ Experimental learning: Beam Expt in Structures lab and Torsion Test apparatus available in MT Lab. Applications: Civil Construction and Automobile Transmission. Video link / Additional online information (related to module if any): Prof. S. K. Bhattacharyya Indian Institute of Technology, Kharagpur Lecture - 33 Deflection of Beams – IV	**10 Hrs**

Prof. S. K. Bhattacharya Dept. of Civil Engineering I.I.T Kharagpur Lecturer#20 Torsion-III	
UNIT-IV	
Virtual work principles: Introduction, Equilibrium and work fundamentals, Principle of virtual work, Principle of virtual work applied to mechanical systems, Principle of virtual work applied to truss structures, Principle of virtual work applied to beams. Principle of complementary virtual work, internal virtual work in beams and solids. Energy methods: Conservative forces, Principle of minimum total potential energy, Strain energy in springs, Strain energy in beams, Strain energy in solids, Applications to trusses, Development of a finite element formulation for trusses, Principle of minimum complementary, Energy theorems, Reciprocity theorems, Saint-Venant's principle Laboratory Sessions/ Experimental learning: Few of the Energy Method Theorems can be explained from Structures Lab. Applications: Virtual work arises in the application of the principle of least action to the study of forces and movement of a mechanical system. Video link / Additional online information (related to module if any): Energy Methods in Structural Analysis Version 2 CE IIT, Kharagpur	**10 Hrs**
UNIT-V	
Mechanical Properties of materials: **Fracture**: Type I, Type II and Type III. **Creep**: Description of the phenomenon with examples. Three stages of creep, creep properties, stress relaxation. **Fatigue**: Types of fatigue loading with examples, Mechanism of fatigue, fatigue properties, fatigue testing and S-N diagram. Laboratory Sessions/ Experimental learning: Impact Tests in MT lab for Fracture. Applications: Boilers, Rotating Machine Elements Video link / Additional online information (related to module if any): Creep Deformation of Materials Dr.SrikantGollapudi Indian Institute of Technology, Bhubaneswar	**10 Hrs**

Prof.K.Gopinath&Prof.M.M.Mayuram, Machine Design II, Indian Institute of Technology Madras	

LABORATORY EXPERIMENTS
1.Hardness Testing-Brinell and Rockwell Hardness test
2.Tensile Test
3.Flexural Test
4.Torsional Test
5.Preparation of specimen for metallographic examination of different engineering materials
6.Dye penetration testing
7.Magnetic particle inspection
8.Heat treatment: annealing, normalizing, hardening and tempering of steel
9.Impact Test – Izod and Charpy Test
10.Shear Test

Course Outcomes: After completing the course, the students will be able to	
CO1	Apply the basic concepts of strength of materials.
CO2	Compute stress, strain under different loadings.
CO3	Acquire the knowledge of deflection of beams
CO4	Acquire the knowledge of virtual work principle and energy methods
CO5	Identify different failures
CO6	Examine the relations among materials properties.
CO7	Apply the knowledge of metallographic testing in aircraft materials.

Reference Books	
1.	T.H.G Megson “Introduction to Aircraft Structural Analysis”, Butterworth-Heinemann Publications, 2007, ISBN 13: 9781856179324
2.	Beer F.P. and Johnston.R, Mechanics of Materials, McGraw Hill Publishers, 2006, ISBN13:978-0073380285.
3.	Timoshenko and Young, Elements of Strength of Materials, East-West Press, 1976, ISBN 10: 8176710199
4.	Maximum four books

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Laboratory- 50 Marks

The laboratory session is held every week as per the time table and the performance of the student is evaluated in every session. The average of the marks over number of weeks is considered for 30 marks. At the end of the semester a test is conducted for 10 marks. The students are encouraged to implement additional innovative experiments in the lab and are awarded 10 marks. Total marks for the laboratory is 50.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks are executed by means of an examination.

The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

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

High-3, Medium-2, Low-1

Semester: III		
MECHANICS OF FLUIDS + FLUID MECHANICS LAB (Theory and Practice)		
Course Code:	**MVJ21AS35/ MVJ21AE35**	**CIE Marks:50+50**
Credits: L:T:P: 3:0:2		**SEE Marks: 50 +50**
Hours:40 L+ 26 P		**SEE Duration: 03+03 Hours**
Course Learning Objectives: The students will be able to		

1	Understand the basic fluid properties.
2	To estimate velocity, acceleration and stream function for an incompressible and inviscid flow along with governing equations of fluid flow.
3	Understand the dimensional analysis and apply Bernoulli's and Euler's equation for flow measuring devices
4	To calculate boundary layer thickness and drag co-efficient for laminar and turbulent flows
5	Acquire the knowledge of compressible flows and boundary Layers

UNIT-I	
Basic Considerations: Introduction, Dimensions- Modules and physical quantities, Continuum view of gases and liquids, Pressure and Temperature scales, Physical properties of fluids. **Fluid Statics:** Pressure distribution in a static fluid, Pressure and its measurement, hydrostatic forces on plane and curved surfaces, buoyancy, illustration by examples. Laboratory Sessions/ Experimental learning: Use of piezometer and manometers Applications: For pressure measurements by using different types of manometers. Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101/103/101103004/	**10 Hrs**
UNIT-II	
Fluids in motion: Methods of describing fluid motion, types of fluid flow, continuity equation in 3 dimensions, velocity potential function and stream function. Types of motion, Source sink, doublet, plotting of stream lines and potential lines Numerical problems. **Fluid Kinematics:** Kinematics of fluid motion and the constitutive equations, Integral (global) form of conservation equations (mass, momentum, energy) and applications, Differential form of conservation equations (continuity, Navier-Stokes equations, energy equation).	**10 Hrs**

Laboratory Sessions/ Experimental learning: An experimental study of the continuity equation and Bernoulli's equation by using Venturimeter, Orificemeter and pitot tube. Applications: For rotational and irrotational fluid flows, laminar and turbulent fluid flows. Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101/103/101103004/	
UNIT-III	
Fluid Dynamics: Equations of motion: Euler's and Bernoulli's equation of motion for ideal and real fluids. Momentum equation, Fluid flow measurements. Numerical problems. **Dimensional analysis and similarity:** Dimensional homogeneity, methods of dimensional analysis, model analysis, types of similarity and similitude. Dimensionless numbers. Model laws. Numerical problems Laboratory Sessions/ Experimental learning: An experimental study of the continuity equation and Bernoulli's equation by using Venturimeter, Orificemeter and pitot tube. Applications: flow measuring devices and model studies. Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101/103/101103004/	**10 Hrs**
UNIT-IV	
Flow past Immersed bodies: Introduction to boundary layer, boundary layer thickness, karman's integral momentum theory, drag on a flat plate for laminar and turbulent flow, Drag on immersed bodies. Expression for drag and lift. Kutta –joukowsky theorem; Fundamentals of airfoil theory Numerical problems. Laboratory Sessions/ Experimental learning: Determination of boundary layer thickness. Applications: Flow over a sloid body, separation point and Understanding of lift and drag. Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101/103/101103004/	**10 Hrs**
UNIT-V	

Compressible flow and Boundary Layers theory: Steady, one-dimensional gas dynamics, Propagation of pressure waves in a compressible medium, velocity of sound , Mach number, Mach cone, Stagnation properties , Bernoulli's eqn for isentropicflow, normal shock waves . Numerical Problem; Laminar and turbulent boundary layers. Laboratory Sessions/ Experimental learning: Propagation of disturbance for different Mach number Applications: Compressible flows through nozzles, diffusers, turbines etc… Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101/103/101103004/	**10 Hrs**

LABORATORY EXPERIMENTS
1.Calibration of Venturimeter.
2.Determination of Coefficient of discharge for a small orifice by a constant head method.
3.Determination of coefficient of friction of flow in a pipe
4.Calibration of contracted Rectangular Notch.
5.Verification of Bernoulli's equation.
6.Pipe friction apparatus with loss of head on pipe fittings.
7.Estimate performance of hydraulic Pumps -Single stage centrifugal pumps
8.Estimate performance of hydraulic Pumps –Multi- stage centrifugal pumps
9.Calibration of contracted V-Notch.
10.Determination of Coefficient of loss of head in a sudden contraction and friction factor.

Course Outcomes: After completing the course, the students will be able to	
CO1	Evaluate the effects of fluid properties

CO2	Estimate velocity, acceleration and stream function for an incompressible and invisid flow along with governing equations of fluid flow.
CO3	Perform dimensional analysis and apply Bernoulli's and Eulers equation for various flow situations involving venturimeter, orificemeter and pitot-tube
CO4	Calculate boundary layer thickness and drag co-efficient for laminar and turbulent flows.
CO5	Illustrate the basic concepts of compressible flows.

Reference Books	
3.	Bansal, R.K, Fluid Mechanics and Hydraulics Machines, Laxmi Publications (P) Ltd., New Delhi 2015,ISBN-13: 978-8131808153
4.	Yunus A. Cengel& John M Cimbala, Fluid Mechanics and Applications, McGraw Hill Education; 3rd edition, 2013, ISBN-13: 978-0073380322.
3.	Rathakrishnan. E, Fluid Mechanics, Prentice-Hall of India Pvt.Ltd, 2010, ISBN 13: 9788120331839.
4.	Ramamritham. S, Hydraulic Fluid Mechanics and Fluid Machines, Dhanpat Rai& Sons, Delhi, 1988, ISBN 13: 9788187433804

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the self -study are 20 (2 presentations are be held for 10 marks each). The marks obtained in test, quiz and self -studies are added to get marks out of 100 and report CIE for 50 marks.

Laboratory- 50 Marks

The laboratory session is held every week as per the time table and the performance of the student is evaluated in every session. The average of the marks over number of weeks is considered for 30 marks. At the end of the semester a test is conducted for 10 marks. The students are encouraged to implement additional innovative experiments in the lab and are awarded 10 marks. Total marks for the laboratory is 50.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks are executed by means of an examination.

The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Laboratory- 50 Marks

Experiment Conduction with proper results is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

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

High-3, Medium-2, Low-1

Semester: III		
Balike Kannada		
Course Code:	**MVJ21BK36**	**CIE Marks:50**
Credits: L:T:P:S: 1:0:0:0		**SEE Marks: 50**
Hours: 20L		**SEE Duration: 3 Hrs**
Course Learning Objectives: This course will enable students to understand Kannada and communicate in Kannada language		
1	Vyavharika Kannada –Parichaya (Introduction to Vyavharikakannada)	
2	Kannada Aksharamaalehaaguuchcharane(Kannada Alphabets and Pronounciation.	
3	Sambhashanegaagi Kannada Padagalu (Kannada Vocubulary for Communication).	
4	Kannada Grammer in Conversations(Sambhasaneyalli Kannada Vyakarana)	
5	Activities in Kannada	

UNIT-I	
Vyavharika Kannada –Parichaya (Introduction to Vyavharikakannada)	**8 Hrs**
UNIT-II	
Kannada Aksharamaalehaaguuchcharane(Kannada Alphabets and Pronounciation	**8 Hrs**
UNIT-III	
Sambhashanegaagi Kannada Padagalu (Kannada Vocubulary for Communication)	**8 Hrs**
UNIT-IV	
Kannada Grammer in Conversations(Sambhasaneyalli Kannada Vyakarana)	**8 Hrs**

UNIT-V	
Activities in Kannada	**8 Hrs**

Scheme of Evaluation:		
Details		**Marks**
Average of three Internal Assessment (IA) Tests of 30 Marks each i.e. Σ (Marks Obtained in each test) / 3	**CIE(50)**	**30**
ASSIGNMENT		**20**
Semester End Examination	**SEE (50)**	**50**
	Total	**100**

Semester: III		
SAMSKRUTHIKA KANNADA		
Course Code:	**MVJ21SK36**	**CIE Marks:50**
Credits: L:T:P:S: 1:0:0:0		**SEE Marks: 50**
Hours: 20L		**SEE Duration: 3 Hrs**
Course Learning Objectives: This course will enable students to understand Kannada and communicate in Kannada language		
1	Samskruthika Kannada –Parichaya (Introduction to Adalitha kannada)	
2	Kannada Kavyagala parichaya (Kannada D Ra Bendre, Siddalingaiha)	

3	Adalithdalli Kannada Padagalu (Kannada Kagunitha Balake, Patra Lekhana, Prabhandha)
4	Kannada Computer Gnyana (Kannada Shabdha Sangraha, Computer Paribashika padagalu)
5	Activities in Kannada.

UNIT-I	
PÀ£ÀßqÀ ¨sÁµÉ-¸ÀAQë¥ÀÛ «ªÀgÀuÉ.	**8 Hrs**
UNIT-II	
¨sÁµÁ ¥ÀæAiÉÆÃUÀ¯ÁèUÀÄªÀ ¯ÉÆÃ¥ÀzÉÆÃµÀUÀ¼ÀÄ ªÀÄvÀÄÛ CªÀÅUÀ¼À ¤ªÁgÀuÉ.	**8 Hrs**
UNIT-III	
¯ÉÃR£À aºÉßUÀ¼ÀÄ ªÀÄvÀÄÛ CªÀÅUÀ¼À G¥ÀAiÉÆÃU.À	**8 Hrs**
UNIT-IV	
¥ÀvÀæ ªÀåªÀºÁgÀ.	**8 Hrs**
UNIT-V	
DqÀ½vÀ ¥ÀvÀæUÀ¼ÀÄ.	**8 Hrs**
UNIT-VI	
¸ÀPÁðgÀzÀ DzÉÃ±À ¥ÀvÀæUÀ¼ÀÄ	**8 Hrs**
UNIT-VII	
¸ÀAQÃ¥ÀÛ ¥Àæ§AzsÀ gÀZÀ£É, ¥Àæ§AzsÀ ªÀÄvÀÄÛ ¨sÁµÁAvÀgÀ	**8 Hrs**
UNIT-VIII	
PÀ£ÀßqÀ ±À§Ý¸ÀAUÀæºÀ	**8 Hrs**
UNIT-IX	
PÀA¥ÀÆålgï ºÁUÀÆ ªÀiÁ»w vÀAvÀæeÁÕ£À	**8 Hrs**
UNIT-X	
¥Áj¨sÁ¶PÀ DqÀ½vÀ PÀ£ÀßqÀ ¥ÀzÀUÀ¼ÀÄ ªÀÄvÀÄÛ vÁAwæPÀ/PÀA¥ÀÆålgï ¥Áj¨sÁ¶PÀ ¥ÀzÀUÀ¼ÀÄ.	**8 Hrs**

Scheme of Evaluation:	
Details	**Marks**

Average of three Internal Assessment (IA) Tests of 30 Marks each i.e. Σ (Marks Obtained in each test) / 3	**CIE(50)**	**30**
ASSIGNMENT		**20**
Semester End Examination	**SEE (50)**	**50**
	Total	**100**

Semester: III		
CONSTITUTION OF INDIA, PROFESSIONAL ETHICS AND CYBER LAW		
Course Code:	**MVJ21CPH36/46**	**CIE Marks:50**
Credits: L:T:P:S: 1:0:0:0		**SEE Marks: 50**
Hours: 20L		**SEE Duration: 3 Hrs**
Course Learning Objectives: The students will be able to		
1	To know the fundamental political codes, structure, procedures, powers, and duties of Indian constitution, Indian government institutions, fundamental rights, directive principles and the duties of the citizens.	

2	To provide overall legal literacy to the young technograts to manage complex societal issues in the present scenario.
3	To understand engineering ethics & their responsibilities, identify their individual roles and ethical responsibilities towards society.

UNIT-I	
Introduction to Indian Constitution The Necessity of the Constitution, The Societies before and after the Constitution adoption. Introduction to the Indian Constitution, The Making of the Constitution, The role of the Constituent Assembly – Preamble and Salient features of the Constitution of India. Fundamental Rights and its Restriction and Limitations in different Complex Situations. Directive Principles of State Policy (DPSP) and its present relevance in our society with examples. Fundamental Duties and its Scope and Significance in Nation Building.	**8 Hrs**
UNIT-II	
Union Executive and State Executive Parliamentary System, Federal System, Centre-State Relations. Union Executive – President, Prime Minister, Union Cabinet, Parliament - LS and RS, Parliamentary Committees, Important Parliamentary Terminologies. Supreme Court of India, Judicial Reviews and Judicial Activism. State Executives – Governor, Chief Minister, State Cabinet, State Legislature, High Court and Subordinate Courts, Special Provisions (Article 370, 371, 371J) for some States.	**8 Hrs**
UNIT-III	
Elections, Amendments and Emergency Provisions Elections, Electoral Process, and Election Commission of India, Election Laws. Amendments - Methods in Constitutional Amendments (How and Why) and Important Constitutional Amendments. Amendments – 7,9,10,12,42,44,61,73,74,75,86, and 91,94,95,100,101,118 and some important Case Studies. Recent Amendments with explanation. Important Judgements with Explanation and its impact on society (from the list of Supreme Court Judgements). Emergency Provisions, types of Emergencies and it's consequences. **Constitutional Special Provisions:**	**8 Hrs**

Special Constitutional Provisions for SC & ST, OBC, Special Provision for Women, Children & Backward Classes.	
UNIT-IV	
Professional / Engineering Ethics Scope & Aims of Engineering & Professional Ethics - Business Ethics, Corporate Ethics, Personal Ethics. Engineering and Professionalism, Positive and Negative Faces of Engineering Ethics, Code of Ethics as defined in the website of Institution of Engineers (India) : Profession, Professionalism, Professional Responsibility. Clash of Ethics, Conflicts of Interest. **Responsibilities in Engineering** - Responsibilities in Engineering and Engineering Standards, the impediments to Responsibility.Trust and Reliability in Engineering, IPRs (Intellectual Property Rights), Risks, Safety and liability in Engineering.	**8 Hrs**
UNIT-V	
Internet Laws, Cyber Crimes and Cyber Laws: Internet and Need for Cyber Laws, Modes of Regulation of Internet, Types of cyber terror capability, Net neutrality, Types of Cyber Crimes, India and cyber law, Cyber Crimes and the information Technology Act 2000, Internet Censorship, Cybercrimes and enforcement agencies.	**8 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1	Have constitutional knowledge and legal literacy
CO2	Understand Engineering and Professional ethics and responsibilities of Engineers.
CO3	Understand the cyber crimes and cyber laws for cyber safety measure.

Reference Books	
1.	Constitution of India and Professional Ethics, T.S. Anupama, Sunstar Publisher
2.	Durga Das Basu (DD Basu): "Introduction to the Constitution on India", (Students Edition.) Prentice –Hall EEE, 19th/20th Edn., (Latest Edition) or 2008.
3.	Shubham Singles, Charles E. Haries, and Et al : "Constitution of India and Professional Ethics" by Cengage Learning India Private Limited, Latest Edition – 2018.

4.	M.Govindarajan, S.Natarajan, V.S.Senthilkumar, "Engineering Ethics", Prentice –Hall of India Pvt. Ltd. New Delhi, 2004.
5.	M.V.Pylee, "An Introduction to Constitution of India", Vikas Publishing, 2002.
6.	Latest Publications of NHRC - Indian Institute of Human Rights, New Delhi.

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 (40 marks each), the final IA marks to be awarded will be the average of three tests

- Assignment (10 marks)

SEE Assessment:

i. Question paper for the SEE consists one part. It is compulsory and consists of objective type 1 mark each for total of 50 marks covering the whole syllabus.

ii. Ten questions 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
CO1	2	2	1	1	1	2	2	1	1	1	1	2
CO2	1	2	2	1	1	2	1	1	1	1	1	2
CO3	2	1	2	1	1	1	1	1	1	1	1	2
CO4	2	2	1	1	1	1	1	1	1	1	1	2
CO5	2	2	1	1	1	2	1	1	1	1	1	2

High-3, Medium-2, Low-1

Semester: III

AEROSAPCE MATERIALS		
Course Code:	**MVJ21AS37/AE37**	**CIE Marks:100**
Credits: L:T:P:S: 2:0:0:0		**SEE Marks: 100**
Hours: 22L		**SEE Duration: 3 Hrs**
Course Learning Objectives: The students will be able to		
1	To impart knowledge on the basics of phase diagrams and their applications.	
2	To make the students to understand the use of non-ferrous materials in aircraft construction:	
3	To introduce various ferrous materials for aircraft construction	

UNIT-I	
Phase diagrams and Microstructures: Basic concepts - Gibbs phase rule – Unary phase diagram (iron) - Binary phase diagrams: isomorphous systems (Cu-Ni). The Fe-Fe3C phase diagram: phases, invariant reactions, development of microstructure in eutectoid, hypoeutectoid and hypereutectoid alloys – influence of other alloying elements in the Fe-C system. Microstructures: pearlite, bainite, spheroidite and martensite. Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101/103/101103004/ https://www.youtube.com/watch?v=woNUlqu8ReE	**8 Hrs**
UNIT-II	
Non-ferrous materials in aircraft construction: Aluminium and its alloys: Types and identification. Properties - Castings - Heat treatment processes - Surface treatments. Magnesium and its alloys: Cast and Wrought alloys - Aircraft application, features specification, fabrication problems, Special treatments. Titanium and its alloys: Applications, machining, forming, welding and heat treatment. Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/113/105/113105021/ https://www.intechopen.com/books/aluminium-alloys-recent-trends-in-processing-characterization-mechanical-behavior-and-applications	**7 Hrs**

UNIT-III	
Ferrous materials in aircraft construction: Steels : low, medium and high carbon steels , alloy steels, corrosion resistant steels, structural applications. Maraging Steels: Properties and Applications. Super Alloys: Use - Nickel base - Cobalt base - Iron base - Forging and Casting of Super alloys - Welding, Heat treatment. Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/113/105/113105057/ https://nptel.ac.in/courses/113/104/113104059/	**7 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1	Apply the knowledge about the phase diagrams and microstructure of alloys.
CO2	Explain the applications of Non-ferrous alloys in Aircraft and Aerospace industry.
CO3	Gain knowledge about the application of Ferrous alloys in Aircraft construction

Reference Books	
1.	Titterton G F, Aircraft Material and Processes, English Book Store, New Delhi, 5th edition, 1998, ISBN-13: 978-8175980136
2.	Introduction to Physical Metallurgy by Sydney Avner, Tata McGraw-Hill Edition 1997.
3.	Hill E T, The Materials of Aircraft Construction, Pitman London.
4.	C G Krishnadas Nair, Handbook of Aircraft materials, Interline publishers, Bangalore, 1993

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50.

The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	0	0	1	0	0	0	0	1	1
CO2	3	1	1	0	1	2	0	0	0	0	0	1
CO3	3	2	1	2	0	2	1	0	0	0	1	1

High-3, Medium-2, Low-1

Diploma Mathematics-I		
Course Code:	**MVJ21MATDIP31**	**CIE Marks:100**
Credits: L:T:P:S: 1:2:0:0		**SEE Marks: 100**
Hours: 30L+26T		**SEE Duration: 3 Hrs**
Course Learning Objectives: The students will be able to		
1	To familiarize the important and basic concepts of Differential calculus and Differential	

	Equation, ordinary/partial differential equations and Vector calculus and analyse the engineering problems.

UNIT-I	
Differential calculus: Recapitulations of successive differentiations -n^{th} derivative -Leibnitz theorem and Problems, Mean value theorem -Rolle's theorem, Lagrange's Mean value theorem , Cauchy's theorem and Taylor's theorem for function of one variables. Video Link: https://users.math.msu.edu/users/gnagy/teaching/ode.pdf	**8 Hrs**
UNIT-II	
Integral Calculus: Review of elementary Integral calculus, Reduction formula $\int_0^{\frac{\pi}{2}} sin^m x\, dx$, $\int_0^{\frac{\pi}{2}} cos^m x\, dx$, $\int_0^{\frac{\pi}{2}} sin^m cos^n x\, dx$ and problems. Evaluation of double and triple integrals and Simples Problems. Video Link: https://www.youtube.com/watch?v=rCWOdfQ3cwQ https://nptel.ac.in/courses/111/105/111105122/	**8 Hrs**
UNIT-III	
Vector Calculus: Derivative of vector valued functions, Velocity, Acceleration and related problems, Scalar and Vector point functions, Gradient, Divergence, Curl, Solenoidal and Irrotational vector fields. Vector identities - div (φA), curl (φA), curl (grad φ), div (curl A). Video Link: https://www.whitman.edu/mathematics/calculus_online/chapter16.html https://www.math.ust.hk/~machas/vector-calculus-for-engineers.pdf	**8 Hrs**
UNIT-IV	
Probability: Introduction-Conditional Probability, Multiplication theorem ,Independent events ,Baye's theorem and Problems.	**8 Hrs**

Video Link: https://www.khanacademy.org/math/statistics-probability/probability-library https://nptel.ac.in/courses/111/105/111105041/	
UNIT-V	
Differential equation: Homogenous differential equation, Linear differential equation, Bernoulli's differential equation and Exact differential equation. Video Link: https://www.mathsisfun.com/calculus/differential-equations.html	**8 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1	Apply the knowledge of Differential calculus in the modeling of various physical and engineering phenomena
CO2	Apply the concept of change of order of integration and variables to evaluate multiple integrals and their usage in computing the area and volumes.
CO3	Study on Vector calculus to understand the various solution to Application to Engineering problems.
CO4	Understand the basic Concepts of Probability
CO5	Solve first order linear differential equation analytically using standard methods.

Reference Books	
1.	B.S. Grewal, "Higher Engineering Mathematics" Khanna Publishers, 43rd Edition, 2013.
2.	Ramana B. V., "Higher Engineering Mathematics", Tata Mc Graw-Hill, 2006.
3.	Erwin Kreyszig, "Advanced Engineering Mathematics", Wiley-India publishers, 10th edition,2014.
4.	G. B. Gururajachar: Calculus and Linear Algebra, Academic Excellent Series Publication, 2018-19

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

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

High-3, Medium-2, Low-1

Semester: IV		
COMPLEX VARIABLES & NUMERICAL METHODS		
Course Code:	**MVJ21MAE41/MAS41/MME41**	**CIE Marks:100**
Credits: L:T:P:S: 2:2:0:0		**SEE Marks: 100**
Hours: 30L+26T		**SEE Duration: 3 Hrs**
Course Learning Objectives: The students will be able to		
1	Understand the concepts of Complex variables and transformation for solving Engineering Problems.	
2	Understand the concepts of complex integration, Poles and Residuals in the stability analysis of engineering problems.	
3	Apply the concept to find external of functional.	
4	Solve initial value problems using appropriate numerical methods.	
5	Students learn to obtain solution s of ordinary and partial differential equations numerically.	

UNIT-I	
Complex variables - 1: Functions of complex variables, Analytic function, Cauchy-Riemann Equations in Cartesian and polar coordinates, Consequences of Cauchy-Riemann Equations, Construction of analytic functions (Using Milne-Thomson method). **Transformations:** Bilinear Transformation, Conformal transformation, Discussion of the transformations $w = z^2$, $w = e^z$ and $w = z + \frac{a}{z}, (z \neq 0)$. **Video Link:** https://www.youtube.com/watch?v=oiK4gTgncww https://www.youtube.com/watch?v=WJOf4PfoHow	**10 Hrs**
UNIT-II	
Complex variables-2: Complex integration - Cauchy theorem, Cauchy's Integral Theorem-Problems, Taylor & Laurent series- Problems, Singularities, Types of Singularities, Poles,	**10 Hrs**

Residues-definitions, Cauchy residue theorem - Problems. **Video Link:** https://math.mit.edu/~jorloff/18.04/notes/topic4.pdf https://math.mit.edu/~jorloff/18.04/notes/topic10.pdf	
UNIT-III	
Numerical methods-1: Numerical solution of Ordinary Differential Equations of first order and first degree, Taylor's series method, Modified Euler's method, Runge-Kutta method of fourth order, Milne's and Adam-Bashforth Predictor and Corrector method. **Video Link:** https://youtu.be/b5VUnapu-qs http://www.nptelvideos.in/	**10 Hrs**
UNIT-IV	
Numerical methods-2: Numerical solution of Ordinary Differential Equations of second order: Runge-Kutta method of fourth order, Milne's Predictor and Corrector method. **Calculus of variations:** Variation of function and Functional, variational problems, Euler's equation, Geodesics. **Applications** : Hanging Chain problem. **Video Link:** https://www.khanacademy.org/ http://www.nptelvideos.in/	**10 Hrs**
UNIT-V	
Numerical methods-3: Numerical solution of Partial Differential Equations: Introduction, Finite difference approximations to derivatives, Numerical Solution of Laplace Equation, Numerical solution of one-dimensional heat equation by Bender - Schmidt's method and by Crank-Nicholson Method, Numerical solution of one-dimensional wave equation. Video Links: https://youtu.be/nNnnBMF03lI	**10 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1	State and prove Cauchy - Riemann equation with its consequences and demonstrate Con-formal Transformation.
CO2	Illustrate Complex Integration using Cauchy's Integral theorem, Cauchy's Integral formula and Cauchy's Residue theorem.
CO3	Identify appropriate numerical methods to solve ODE.
CO4	Determine the extremals of functionals and solve the simple problems of the calculus of variations.
CO5	Choose appropriate numerical methods to solve Partial Differential Equations.

Reference Books	
1.	Prof G.B.Gururajachar "Engineering Mathematics-III , Academic Excellent series Publications, 2016-17
2.	B.S. Grewal, "Higher Engineering Mathematics" Khanna Publishers, 43rd Edition, 2013.
3.	B.V.Ramana, "Higher Engineering Mathematics", Tata McGraw-Hill, 2006
4.	N.P. Bali & Manish Goyal, "A text book of Engineering Mathematics", Laxmi Publications, 8th Edition.
5.	H K Dass: **"Advanced Engineering Mathematics"**- S Chand & Company Ltd.12th edition.

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

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

High-3, Medium-2, Low-1

Semester: IV		
INCOMPRESSIBLE AERODYNAMICS		
Course Code:	**MVJ21AE42/AS42**	**CIE Marks:100**
Credits: L:T:P:S: 3:0:0:0		**SEE Marks: 100**
Hours: 40L		**SEE Duration: 3 Hrs**
Course Learning Objectives: The students will be able to		
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
3	Acquire knowledge of incompressible flows over airfoil
4	Understand the fundamentals of incompressible flow over finite wings
5	Assimilate the understanding of application of finite wing theory and high lift systems

UNIT-I	
Review of Basic Fluid Mechanics Continuity, momentum and energy equation, Control volume approach to Continuity, momentum and energy equation, Types of flow, pathlines, streamlines, and streaklines, units and dimensions, inviscid and viscous flows, compressibility, Mach number regimes. Vorticity, Angular velocity, Stream function, velocity potential function, Circulation, Numericals, Mach cone and Mach angle, Speed of sound. Laboratory Sessions/ Experimental learning: Smoke flow visualization studies on a two dimensional airfoil at different angles of incidence at low speeds Applications: provides a proper understanding of the flow properties and their characteristics features which helps in the study of flow over airfoils Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101105059/	**10 Hrs**
UNIT-II	
Airfoil Characteristics Fundamental aerodynamic variables, Airfoil nomenclature, airfoil characteristics. wing planform geometry, aerodynamic forces and moments, centre of pressure, pressure coefficient, aerodynamic center, calculation of airfoil lift and drag from measured surface pressure distributions, typical airfoil aerodynamic characteristics at low speeds. Types of drag-Definitions. Laboratory Sessions/ Experimental learning: Smoke flow visualization studies on a two-dimensional circular cylinder at low speeds Applications: understand the characteristics and the distribution of pressure over the airfoil Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101105059/	**10 Hrs**
UNIT-III	

Two Dimensional Flows & Incompressible Flow Over Airfoil Uniform flow, Source flow, Sink flow, Combination of a uniform flow with source and sink. Doublet flow. Non-lifting flow over a circular cylinder. Vortex flow. Lifting flow over a circular cylinder. Kutta-Joukowski theorem and generation of Lift, D'Alembert's paradox, Numericals,Incompressible flow over airfoils: Kelvin's circulation theorem and the starting vortex, vortex sheet, Kutta condition, Classical thin airfoil theory for symmetric and cambered airfoils. KuttaJoukowski theorem. and generation of Lift, Numerical. Laboratory Sessions/ Experimental learning: Calculation of total drag of a two-dimensional circular cylinder at low speeds using pitot-static probe wake survey. Applications: study the lifting and non lifting flows over cylinders and arbitrary bodies and understanding the theory behind lift generation Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101105059/	**10 Hrs**
UNIT-IV	
IncompressibleFlowOverFiniteWings Biot-Savart law and Helmholtz's theorems, Vortex filament: Infinite and semi-infinite vortex filament, Induced velocity. Prandtl's classical lifting line theory:Downwash and induced drag. Elliptical and modified elliptical lift distribution.Lift distribution on wings. Limitations of Prandtl's lifting line theory. Extended lifting line theory-lifting surface theory, vortex lattice method for wings. Lift, drag and moment characteristics of complete airplane Laboratory Sessions/ Experimental learning: Surface pressure distributions on a two-dimensional cambered airfoil at different angles of incidence and calculation of lift and pressure drag. Applications: understanding the theory of lift generation over finite wings and their flow patterns Video link / Additional online information (related to module if any): http://web.iaa.ncku.edu.tw/~aeromems/Aerodynamics/Ch5.pdf	**10 Hrs**
UNIT-V	
Applications of Finite Wing Theory & High Lift Systems Simplified horse-shoe vortex model, influence of downwash on tail plane, ground effects. Swept wings: Introduction to sweep effects, swept wings, pressure coefficient, and typical aerodynamic characteristics. Introduction to high-lift systems, flaps,	**10 Hrs**

leading-edge slats and typical high – lift characteristics. Effects of thickness, camber and aspect ratio of wings, tip effects. Introduction to Source panel & vortex lattice method Laboratory Sessions/ Experimental learning: Calculation of aerodynamic coefficients forces acting on a model aircraft using force balance at various angles of incidence, speed. Applications: study the typical aerodynamics characteristics of swept wings and different types of high lift devices Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101/106/101106035/	

Course Outcomes: After completing the course, the students will be able to	
CO1	Describe the fundamental equations of continuity, momentum & energy of fluid flow.
CO2	Evaluate typical airfoil characteristics and two-dimensional flows over airfoil
CO3	Analyze the incompressible flow over airfoil
CO4	Compute and analyze the incompressible flow over finite wings
CO5	Apply finite wing theory and analyze high lift systems

Reference Books	
1.	Anderson J.D, Fundamental of Aerodynamics, 5th edition, McGraw-Hill International Edition, New York **(**2011), ISBN-13: 978-0073398105.
2.	E. L. Houghton, P.W. Carpenter, Aerodynamics for Engineering Students, 5th edition, Elsevier, New York. (2010), ISBN-13: 978-0080966328
3.	Clancy L. J., Aerodynamics, Sterling book house, New Delhi. (2006), ISBN 13: 9780582988804
4.	Louis M. Milne-Thomson, Theoretical Aerodynamics, Imported Edition, Dover Publications, USA (2011), ISBN 9780486619804.

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	0	1	1	0	1	1	0	11
CO2	3	3	2	3	0	1	1	0	1	1	0	1
CO3	3	3	3	3	1	1	1	0	1	1	0	1
CO4	3	3	3	3	1	1	1	0	1	1	0	1
CO5	3	3	3	2	1	1	1	0	1	1	0	1

High-3, Medium-2, Low-1

Semester: IV		
FINITE ELEMENT METHODS		
Course Code:	**MVJ21AE53/AS43**	**CIE Marks:100**
Credits: L:T:P:S: 2:2:0:0		**SEE Marks: 100**
Hours: 30L+26T		**SEE Duration: 3 Hrs**
Course Learning Objectives: The students will be able 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.	

UNIT-I	
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** 1. https://nptel.ac.in/courses/112/104/112104193/ 2. https://nptel.ac.in/courses/112/104/112104116/	**10 Hrs**

https://ocw.mit.edu/courses/mechanical-engineering/2-092-finite-element-analysis-of-solids-and-fluids-i-fall-2009/study-materials/	
UNIT-II	
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/ https://ocw.mit.edu/courses/mechanical-engineering/2-092-finite-element-analysis-of-solids-and-fluids-i-fall-2009/study-materials/	**10 Hrs**
UNIT-III	
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:**	**10 Hrs**

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

Laboratory Sessions/ Experimental learning: Performing Heat Transfer Analysis Using ANSYS **Applications:** 1. Problem involving heat flow 2. Structural dynamics **Video link / Additional online information:** 1. https://nptel.ac.in/courses/112/104/112104193/ 2. https://nptel.ac.in/courses/112/104/112104116/ https://ocw.mit.edu/courses/mechanical-engineering/2-092-finite-element-analysis-of-solids-and-fluids-i-fall-2009/study-materials/	

Course Outcomes: After completing the course, the students will be able to	
CO202.1	Apply discretization technique for domain using different finite elements
CO202.2	Evaluate the effects of different loading and boundary conditions
CO202.3	Analyse the governing equations of finite element analysis
CO202.4	Formulating mathematical model using higher order element type
CO202.5	Analyse heat flow problem by considering dynamic consideration

Reference Books	
1.	ChandruPatla T. R, PHI Finite Elements in engineering, 3rd edition, 2002
2.	BhaviKatti, 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
	Rao S. S, Elsevier, Finite Elements Method in Engineering, 5th edition, 2008

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The

number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

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

MECHANISM AND MACHINE THEORY + MACHINE SHOP AND MMM LAB (Theory and Practice)		
Course Code:	**MVJ21AE44/MVJ21AS44**	**CIE Marks:50+50**
Credits: L:T:P: 3:0:1		**SEE Marks: 50 +50**
Hours:40 L+ 26 P		**SEE Duration: 03+03 Hours**
Course Learning Objectives: The students will be able to		

1	Understand the theory of mechanisms including velocity, acceleration and static force analysis.
2	Acquire knowledge of spur gears, gear train, balancing of rotating and reciprocating masses.
3	Understand the concept of governors and gyroscope.
4	Learn the concepts of mechanical measurements and metrology
5	Acquire the knowledge of basic metrological instruments

UNIT-I	
Introduction to Mechanisms: Types of constrained motion, Link and its types, joints and its types, kinematic pair and its types, degrees of freedom, Grubler's criterion, Types of kinematic chains and inversions: Inversions of Four bar chain: Beam engine, coupling rod of a locomotive, Watt's indicator mechanism. Inversions of Single Slider Crank Chain: Pendulum pump or Bull engine, Oscillating cylinder engine, Rotary internal combustion engine, Crank and slotted lever quick return motion mechanism, Whitworth quick return motion mechanism. Inversions of Double Slider Crank Chain: Elliptical trammels, Scotch yoke mechanism, Oldham's coupling. Straight line motion mechanisms: Peaucellier's mechanism and Robert's mechanism. Intermittent Motion mechanisms: Geneva wheel mechanism and Ratchet and Pawl mechanism, Ackerman steering gear mechanism. Laboratory Sessions/ Experimental learning: Whitworth quick return motion mechanism. (Machine Shop) Applications: Ackerman steering gear mechanism. Video link / Additional online information: https://www.youtube.com/watch?v=g8uqeru2LQw	**10 Hrs**
UNIT-II	
Velocity, Acceleration and static force analysis of Mechanisms (Graphical Methods): Velocity and acceleration analysis of Four Bar mechanism, slider crank mechanism and Simple Mechanisms by vector polygons. Static force analysis:	**10 Hrs**

Introduction: Static equilibrium, Equilibrium of two and three force members. Members with two forces and torque. Free body diagrams, principle of virtual work. Static force analysis of four bar mechanism and slider-crank mechanism with and without friction Video link / Additional online information: https://www.youtube.com/watch?v=CTcdQzH5e04	
UNIT-III	
Spur Gears and Gear Trains Spur Gears: Gear terminology, law of gearing, Path of contact, Arc of contact, Contact ratio of spur gear, Interference in involute gears, Methods of avoiding interference. Gear Trains: Simple gear trains, Compound gear trains, Reverted gear trains, Epicyclic gear trains, Analysis of epicyclic gear train (Algebraic and tabular methods), torques in epicyclic trains. Applications: Design Of spur Gear Video link / Additional online information: https://www.youtube.com/watch?v=N0hTFnvIE7A	**10 Hrs**
UNIT-IV	
Balancing of Rotating and Reciprocating Masses Balancing of Rotating Masses: Balancing of Several Masses Rotating in the Same Plane, Balancing of Several Masses Rotating in Different Planes (only Graphical Methods). Balancing of Reciprocating Masses: Primary and Secondary Unbalanced Forces of Reciprocating Masses, Partial Balancing of Unbalanced Primary Force in a Reciprocating Engine, Balancing of Primary and secondary Forces of Multi-cylinder In-line Engines, Balancing of Radial Engines (only Graphical Methods) Video link / Additional online information: https://www.youtube.com/watch?v=N0hTFnvIE7A	**10 Hrs**
UNIT-V	
Types of governors; force analysis of Porter and Hartnell governors, Controlling force, stability, sensitiveness, isochronism, effort and power of Porter and Hartnell governors. Gyroscopes: Vectorial representation of angular motion, gyroscopic couple, effect of gyroscopic couple on plane disc and aeroplane Laboratory Sessions/ Experimental learning: Porter and Hartnell governors	**10 Hrs**

(Design lab) Applications:: Working Of Governors Links https://www.youtube.com/watch?v=FydJu1A1oeM	

LABORATORY EXPERIMENTS
1.Machining and machining time estimation for plain turning and step turning & taper turning.
2.Machining and machining time estimation for drilling, boring and knurling operation
3.Machining and machining time estimation for thread cutting
4.Cutting of gear teeth using milling machine
5.Calibration of Pressure Gauge and Thermocouple
6.Calibration of Load Cell and LVDT
7.Calibration of micrometer using slip gauges.
8.Measurements of angle using: a. Sine Centre b. Sine Bar c. Bevel protractor
9.Machining of hexagon in shaping machine
10.Measurements of alignment using Autocollimator

Course Outcomes: After completing the course, the students will be able to	
CO1	Apply the theory of velocity, acceleration and static force analysis to design of mechanisms.
CO2	Analyze static and dynamic force analysis of mechanisms.
CO3	Design of spur gears & Gear train.

CO4	Evaluate spur gears, gear train, balancing of rotating and reciprocating masses.
CO5	Analyse governors and gyroscope
CO6	Use different measuring tools related to experiments
CO7	Conduct, Analyse, interpret, and present measurement data from measurements Identify, define, and explain accuracy, precision, and some additional terminology

Reference Books	
1.	Rattan S.S, "Theory of Machines", Tata McGraw-Hill Publishing Company Ltd., New Delhi, and 3rd edition -2009, ISBN: 007014477X, 9780070144774.
2.	J.J. Uicker, G.R. Pennock, J.E. Shigley. "Theory of Machines & Mechanisms", OXFORD 3rd Ed. 2009, ISBN-13: 978-0195371239
3.	R. S. Khurmi, J.K. Gupta, "Theory of Machines", Eurasia Publishing House, 2008, ISBN 13: 9788121925242.

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the self -study are 20 (2 presentations are be held for 10 marks each). The marks obtained in test, quiz and self -studies are added to get marks out of 100 and report CIE for 50 marks.

Laboratory- 50 Marks

The laboratory session is held every week as per the time table and the performance of the student is evaluated in every session. The average of the marks over number of weeks is considered for 30 marks. At the end of the semester a test is conducted for 10 marks. The

students are encouraged to implement additional innovative experiments in the lab and are awarded 10 marks. Total marks for the laboratory is 50.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks are executed by means of an examination.

The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Laboratory- 50 Marks

Experiment Conduction with proper results is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

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

High-3, Medium-2, Low-1

Semester: IV		
FUNDAMENTALS OF AIRCRAFT STRUCTURES + CAAD LAB (Theory and Practice)		
Course Code:	**MVJ21AS45**	**CIE Marks:50+50**
Credits: L:T:P: 3:0:2		**SEE Marks: 50 +50**
Hours:40 L+ 26 P		**SEE Duration: 03+03 Hours**
Course Learning Objectives: The students will be able to		
1	Comprehend the basic concepts of stress strain and understand the different failure theories and to learn the concept of static strength	
2	Illustrate the methods to design a structure against impact and fatigue loads.	
3	Acquire the knowledge of types of loads on aerospace vehicles.	
4	Understand the theory of elasticity.	
5	Apply different Energy methods in calculations related to structural components and to understand the different methods to analyse columns	

UNIT-I	
Design for Static Strength: Introduction: Normal, shear, biaxial and tri-axial stresses, Stress tensor, Principal Stresses, Stress Analysis, Design considerations, Codes and Standards. Static Strength: Static loads and factor of safety, Theories of failure: Maximum normal stress theory, Maximum shear stress theory, Maximum strain theory, Strain energy theory, and Distortion energy theory, failure of brittle and ductile materials, Stress concentration, and Determination of Stress concentration factor. Laboratory Sessions/ Experimental learning: 1. Determination of Stress concentration factor for static load. 2. Determine the strain in x-y-z directions using strain gauge for a given beam Applications: Stress Analysis, Theory of failures	**10 Hrs**

Video link / Additional online information (related to module if any): https://www.youtube.com/watch?v=NnvImUMfYyc	
UNIT-II	
Design for Impact and Fatigue Strength: Impact Strength: Introduction, Impact stresses due to axial, bending and torsional loads, effect of inertia. Fatigue Strength: Introduction, S-N Diagram, Low cycle fatigue, High cycle fatigue, Endurance limit, modifying factors: size effect, surface effect, Stress concentration effects, Fluctuating stresses, Goodman and Soderberg relationship, stresses due to combined loading, cumulative fatigue damage. Laboratory Sessions/ Experimental learning: 1. Determine the notch sensitivity and impact toughness of engineering materials**.** 2. Demonstrate how fatigue tests are conducted and how to interpret results Applications: Fatigue Testing, Combined Loading Video link / Additional online information (related to module if any): https://www.youtube.com/watch?v=ZsIwEp574ho https://www.youtube.com/watch?v=X-_qUQ3xaTA	**10 Hrs**
UNIT-III	
Loads on Aircraft and Spacecrafts: Structural nomenclature, Types of loads, load factor, Aerodynamic loads, Symmetric manoeuvre loads, Velocity diagram, Function of structural components. **Spacecraft Structures:** StaticallyDeterminate and Indeterminate structures, Analysis of plane truss, Method of joints, 3D Truss, Plane frames, Composite beam, Clapeyron's Three Moment Equation. Laboratory Sessions/ Experimental learning: 1. Determination of Deflection in a beam by applying point load and combined loading. 2. Determine the deflection of composite beam Applications: Analysis of Loads, Determinate and Indeterminate structures. Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/105105166/https://www.youtube.com/watch?v=q0_piF4-eNc	**10 Hrs**
UNIT-IV	

Theory of Elasticity: Theory of Elasticity: Concept of stress and strain, derivation of Equilibrium equations, strain displacement relation, compatibility conditions and boundary conditions. Plane stress and Plane strain problems in 2D elasticity. Principle Stresses and Orientation of Principle Directions. **Columns**: Columns with various end conditions, Euler's Column curve, Rankine's formula, Column with initial curvature, Eccentric loading, southwell plot, Beam-column. Laboratory Sessions/ Experimental learning: 1. Determine the Spring Stiffness for the given spring. 2. Buckling load of slender Eccentric Columns and Construction of Southwell Plot Applications: Stress and Strain displacement, Columns Video link / Additional online information (related to module if any): http://www.digimat.in/nptel/courses/video/112101095/L02.htmlhttps://www.digimat.in/nptel/courses/video/105105177/L01.html	**10 Hrs**
UNIT-V	
Energy Methods: Strain Energy due to axial, bending and Torsional loads. Castigliano's theorem, Maxwell's Reciprocal theorem. **Introduction to Shear Flow:** Symmetrical and Unsymmetrical bendingConcept of shear flow – The shear centre and its determination – Shear flow distribution in symmetrical and unsymmetrical thin-walled sections. Laboratory Sessions/ Experimental learning: 1. Verify Maxwell's Reciprocal theorem 2. Determining of Shear centre location for open sections-unsymmetrical bending Applications: Maxwell's Theorem, Shear Flow and Shear Center Video link / Additional online information (related to module if any): https://www.youtube.com/watch?v=149j7Ys0F58http://www.nptelvideos.com/video.php?id=1637	**10 Hrs**
LABORATORY EXPERIMENTS	
Part A- Sections of Solids: Sections of Pyramids, Prisms, Cubes, Tetrahedrons, Cones and Cylinders resting only on their bases (No problems on axis inclinations, spheres and hollow solids). True shape of sections.	

Orthographic Views: Conversion of pictorial views into orthographic projections of simple machine parts with or without section. (Bureau of Indian Standards conventions are to be followed for the drawings) Hidden line conventions. Precedence of lines.

Laboratory Sessions/ Experimental learning: CAAD Lab

Applications: Helps to understand Engineering Drawing.

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

https://www.youtube.com/watch?v=f1Hdtf_iAWk

Part B-Thread Forms: Thread terminology, sectional views of threads. ISO Metric (Internal & External) BSW (Internal & External) square and Acme. Sellers thread, American Standard thread.

Fasteners: Hexagonal headed bolt and nut with washer (assembly), square headed bolt and nut with washer (assembly) simple assembly using stud bolts with nut and lock nut. Flanged nut, slotted nut, taper and split pin for locking, counter sunk head screw, grub screw, Allen screw.

Riveted Joints: Single and double riveted lap joints, butt joints with single/double cover strap.

https://www.youtube.com/watch?v=70hESLwUhME

https://www.youtube.com/watch?v=Gdvtw0pTAOs

Part C - Assembly Drawings

1. Modeling of propeller and hub assembly
2. Modeling of wing assembly
3. Modeling of fuselage assembly
4. Modeling of Engine Mounts
5. Modeling of Landing Gear Assembly

Laboratory Sessions/ Experimental learning: CAAD Lab Applications: To Design an Aircraft Model.

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

https://www.youtube.com/watch?v=rmlUXhvJHt0

Course Outcomes: After completing the course, the students will be able to

CO1	Apply the different failure theories to understand the concept of static strength.
CO2	Design a structure against fatigue loads and to design a material for impact load.
CO3	Analyze various loads experienced by an aircraft in flight and to understand the usage of different materials.
CO4	Assess compatibility conditions and boundary conditions to find the stress and strain of an elastic material.
CO5	Formulate different Energy methods in calculations related to structural components and to understand the different methods to analyse columns.
CO6	Distinguish drawings of machine and aircraft components
CO7	Identify assembly drawings either manually or by using standard CAD packages.

Reference Books	
1.	Megson, T.H.G., "Aircraft Structures for Engineering Students", Edward Arnold, 6th Edition 2017, Elsevier Aerospace Engineering series, ISBN-13: 978-0081009147, ISBN10: 9780081009147.
2.	Bruhn E.F., "Analysis and Design of Flight Vehicles Structures", Tri-State offset Co.USA,1985
3.	Bruce K Donaldson, "Analysis of Aircraft structures", Cambridge Aerospace Series, reprint 2012, ISBN- 9780511801631
4.	Peery, D.J., and Azar, J.J., "Aircraft Structures", McGraw, Hill, N.Y, 2nd edition, 1993

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The

three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the self -study are 20 (2 presentations are be held for 10 marks each). The marks obtained in test, quiz and self -studies are added to get marks out of 100 and report CIE for 50 marks.

Laboratory- 50 Marks

The laboratory session is held every week as per the time table and the performance of the student is evaluated in every session. The average of the marks over number of weeks is considered for 30 marks. At the end of the semester a test is conducted for 10 marks. The students are encouraged to implement additional innovative experiments in the lab and are awarded 10 marks. Total marks for the laboratory is 50.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks are executed by means of an examination.

The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Laboratory- 50 Marks

Experiment Conduction with proper results is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

CO1	3	2	2	1	1	1	1	0	1	1	0	1
CO2	3	2	2	1	1	1	1	1	1	1	0	1
CO3	3	2	2	1	1	1	1	0	1	1	0	1
CO4	3	2	2	1	1	1	1	0	1	1	0	1
CO5	3	2	2	1	1	1	1	1	1	1	0	1

High-3, Medium-2, Low-1

Semester: III		
Balike Kannada		
Course Code:	**MVJ21BK36**	**CIE Marks:50**
Credits: L:T:P:S: 1:0:0:0		**SEE Marks: 50**
Hours: 20L		**SEE Duration: 3 Hrs**
Course Learning Objectives: This course will enable students to understand Kannada and communicate in Kannada language		
1	Vyavharika Kannada –Parichaya (Introduction to Vyavharikakannada)	
2	Kannada Aksharamaalehaaguuchcharane(Kannada Alphabets and Pronounciation.	
3	Sambhashanegaagi Kannada Padagalu (Kannada Vocubulary for Communication).	
4	Kannada Grammer in Conversations(Sambhasaneyalli Kannada Vyakarana)	
5	Activities in Kannada	

UNIT-I	
Vyavharika Kannada –Parichaya (Introduction to Vyavharikakannada)	**8 Hrs**
UNIT-II	
Kannada Aksharamaalehaaguuchcharane(Kannada Alphabets and Pronounciation	**8 Hrs**
UNIT-III	
Sambhashanegaagi Kannada Padagalu (Kannada Vocubulary for Communication)	**8 Hrs**

UNIT-IV	
Kannada Grammer in Conversations(Sambhasaneyalli Kannada Vyakarana)	**8 Hrs**
UNIT-V	
Activities in Kannada	**8 Hrs**

Scheme of Evaluation:		
Details		**Marks**
Average of three Internal Assessment (IA) Tests of 30 Marks each i.e. Σ (Marks Obtained in each test) / 3	**CIE(50)**	**30**
ASSIGNMENT		**20**
Semester End Examination	**SEE (50)**	**50**
	Total	**100**

Semester: III		
SAMSKRUTHIKA KANNADA		
Course Code:	**MVJ21SK36**	**CIE Marks:50**
Credits: L:T:P:S: 1:0:0:0		**SEE Marks: 50**
Hours: 20L		**SEE Duration: 3 Hrs**
Course Learning Objectives: This course will enable students to understand Kannada and communicate in Kannada language		
1	Samskruthika Kannada –Parichaya (Introduction to Adalitha kannada)	
2	Kannada Kavyagala parichaya (Kannada D Ra Bendre, Siddalingaiha)	

3	Adalithdalli Kannada Padagalu (Kannada Kagunitha Balake, Patra Lekhana, Prabhandha)
4	Kannada Computer Gnyana (Kannada Shabdha Sangraha, Computer Paribashika padagalu)
5	Activities in Kannada.

UNIT-I	
PÀ£ÀßqÀ ¨sÁµÉ-¸ÀAQë¥ÀÛ «ªÀgÀuÉ.	**8 Hrs**
UNIT-II	
¨sÁµÁ ¥ÀæAiÉÆÃUÀ¯ÁèUÀÄªÀ ¯ÉÆÃ¥ÀzÉÆÃµÀUÀ¼ÀÄ ªÀÄvÀÄÛ CªÀÅUÀ¼À ¤ªÁgÀuÉ.	**8 Hrs**
UNIT-III	
¯ÉÃR£À aºÉßUÀ¼ÀÄ ªÀÄvÀÄÛ CªÀÅUÀ¼À G¥ÀAiÉÆÃU.À	**8 Hrs**
UNIT-IV	
¥ÀvÀæ ªÀåªÀºÁgÀ.	**8 Hrs**
UNIT-V	
DqÀ½vÀ ¥ÀvÀæUÀ¼ÀÄ.	**8 Hrs**
UNIT-VI	
¸ÀPÁðgÀzÀ DzÉÃ±À ¥ÀvÀæUÀ¼ÀÄ	**8 Hrs**
UNIT-VII	
¸ÀAQÃ¥ÀÛ ¥Àæ§AzsÀ gÀZÀ£É, ¥Àæ§AzsÀ ªÀÄvÀÄÛ ¨sÁµÁAvÀgÀ	**8 Hrs**
UNIT-VIII	
PÀ£ÀßqÀ ±À§Ý¸ÀAUÀæºÀ	**8 Hrs**
UNIT-IX	
PÀA¥ÀÆålgï ºÁUÀÆ ªÀiÁ»w vÀAvÀæeÁÕ£À	**8 Hrs**
UNIT-X	
¥Áj¨sÁ¶PÀ DqÀ½vÀ PÀ£ÀßqÀ ¥ÀzÀUÀ¼ÀÄ ªÀÄvÀÄÛ vÁAwæPÀ/PÀA¥ÀÆålgï ¥Áj¨sÁ¶PÀ ¥ÀzÀUÀ¼ÀÄ.	**8 Hrs**

Scheme of Evaluation:	
Details	**Marks**

Average of three Internal Assessment (IA) Tests of 30 Marks each i.e. Σ (Marks Obtained in each test) / 3	**CIE(50)**	**30**
ASSIGNMENT		**20**
Semester End Examination	**SEE (50)**	**50**
	Total	**100**

Semester: IV		
CONSTITUTION OF INDIA, PROFESSIONAL ETHICS AND CYBER LAW		
Course Code:	**MVJ21CPH36/46**	**CIE Marks:50**
Credits: L:T:P:S: 1:0:0:0		**SEE Marks: 50**
Hours: 20L		**SEE Duration: 3 Hrs**
Course Learning Objectives: The students will be able to		
1	To know the fundamental political codes, structure, procedures, powers, and duties of Indian constitution, Indian government institutions, fundamental rights, directive principles and the duties of the citizens.	
2	To provide overall legal literacy to the young technograts to manage complex societal issues in the present scenario.	
3	To understand engineering ethics & their responsibilities, identify their individual roles and ethical responsibilities towards society.	

UNIT-I	
Introduction to Indian Constitution The Necessity of the Constitution, The Societies before and after the Constitution adoption. Introduction to the Indian Constitution, The Making of the Constitution, The role of the Constituent Assembly – Preamble and Salient features of the	**8 Hrs**

Constitution of India. Fundamental Rights and its Restriction and Limitations in different Complex Situations. Directive Principles of State Policy (DPSP) and its present relevance in our society with examples. Fundamental Duties and its Scope and Significance in Nation Building.	
UNIT-II	
Union Executive and State Executive Parliamentary System, Federal System, Centre-State Relations. Union Executive – President, Prime Minister, Union Cabinet, Parliament - LS and RS, Parliamentary Committees, Important Parliamentary Terminologies. Supreme Court of India, Judicial Reviews and Judicial Activism. State Executives – Governor, Chief Minister, State Cabinet, State Legislature, High Court and Subordinate Courts, Special Provisions (Article 370, 371, 371J) for some States.	**8 Hrs**
UNIT-III	
Elections, Amendments and Emergency Provisions Elections, Electoral Process, and Election Commission of India, Election Laws. Amendments - Methods in Constitutional Amendments (How and Why) and Important Constitutional Amendments. Amendments – 7,9,10,12,42,44,61,73,74,75,86, and 91,94,95,100,101,118 and some important Case Studies. Recent Amendments with explanation. Important Judgements with Explanation and its impact on society (from the list of Supreme Court Judgements). Emergency Provisions, types of Emergencies and it's consequences. **Constitutional Special Provisions:** Special Constitutional Provisions for SC & ST, OBC, Special Provision for Women, Children & Backward Classes.	**8 Hrs**
UNIT-IV	
Professional / Engineering Ethics Scope & Aims of Engineering & Professional Ethics - Business Ethics, Corporate Ethics, Personal Ethics. Engineering and Professionalism, Positive and Negative Faces of Engineering Ethics, Code of Ethics as defined in the website of Institution of Engineers (India) : Profession, Professionalism, Professional Responsibility. Clash of Ethics, Conflicts of Interest. **Responsibilities in Engineering** - Responsibilities in Engineering and Engineering Standards, the	**8 Hrs**

impediments to Responsibility.Trust and Reliability in Engineering, IPRs (Intellectual Property Rights), Risks, Safety and liability in Engineering.	
UNIT-V	
Internet Laws, Cyber Crimes and Cyber Laws: Internet and Need for Cyber Laws, Modes of Regulation of Internet, Types of cyber terror capability, Net neutrality, Types of Cyber Crimes, India and cyber law, Cyber Crimes and the information Technology Act 2000, Internet Censorship, Cybercrimes and enforcement agencies.	**8 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1	Have constitutional knowledge and legal literacy
CO2	Understand Engineering and Professional ethics and responsibilities of Engineers.
CO3	Understand the cyber crimes and cyber laws for cyber safety measure.

Reference Books	
1.	Constitution of India and Professional Ethics, T.S. Anupama, Sunstar Publisher
2.	Durga Das Basu (DD Basu): "Introduction to the Constitution on India", (Students Edition.) Prentice –Hall EEE, 19th/20th Edn., (Latest Edition) or 2008.
3.	Shubham Singles, Charles E. Haries, and Et al : "Constitution of India and Professional Ethics" by Cengage Learning India Private Limited, Latest Edition – 2018.
4.	M.Govindarajan, S.Natarajan, V.S.Senthilkumar, "Engineering Ethics", Prentice –Hall of India Pvt. Ltd. New Delhi, 2004.
5.	M.V.Pylee, "An Introduction to Constitution of India", Vikas Publishing, 2002.
6.	Latest Publications of NHRC - Indian Institute of Human Rights, New Delhi.

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 (40 marks each), the final IA marks to be awarded will be the average of three tests - Assignment (10 marks)

SEE Assessment:
i. Question paper for the SEE consists one part. It is compulsory and consists of objective type 1 mark each for total of 50 marks covering the whole syllabus. ii. Ten questions 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
CO1	2	2	1	1	1	2	2	1	1	1	1	2
CO2	1	2	2	1	1	2	1	1	1	1	1	2
CO3	2	1	2	1	1	1	1	1	1	1	1	2
CO4	2	2	1	1	1	1	1	1	1	1	1	2
CO5	2	2	1	1	1	2	1	1	1	1	1	2

High-3, Medium-2, Low-1

Semester: IV		
TURBOMACHINES		
Course Code:	**MVJ21AEC47**	**CIE Marks:100**
Credits: L:T:P:S: 2:0:0:0		**SEE Marks: 100**
Hours: 22L		**SEE Duration: 3 Hrs**
Course Learning Objectives: The students will be able to		
1	Understand the basics of turbomachines, classification and energy transfer in turbomachines.	
2	Acquire the knowledge on analysis of centrifugal and axial compressors.	
3	Acquire the knowledge on analysis of centrifugal and axial turbines.	

UNIT-I	
Introduction and Energy transfer in turbomachines:	**8 Hrs**

Classification and parts of a turbo machines, comparison with positive displacement machines. Euler turbine equation and its alternate form; components of energy transfer; general expression for degree of reaction; construction of velocity triangles for different values of degree of reaction. **Laboratory Sessions/ Experimental learning:** Aircraft propulsion lab for acquiring knowledge of Gas turbine engine. **Applications**: Study of Turbomachines, components of gas turbine engines. **Video link / Additional online information:** https://nptel.ac.in/courses/112/106/112106200/	
UNIT-II	
Analysis of centrifugal and axial flow compressors **Centrifugal compressors:** Parts of centrifugal compressor, principle operation, energy transfer, h-s diagram, blade shapes and velocity triangles, analysis of flow through the compressor, performance parameter and characteristics, and illustrative examples **Axial compressors:** Geometry and working principle, stage velocity triangles, h-s diagram, work input, work done factor, performance coefficients degree of reaction (low, fifty percent and high), and illustrative examples. **Laboratory Sessions/ Experimental learning**: Aircraft Propulsion lab and Fluid Mechanics lab for compressor and turbines. **Applications**: Compressors and Turbines in Aircraft engines. **Video link / Additional online information**: https://nptel.ac.in/courses/101/101/101101058/ https://www.youtube.com/watch?v=oitC03G-QYE	**7 Hrs**
UNIT-III	
Analysis of centrifugal and axial flow turbines **Radial flow turbines:** Elements of radial turbine stage, stage velocity triangles, energy transfer, h-s diagram, degree of reaction, performance characteristics, outward flow radial stages, and illustrative examples.	**7 Hrs**

Axial flow turbines: Stage velocity triangles, energy transfer, h-s diagram, impulse and reaction stages (zero, fifty percent, hundred percent and negetive), performance chats, and illustrative examples. **Laboratory Sessions/ Experimental learning**: Aircraft propulsion lab and Fluid mechanics lab, **Applications:** Turbojet, turbofan, turbo shaft engines. **Video link / Additional online information**: http://www.infocobuild.com/education/audio-video-courses/aeronautics-and-astronautics/TurbomachineryAerodynamics-IIT-Bombay/lecture-22.html **https://www.youtube.com/watch?v=h4LYyUOtQow**	

Course Outcomes: After completing the course, the students will be able to	
CO1	Illustrate the classification of turbomachines and compute the energy transfer in turbomachines.
CO2	Illustrate the knowledge on centrifugal and axial flow compressors.
CO3	Illustrate the knowledge on radial and axial flow turbines.

Reference Books	
1.	S.M. Yahya, Turbines, Compressors & Fans, Tata-McGraw Hill, 2nd Edition, ISBN 13: 9780070707023.
2.	V Ganesan, Gas Turbines, Tata-McGraw Hill, 3rd Edition, ISBN 13: 9780070681927

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	1	1	1	1	0	1	0	0	1
CO2	3	3	3	2	1	1	1	0	1	0	0	1
CO3	3	3	3	2	1	1	1	0	1	0	0	1

High-3, Medium-2, Low-1

Semester: IV		
Diploma Mathematics-II		
Course Code:	**MVJ21MATDIP41**	**CIE Marks:100**
Credits: L:T:P:S: 1:2:0:0		**SEE Marks: 100**
Hours: 30L+26T		**SEE Duration: 3 Hrs**
Course Learning Objectives: The students will be able to		
1	To familiarize the important and basic concepts of Differential calculus and Differential	

	Equation, ordinary/partial differential equations and Vector calculus and analyse the engineering problems.

UNIT-I	
Linear Algebra: Introduction, Rank of a matrix-echelon form. Solution of system of linear equations – consistency. Gauss-elimination method and problems. Eigen values and Eigen vectors of square matrix and Problems. Video Link: **https://www.math.ust.hk/~machas/matrix-algebra-for-engineers.pdf** **https://nptel.ac.in/content/storage2/courses/122104018/node18.html**	**8 Hrs**
UNIT-II	
Differential calculus: **Tangent and normal, sub tangent and subnormal both Cartesian and polar forms. Increasing and decreasing functions, Maxima and Minima for a function of one variable. Point of inflections and Problems** **Beta and Gamma functions:** **Beta functions, Properties of Beta function and Gamma function ,Relation Between beta and Gamma function-simple problems.** **Video Link:** **https://www.youtube.com/watch?v=6RwOoPN2zqE** **https://www.youtube.com/watch?v=s6F5yjY6jWk&list=PLMLsjhQWWlUqBoTCQDtYlloI-o-9hxp11** **http://tutorial.math.lamar.edu/Classes/DE/IntroPDE.aspx**	**8 Hrs**
UNIT-III	
Analytical solid geometry : Introduction –Directional cosine and Directional ratio of a line, Equation of line in space- different forms, Angle between two line, shortest distance between two line, plane and equation of plane in different forms and problems. Video Link: https://www.toppr.com/guides/maths/three-dimensional-geometry/	**8 Hrs**

https://www.toppr.com/guides/maths/three-dimensional-geometry/distance-between-skew-lines/	
UNIT-IV	
Probability: Random variable, Discrete probability distribution, Mean and variance of Random Variable, Theoretical distribution-Binomial distribution, Mean and variance Binomial distribution -Problems. Poisson distribution as a limiting case of Binomial distribution, Mean and variance of Poisson distribution. Normal Distribution-Basic properties of Normal distribution –standard form of normal distribution and Problems. Video Link: https://nptel.ac.in/courses/111/105/111105041/ https://www.mathsisfun.com/data/probability.html	**8 Hrs**
UNIT-V	
Partial differential equation: Formation of PDE's by elimination of arbitrary constants and functions. Solution of non-homogeneous PDE by direct integration. Homogeneous PDEs involving derivative with respect to one independent variable only. Video Link: http://tutorial.math.lamar.edu/Classes/DE/IntroPDE.aspx https://www.studyyaar.com/index.php/module-video/watch/233-cauchys-legendres-de-a-method- of- variation-of-parameters	**8 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1	Apply the knowledge of Matrices to solve the system of linear equations and to understand the concepts of Eigen value and Eigen vectors for engineering problems.

CO2	Demonstrate various physical models, find Maxima and Minima for a function of one variable., Point of inflections and Problems. Understand Beta and Gamma function
CO3	Understand the 3-Dimentional geometry basic, Equation of line in space-different forms, Angle between two line and studying the shortest distance.
CO4	Concepts OF Probability related to engineering applications.
CO5	Construct a variety of partial differential equations and solution by exact methods.

Reference Books	
1.	B.S. Grewal, "Higher Engineering Mathematics" Khanna Publishers, 43rd Edition, 2013.
2.	Ramana B. V., "Higher Engineering Mathematics", Tata Mc Graw-Hill, 2006.
3.	Erwin Kreyszig, "Advanced Engineering Mathematics", Wiley-India publishers, 10thedition,2014.
4.	G. B. Gururajachar: Calculus and Linear Algebra, Academic Excellent Series Publication, 2018-19

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

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

High-3, Medium-2, Low-1

Course Title	**Aviation Management**	**Semester**	V
Course Code	MVJ21AS51/ MVJ21AE51	**CIE**	50
Total No. of Contact Hours	40L: T: P::3: 0 :0	**SEE**	50
No. of Contact Hours/week	4	**Total**	100
Credits	3	**Exam. Duration**	3 Hours

Course objective is to: This course will enable students to

- Introduce the field of management, task of the manager, importance of planning and types of planning, staff recruitment and selection process.
- Explain need of coordination between the manager and staff, the social responsibility of business and leadership.
- Comprehend the fundamentals of maintenance and certification.
- Understand the Aircraft Management Maintenance.
- Acquire knowledge of maintenance safety and trouble shooting in Airlines.

Module-1	**L1., L2**	**8Hours**

Management: Definition, Importance – Nature and Characteristics of Management, Management Functions, Roles of Manager, Levels of Management, Managerial Skills, Management & Administration, Management as a Science, Art &Profession.

Planning: Nature, Importance and Purpose Of Planning, Types of Plans, Steps in Planning, Limitations of Planning, Decision Making – Meaning, Types of Decisions- Steps in Decision Making.

Laboratory Sessions/ Experimental learning: Case study on decision making process in a corporate.

Applications: Planning in engineering field.

Web Link and Video Lectures

https://nptel.ac.in/courses/110/105/110105146/

https://nptel.ac.in/courses/122/108/122108038/

Module-2	**L1., L2**	**8Hours**

Organizing and Staffing: Meaning, Nature and Characteristics of Organization – Process of Organization, Principles of Organization, Departmentalization, Committees – meaning, Types of Committees, Centralization Vs Decentralization of Authority and Responsibility, Span of Control, Nature and Importance of Staffing, Process of Selection and Recruitment.

Directing and Controlling: Meaning and Nature of Directing-Leadership Styles, Motivation Theories, Communication – Meaning and Importance, Coordination- Meaning and Importance, Techniques of Coordination. Controlling – Meaning, Steps in Controlling.

Laboratory Sessions/ Experimental learning

Case study of steel plant departmentalization.

Applications: Effective communication in a corporate.

Web Link and Video Lectures

https://nptel.ac.in/content/storage2/courses/122106031/slides/3_2s.pdf

https://www.slideshare.net/100005130728571/27-nature-of-directing

Module-3	**L1., L2**	**8Hours**

Fundamentals of Maintenance & Certification:

Types of maintenance, Redesign, Failure rate pattern, Other maintenance considerations. Aviation industry certification requirements, Type certificate (FAA form 8110.9), Airworthiness certificate (FAA form 8100-2), Aviation maintenance certifications, General, Airframe, Power plant, Avionics courses.

Laboratory Sessions/ Experimental learning:A demo on maintenance procedure in wind tunnel lab.

Applications: Apply the certification process in Aircraft industry.

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

1. https://www.youtube.com/watch?v=KEF2szWaEgg – Introduction about Aircraft Maintenance-NPTEL-IITK
2. https://www.youtube.com/watch?v=CoLWYZP9BkY&list=PLExlUJZK1IOnUv8IeOXLk_njBYhc-Xh6V –Aircraft Maintenance-NPTEL-IITK
3. https://www.youtube.com/watch?v=H45vSzyiXH4 – Airplane Maintenance

Module-4	**L1., L2**	**8Hours**

Aircraft Management Maintenance

Structure, Role of aviation management, Line supervisory management, Management areas of concern in airlines, Manager of overhaul shops, Line maintenance control center flight line (preflight& post flight), Aircraft Logbook, Maintenance crew skill requirements.

Laboratory Sessions/ Experimental learning: A demo on aircraft logbook.

Applications: Implement the aviation management in airlines.

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

1. https://www.youtube.com/watch?v=f6F_ecq1njc – Aviation management

https://www.youtube.com/watch?v=P7GfDmd7Nqw-Aircraft line maintenance check example

Module-5	**L1., L2**	**8Hours**

Maintenance Safety & Trouble shooting

Safety regulations, occupational safety and health standards maintenance safety program, Airlines safety management, General safety rules, Accident & injury reporting, Hazardous materials storage and handling aircraft furnishing practices trouble shooting, Knowledge of malfunctions.

Laboratory Sessions/ Experimental learning: A demo on safety system in wind tunnel lab.

Applications: Apply the safety regulations, OSHA safety programs and troubleshooting systems in aircraft.

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

1. https://www.youtube.com/watch?v=aRA7QR2Mr_w – Airlines safety management system
2. https://www.youtube.com/watch?v=5bc1qBtkRWA –How do Airline store aircraft?

https://www.youtube.com/watch?v=89IWlG0Uhz0 – trouble shooting procedure for the aircraft systems

Course outcomes:

CO1	Understand the concept of Management
CO2	Understand the staffing process
CO3	Apply the certification procedure for aircraft maintenance.
CO4	Apply the management system in aircraft maintenance.
CO5	Examine the quality control and calibration on Aircraft.

Reference Books:

1	StephenP.Robbins&MaryCoulter,Management‖,PrenticeHall(India)Pvt.Ltd.,10th Edition, 2009
2	Harry A Kinnison, Tariq Siddiqui, Aviation Maintenance Management, Mc Graw Hill education (India) Private Ltd, 2013.
3	Kroes, Watkins, Delp, Aircraft maintenance and repair, Mc Graw Hill,2013.
4	Larry Reithmaier, Aircraft Repair Manual, Palmar Books, Marquette,1992.

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:

i. Question paper for the SEE consists of 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.

ii. 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.

iii. 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
CO1	2	3	3	2				1	1		1	1
CO2	2	2	1	2	2			1	1	1	1	1
CO3	2	2	1	2	2		1	1	1		1	1
CO4	2	2	1	1							1	1
CO5	3	3	2	2	2			1	1	1	1	1

High:3, Medium:2, Low:1

Course Title	**Computational Fluid Dynamics**	**Semester**	**V**
Course Code	**MVJ21AS52**	**CIE**	**50**
Total No. of Contact Hours	**40 L : T : P :: 3 : 0:0**	**SEE**	**50**
No. of Contact Hours/week	**4**	**Total**	**100**
Credits	**3**	**Exam. Duration**	**3hrs**

The Course objective is to:

1. Gain knowledge of CFDideas, and Flow Equations
2. Learn the Mathematical behaviour of PDEs vis a visnature of flow

3. Know the discretisationtechniques 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**	10Hrs.

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**	10Hrs.

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**	10Hrs.

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**	10Hrs.

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**	10Hrs.

Finite Volume Techniques and some Applications: Spatialdiscretisation:-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:

iv. 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.

v. 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.

vi. 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	PSO 1	PSO 2
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	**Compressible Aerodynamics (+Aerodynamic Lab)**	**Semester**	**V**

Course Code	**MVJ21AS53/ MVJ21AE53**	**CIE**	**50**
Total No. of Contact Hours	**50 L: T: P: 3:1:0**	**SEE**	**50**
No. of Contact Hours/week	**5**	**Total**	**100**
Credits	**4**	**Exam. Duration**	**3 Hrs.**

The course objective is to:

1. Understand the concepts of compressible flow

2. Acquire knowledge of normal shock waves

3. Comprehend the phenomenon of oblique shocks and expansion waves

4.Understand the concepts of Differential Equations of Motion for Steady Compressible Flows

5. Gain knowledge of flow measurement techniques

Module 1	**L1,L2**	10 Hrs.

One Dimensional Compressible Flow: Energy, Momentum, continuity and state equations, velocity of sound, Adiabatic steady state flow equations, Flow through converging, diverging passages, Performance under various back pressures. Numerical

Laboratory Sessions/ Experimental learning: Visualization of Flow analysis in Ansys Lab

Applications: Understanding the close coupling of thermodynamics and fluid dynamics and analyse typical aircraft systems like nozzles, diffusers, intakes

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

4. https://www.youtube.com/watch?v=mS3ZVuOn_lU&list=PLwdnzlV3ogoWb_iTQza6Z8dYHR-_1qhh0&index=2
5. https://youtu.be/mS3ZVuOn_lU?list=PLwdnzlV3ogoWb_iTQza6Z8dYHR-_1qhh0
6. https://youtu.be/HfZ5gfybJK4?list=PLwdnzlV3ogoWb_iTQza6Z8dYHR-_1qhh0

Module 2	**L1,L2,**	10 Hrs.

Normal Shock: Prandtl Meyer equation and Rankine – Hugonoit relation, Normal shock equations: Property ratios in terms of upstream Mach number, Numericals, Moving Normal Shock wave. Shock tube.

Laboratory Sessions/ Experimental learning: Visualization of airfoil cross-section in Aerodynamics Lab

Applications: Analyzing the supersonic flow problems involving normal shock waves to design and analyze aircraft systems like nozzles, diffusers, intakes, shock tubes, wind tunnels, pipe flows.

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

1. https://nptel.ac.in/courses/112/106/112106166/
2. https://nptel.ac.in/courses/101/108/101108086/#

Module 3	L1,L2	10 Hrs.

Oblique shocks and Expansion waves: Prandtl equation and Rankine – Hugonoit relation, Normal shock equations, Pitot static tube, corrections for subsonic and supersonic flows, Oblique shocks and corresponding equations, Hodograph and pressure turning angle, shock polars, flow past wedges and concave corners, strong, weak and detached shocks, Flow past convex corners, Prandtl –Meyer expansion function, Reflection and interaction of shocks and expansion waves.

Laboratory Sessions/ Experimental learning: Visualization of airfoil cross-section in Aerodynamics Lab

Applications: Analyzing the supersonic flow problems involving oblique shock waves to design and analyze aircraft systems like nozzles, diffusers, intakes, shock tubes, wind tunnels, pipe flows

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

2. https://nptel.ac.in/courses/112/106/112106056/
3. https://nptel.ac.in/courses/112/106/112106056/
4. https://nptel.ac.in/courses/112/106/112106056/

Module 4	L1,L2	10 Hrs.

Differential Equations of Motion for Steady Compressible Flows: Basic potential equations for compressible flow. Linearisation of potential equation-small perturbation theory. Methods for solution of nonlinear potential equation –Introduction, Method of characteristics, Boundary conditions, Pressure coefficient expression, small perturbation equation for compressible flow - Prandtl, Glauret and Geothert's rules - Ackert's supersonic airfoil theory, Von-Karman rule for transonic flow, Lift, drag pitching moment and center of pressure of supersonic profiles

Laboratory Sessions/ Experimental learning: Flow Problems using Ansys Lab

Applications: Analyze and interpret the flow behavior

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

1. https://nptel.ac.in/courses/101/106/101106044/
2. https://nptel.ac.in/courses/112/106/112106056/

Module 5	L1,L2	10Hrs.

Measurements in High-speed Flow: Types of subsonic wind tunnels Balances and measurements - Interference effects transonic, Supersonic and hypersonic wind tunnels and characteristic features, their operation and performance – Shock tubes and shock tunnels - Free flight testing - Measurements of pressure, velocity and Mach number -Flow visualization methods of subsonic and supersonic flows.

Laboratory Sessions/ Experimental learning: Wind Tunnel model force measurements

Applications: Understand the significance of wind tunnels in Aeronautics/Aerospace and perform experiments on appropriate model's wind tunnel

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

1. https://nptel.ac.in/courses/101/106/101106040/

2. https://nptel.ac.in/courses/101/106/101106044/

Course outcomes:

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

CO302.1	Apply the basic concepts of compressible flow
CO302.2	Evaluate the concepts of normal shock phenomenon
CO302.3	Apply the concepts of oblique shock and expansion wave formation.
CO302.4	Utilize the concepts of Differential Equations of Motion for Steady Compressible Flows
CO302.5	Investigate the parameters of high-speed flow.

Reference Books:

1.	John D Anderson, Modern Compressible Flow, McGraw Hill,3rd edition,2012,ISBN-13: 978-1259027420.
2.	Radhakrishnan, E., Gas Dynamics, Prentice Hall of India,5th edition,2014,ISBN-13: 978-8120348394
3.	Ascher.H. Saphiro, Dynamics and Thermodynamics of Compressible fluid flow, John Wiley& Sons,1st edition,1977, ISBN-13: 978-0471066910.
4.	Yahya, S.M., Fundamentals of Compressible flow, NEW AGE, 2009, ISBN-13: 978-8122426687.
5.	H.W. Liepmann and A. Roshko, Elements of Gas Dynamics, Dover Publications Inc,2003,ISBN-13: 978-0486419633.

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:

vii. 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.

viii. 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.

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

High,3, Medium,2, Low,1

Course Title	AERODYNAMICS LAB	**Semester**	V

Course objective is to:

- Be acquainted with basic principles of aerodynamics using wind tunnel.
- Acquire the knowledge on flow visualization techniques.
- Understand the procedures used for calculating the lift and drag.

Sl No	**Experiment Name**	**RBT Level**	**Hours**
1	Calibration of a subsonic wind tunnel: test section static pressure and total head distributions.	L1,L2, L3	03
2	Smoke flow visualization studies on a two-dimensional circular cylinder at low speeds.	L1,L2, L3	03
3	Smokeflowvisualizationstudiesonatwodimensionalairfoilatdifferentanglesofincidenceatlowspeeds	L1,L2, L3	03
4	Smoke flow visualization studies on a two-dimensional wing with flaps and slats at different angles of incidence at low speeds	L1,L2, L3	03
5	Tuft flow visualization on a wing model at different angles of incidence at low speeds: identify zones of attached and separated flows.	L1,L2, L3	03

6	Surface pressure distributions on a two-dimensional smooth circular cylinder at low speeds and calculation of pressure drag.	L1,L2, L3	03
7	Surface pressure distributions on a two-dimensional wing of symmetric airfoil and estimation of Center of pressure and Aerodynamic center	L1,L2, L3	03
8	Surface pressure distributions on a two-dimensional wing of cambered airfoil at different angles of incidence, and estimation of Center of pressure and Aerodynamic center.	L1,L2, L3	03
9	Calculation of total drag of a two-dimensional circular cylinder at low speeds using pitot-static probe wake survey.	L1,L2, L3	03
10	Calculation of total drag of a two-dimensional wing of cambered airfoil at low speeds at incidence using pitot-static probe wake survey.	L1,L2, L3	03
11	Measurement of a typical boundary layer velocity profile on the tunnel wall (at low speeds) using a pitot probe and calculation of boundary layer displacement and momentum thickness.	L1,L2, L3	03
12	Calculation of aerodynamic forces and moments acting on a model aircraft at various Angle of Attack and speeds using wind tunnel balance With Yaw.	L1,L2, L3	03
13	Calculation of aerodynamic coefficients and forces acting on a model aircraft at various Angle of Attack and speeds using wind tunnel balance Without Yaw.	L1,L2, L3	03
14	Pressure measurements on aero foil for a case of reverse flow.	L1,L2, L3	03

Course outcomes:

CO1	Apply the flow visualization techniques
CO2	Estimate the pressure distribution over the bodies
CO3	Calculate the forces and moments on models.

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	**Aerospace Propulsion (+Aerospace Propulsion Lab)**	**Semester**	**V**
Course Code	**MVJ21AS54**	**CIE**	**50**
Total No. of Contact Hours	**50 L: T: P: 3 : 1: 0**	**SEE**	**50**
No. of Contact Hours/week	**50**	**Total**	**100**
Credits	**4**	**Exam. Duration**	**3 Hours**

Course objective is to:

- Understand the basic principle and working of Air breathing and Non Air breathing engines
- Acquire knowledge on the significance of Supersonic Inlets
- Acquire knowledge on the design and working of combustion chambers and nozzles
- Understand the fundamentals of rocket propulsion
- Acquire knowledge on Rocket Testing and materials used in Rockets

Module-1	**L1,L2**	**8Hours**

Introduction: Review of thermodynamic principles, Principles of aircraft propulsion, Types of power plants, Working principles of internal combustion engine, Two–stroke and four–stroke piston engines, Gas turbine engines, Cycle analysis of reciprocating engines and jet engines , advantages and disadvantages, Non Air-breathing engines- introduction, numerical problems

Laboratory Sessions/ Experimental learning:

1. Identify and demonstrate the various components of Guiberson T-1020 (9 cylinder radial engine) andTumansky R-25-300 R-26(Jet engine)

Applications: Automobile industries , Gas turbine industries and Power plants

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

1. https://nptel.ac.in/courses/101/101/101101001/
2. https://youtu.be/XKcRf2R5h4o3. https://youtu.be/fTAUq6G9apg

Module-2	**L1,L2**	**8Hours**

Jet propulsion and Supersonic Inlets

Jet Propulsion: Illustration of working of gas turbine engine–The thrust equation–Factors affecting

thrust–Effect of pressure, velocity and temperature changes of air entering compressor– Methods of thrust augmentation–Characteristics of turboprop, turbofan and turbojet– Performance characteristics.

Supersonic inlets: Supersonic inlets, starting problem in supersonic inlets, Shock swallowing by area variation, External deceleration. Modes of inlet operation.

Laboratory Sessions/ Experimental learning:

Study of an aircraft jet engine (Includes study of assembly of sub systems, variouscomponents, their functions and operating principles)

Performance studies on a scaled jet engine

Applications: Gas turbine and aircraft engine design industries

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

https://nptel.ac.in/courses/101/101/101101001/

https://nptel.ac.in/courses/101/101/101101002/

https://youtu.be/KjiUUJdPGX0

Module-3	**L1,L2**	**8Hours**

Combustion chamber and Nozzles

Combustion chamber: Classification of combustion chambers, important factors affecting combustion chamber design, Combustion process, Combustion chamber performance Effect of operating variables on performance, Flame tube cooling, Flame stabilization Use of flame holders **Nozzles:** Theory of flow in isentropic nozzles, Convergent nozzles and nozzle choking, Nozzle throat conditions. Nozzle efficiency, Losses in nozzles. Over-expanded and under-expanded nozzles, Ejector and variable area nozzles, Thrust reversal

Laboratory Sessions/ Experimental learning:

Measurement of nozzle flow.

Make a model and explain thrust reversal technique

Applications: Gas turbine industries

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

https://nptel.ac.in/courses/101/101/101101002/

https://www.youtube.com/watch?v=3u7d-IlvRqs&feature=youtu.be

https://www.youtube.com/watch?v=nvDoiHQXXJk&feature=youtu.be

Module-4	**L1,L2**	**8Hours**

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:

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):

https://nptel.ac.in/courses/101/104/101104078/

https://nptel.ac.in/courses/101/104/101104019/

https://nptel.ac.in/courses/101106033/

Module-5	**L1,L2**	**8Hours**

Rocket testing and Rocket materials

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

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

Laboratory Sessions/ Experimental learning:

Find the specific impulse of the sugar rocket

Applications: Testing and material manufacturing facilities

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

https://nptel.ac.in/courses/101/104/101104078/

https://nptel.ac.in/courses/101/104/101104019/

Course outcomes:

CO213.1	Apply the basic thermodynamic principles and theories in aircraft propulsion.
CO213.2	Evaluate Thrust and performance of Supersonic Inlets
CO213.3	Analyze the performance of Combustion chambers and Nozzles
CO213.4	Apply the basic principles of rocket propulsion.
CO213.5	Analyze Rocket testing and materials used in rockets

Reference Books:

1	Bhaskar Roy, Aircraft propulsion, Elsevier (2011),ISBN-13: 9788131214213
2	V. Ganesan, Gas Turbines, Tata McGraw-Hill,2010, New Delhi, India, ISBN: 0070681929

3	Hill, Philip G., and Carl R. Peterson. "Mechanics and Thermodynamics of Propulsion, 0201146592." (2010).
4	Cohen,H.Rogers,G.F.C.andSaravanamuttoo,H.I.H.,GasTurbineTheory,Longman,1989, ISBN 13: 9780582236325

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:

x. 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.

xi. 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.

xii. 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
CO1	3	3	1	2	1	1	1	0	1	1	-	1
CO2	3	2	1	1	1	1	1	0	1	1	-	1
CO3	3	2	1	1	1	1	1	0	1	1	-	1
CO4	3	1	1	-	-	1	1	0	1	1	-	1
CO5	3	1	1	-	-	1	1	0	1	1	-	1

High-3, Medium-2, Low-1

Course Title	**AEROSPACE PROPULSION LAB**	**Semester**	V

- **Course objective is to:**
- Study of heat transfer phenomenon
- Learn flame propagation phenomenon.

- Acquire knowledge of burning of propellants

Sl No	Experiment Name	RBT Level	Hours
1	Study of an aircraft jet engine (Includes study of assembly of sub systems, various components, their functions, and operating principles)	L1,L2,L3	03
2	Study of forced convective heat transfer over.	L1,L2,L3	03
3	Study of free convective heat transfer over a flat plate.	L1,L2,L3	03
4	Determination of heat of combustion of aviation fuel.	L1,L2,L3	03
5	Measurement of burning velocity of a premixed flame.	L1,L2,L3	03
6	Flame stability of pre-mixed flame through flame stability setup.	L1,L2,L3	03
7	Study of Free Jet/Wall Jet.	L1,L2,L3	03
8	Investigationofthepressureinaconvergent–divergentnozzleforunderexpandingandoverexpandingconditions.	L1,L2,L3	03
9	Preparation of a Solid Propellant.	L1,L2,L3	03
10	Computation of burning rate of the propellant.	L1,L2,L3	03
11	Determine the Calorific value of liquid fuel.	L1,L2,L3	03
12	MeasurementofIgnitiondelayofasinglepropellantwithdifferentshapes.	L1,L2,L3	03
13	Determine the specific impulse of solid motor.	L1,L2,L3	03
14	Performance study of Hybrid Motor using a thrust stand	L1,L2,L3	03

Course outcomes:

CO1	Analyze heat transfer phenomenon
CO2	Investigate flame propagations
CO3	Evaluate propellant burning

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	**HEAT & MASS TRANSFER IN AEROSPACE APPLICATION**	**Semester**	**V**
Course Code	**MVJ21AS551**	**CIE**	**50**
Total No. of Contact Hours	**40 L: T: P: 3 :0: 0**	**SEE**	**50**
No. of Contact Hours/week	**4**	**Total**	**100**
Credits	**3**	**Exam. Duration**	**3 Hrs.**

The courseobjective is to:

1. Understand the different modes of heat transfer.
2. Understand the conduction mode of heat transfer
3. Understand the free convection and forced convection.
4. Acquire the knowledge of heat exchangers.
5. Acquire knowledge on the application of heat exchangers in Aerospace Industry

Module 1	**L1,L2**	10 Hrs.

Fundamentals:

- Different modes of heat transfer and mass and momentum transfer, elements of mass diffusion and boundary layer theory.
- Mass transfer definition and terms used in mass transfer analysis, Fick's First law of diffusion.Numerical problems

Laboratory Sessions/ Experimental learning: Heat and mass transfer lab

Applications: Gas turbine engines, Heat exchangers in Aero applications.

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

7. https://nptel.ac.in/courses/112/101/112101097/

Module 2	**L1,L2,L3**	10 Hrs.

Conduction: Derivation of general three-dimensional conduction equation in Cartesian coordinate, special cases, discussion on 3-D conduction in cylindrical and spherical coordinate systems.

Effect of variation of thermal conductivity on heat transfer in solids - Heat transfer problems in infinite and semi-infinite solids - Extended surfaces.

One dimensional transient heat conduction: Systems with negligible internal resistance, Significance of Biot and Fourier Numbers, Chart solutions of transient conduction systems.

Laboratory Sessions/ Experimental learning: Heat conduction experiment in HMT lab

Applications: Gas turbine combustion chamber, turbine and afterburners etc

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

https://nptel.ac.in/courses/112/105/112105271/

Module 3	**L1,L2,L3**	10 Hrs.

Convection: Concepts of Continuity, Momentum and Energy Equations. Dimensional analysis-Buckingham's Pi Theorem - Application for developing non-dimensional correlation for convective heat transfer

- **Free Convection:**Development of Hydrodynamic and thermal boundary layer along a vertical plate, Use of empirical relations for Vertical plates and pipes.
- **Forced Convection:**External Flows, Concepts of hydrodynamic and thermal boundary layer and use of empirical correlations for Flat plates and Cylinders. Internal Flows, Concepts about Hydrodynamic and Thermal Entry Lengths, use of empirical correlations for Horizontal Pipe Flow and annulus flow.

Laboratory Sessions/ Experimental learning: Free and Forced convection experiments in HMT lab

Applications: Heat exchangers in Aero applications,Gas turbine combustion chamber, turbine and afterburners etc

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

https://nptel.ac.in/courses/112/106/112106170/

Module 4	**L1,L2,L3**	10 Hrs.

Radiation:

- Introduction to physical mechanism - Radiation properties - Radiation shape factors Heat exchange between non-black bodies – Radiation shields

Heat Exchangers:

- Heat Exchangers used in Aerospace Industry: Classification of heat exchangers; overall heat transfer coefficient, Heat exchanger components, Numerical problems.

Laboratory Sessions/ Experimental learning: Radiation experiment in HMT lab

Applications: Combustion chambers in Rockets and varies gas turbine engines.

Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/112/106/112106170/		
Module 5	**L1,L2,L3,**	10Hrs.
Heat and Mass Transfer Problems in Aerospace Engineering: • Abrative heat transfer, heat transfer in rocket thrust chambers. Heat and mass transfer in satellite systems • Spacecraft environmental control.Thermal control in re-entry vehicles. **Laboratory Sessions/ Experimental learning: Basics in Aerospace propulsion lab** **Applications:** Rocket thrust chambers - Aerodynamic heating -Ablative heat transfer turbine and nozzle blades. **Video link / Additional online information (related to module if any):** https://nptel.ac.in/courses/112/101/112101097/		

Course outcomes:	
Upon completion of the course, students will be able to:	
CO305.3.1	Analyse the fundamentals of heat and mass transfer
CO305.3.2	Explain the concept of one dimensional steady and transient heat conduction through various systems
CO305.3.3	Evaluate the heat transfer by convection with the flow of fluids
CO305.3.4	Analyzing heat transfer in heat exchangers
CO305.3.5	Analysing heat transfer problems occurring in aerospace systems.

Reference Books:	
1.	Ozisik, Heat transfer-A basic approach, Tata McGraw Hill 2002
2.	Holman Heat Transfer, J.P McGraw Hill Book Co., Inc., New York 8th edition,1996
3.	Sachdeva.Fundamentals of Engineering Heat and Mass Transfer, S.C Wiley Eastern Ltd., New Delhi 1981
4.	Sutton,Rocket Propulsion Elements, G.P John Wiley and Sons 5th Edn.1986

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:

xiii. 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.

xiv. 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.

xv. 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	0	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	**THOERY OF VIBRATIONS**	**Semester**	**V**
Course Code	**MVJ21AS552/AE552**	**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:

1.Understand the basic concepts of vibrations

2.Gain the knowledge of the undamped free vibration and damped free vibrations

3. Learn the vibration measuring instrumentation

4. Acquire knowledge of two degrees of freedom systems

5. Understand numerical methods for Multi-Degree Freedom Systems

Module 1	**L1,L2,L3**	10 Hrs.

Types of vibrations, S.H.M, principle of super position applied to Simple Harmonic Motions.Beats, Fourier theorem and simple problems.

Laboratory Sessions/ Experimental learning:

Simple pendulum experiment to understand concept of wave motion

Applications: Various types of vibrations and its real time applications

Concept of wave and its characteristics.

Video link / Additional online information (related to module if any): (NPTEL,IIT ROORKEE)

https://www.youtube.com/watch?v=9r630K5HmJc&list=PLSGws_74K01_pG3R7rgtDtrDZBjcTgPdR

Module 2	**L1,L2,L3**	10 Hrs.

Undamped Free Vibrations: Single degree of freedom systems. Undamped free vibration, natural frequency of free vibration, Spring and Mass elements, effect of mass of spring, Compound Pendulum.

Damped Free Vibrations: Single degree of freedom systems, different types of damping, concept of critical damping and its importance, study of response of viscous damped systems for cases of under damping, criticaland over damping, Logarithmic decrement

Laboratory Sessions/ Experimental learning:

Identifying Damping ration experiment allows students to understand behavior of vicious damper. [Design lab]

Applications: Various types of dampers and its real time applications**.**

Video link / Additional online information (related to module if any) (NPTEL,IIT MADRAS)

https://www.youtube.com/watch?v=tJNaPt5aPmg

Module 3	**L1,L2.L3**	10 Hrs.

Forced Vibration: Single degree of freedom systems, steady state solution with viscous damping due toharmonic force. Solution by Complex algebra, reciprocating and rotating unbalance, vibration isolation,transmissibility ratio due to harmonic excitation and support motion.

Vibration Measuring Instruments & Whirling of Shafts: Vibration of elastic bodies – Vibration of strings –Longitudinal, lateral and torsional Vibrations.

Laboratory Sessions/ Experimental learning:

Whirling of shaft experiment [Design Lab]

Applications:

Isolators and its Application.

Video link / Additional online information (related to module if any): (NPTEL,IIT KANPUR)

https://www.youtube.com/watch?v=XGQr1uEX-Dc		
Module 4	**L1,L2,L3**	10 Hrs.
Systems with Two Degrees of Freedom: Introduction, principle modes and Normal modes of vibration, coordinatecoupling, generalized and principal co-ordinates, Free vibration in terms of initial conditions. Gearedsystems. Forced Oscillations-Harmonic excitation. Applications: Vehicle suspension, Dynamic vibrationabsorber and Dynamics of reciprocating Engines. **Continuous Systems:** Introduction, vibration of string, longitudinal vibration of rods, Torsional vibration ofrods, Euler's equation for beams. **Laboratory Sessions/ Experimental learning:**Determination of two natural frequencies, or modes, for the system **Applications: Dynamic vibration absorber and its application in reciprocating engine.** **Video link / Additional online information (related to module if any): (NPTEL,IIT MADRAS)** https://www.youtube.com/watch?v=V_Lj4Pun_WM		
Module 5	**L1,L2**	10Hrs.
Numerical Methods for Multi-Degree Freedom Systems: Introduction, Influence coefficients, Maxwell reciprocal theorem, Dunkerley's equation. Orthogonalityofprincipal modes, Method of matrix iteration-Method of determination of all the natural frequencies usingsweeping matrix and Orthogonality principle. Holzer's method, Stodola method. **Non-Linear Vibration** : (Advance theory of vibration by ssrao) **Laboratory Sessions/ Experimental learning:** Plotting displacement curve using Analytical Approach**.** **Applications:** Understanding non linear behavior of waves or vibration. **Video link / Additional online information (related to module if any): (NPTEL,IIT MADRAS)** https://www.youtube.com/watch?v=V_Lj4Pun_WM		

Course outcomes:

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

CO304.1	Apply the principle of super position to Simple Harmonic Motions.
CO304.2	Analyse undamped free and damped free vibration
CO304.3	Perform measurements of vibrations
CO304.4	Evaluate the equations of twodegrees of freedom systems.
CO304.5	Evaluate themulti degree of freedom system.

Reference Books:	
1.	W.T. Thomson and MarieDillonDahleh, Theory of Vibration with Applications, Pearson Education, 2008
2.	V.P. Singh, Mechanical Vibrations, DhanpatRai& Company Pvt. Ltd, 2016
3.	S.S. Rao, Mechanical Vibrations, Pearson Education Inc, 2003
4.	S. Graham Kelly, Mechanical Vibrations, Tata McGraw Hill, 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:

xvi. 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.

xvii. 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.

xviii. 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	3	3	1	1	1	1	1	1	0	2	3	1	1
CO2	3	3	1	3	1	1	0	1	1	0	1	3	1	1
CO3	3	3	2	3	2	1	0	0	1	0	1	3	1	1
CO4	3	3	2	3	3	2	0	0	1	0	01	3	1	1
CO5	2	2	2	2	1	1	0	1	1	0	0	3	1	1

High,3, Medium,2, Low,1

ROCKETS AND MISSILES		
Course Code:	**MVJ21AS553**	**CIE Marks:100**
Credits:3 L:T:P:S: 3:1:0:0		**SEE Marks: 100**
Hours: 40 Hours		**SEE Duration: 3 Hrs**
Course Learning Objectives: The students will be able to		
1	Basics of Rockets and Missiles is an elective course offered in 5th semester Aeronautical Engineering curriculum.	
2	This subject covers extensively regarding design and analysis of rockets and missiles.	
3	The different types of Airframe components, types of propulsion system, and types of guidance systems are also covered in this subject.	
4	This subject will make student to understand advanced problems facing in launch vehicles and missiles.	
5		

UNIT-I	
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. **Applications**: **Web Link and Video Lectures:** https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-512-rocket-propulsion-fall-2005/ https://www.isro.gov.in/launchers	**8 Hrs**
UNIT-II	
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.	**8 Hrs**

Applications: **Web Link and Video Lectures:** https://www.esa.int/Our_Activities/Space_Transportation/Launch_vehicles/Ariane_5 https://www.nasa.gov/centers/glenn/about/history/lvpo.html	
UNIT-III	
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, lift and drag forces, drag estimation, body upwash and downwash in missiles. Rocket dispersion, re-entry body design considerations. **Applications**: **Web Link and Video Lectures:** https://www.nasa.gov/connect/ebooks/aeronautics_ebooks_archive_1.html	**8 Hrs**
UNIT-IV	
LAUNCH VEHICLE DYNAMICS & ATTITUDE CONTROL OF ROCKETS **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.Λ **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 **Applications** **Web Link and Video Lectures:** http://nptel.ac.in/courses/101104019/	**8 Hrs**
UNIT-V	
ROCKET TESTING AND MATERIALS **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 atypical space launch vehicle launch procedure. **Materials:** Criteria for selection of materials for rockets and missiles, requirements for choice of materials for propellant tanks, liners, insulators, inhibitors, at cryogenic temperatures, requirements of materials at extremely high temperatures, requirements of materials for Thermal protection and for pressure vessels. **Applications**: **Web Link and Video Lectures:** http://nptel.ac.in/courses/101105030/33	**8 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1	Identify the types of space launch vehicles and missiles.
CO2	Distinguish the solid and liquid propellant motors.
CO3	Classify different types of missiles, understand missile aerodynamics.
CO4	Acquire the knowledge on launch vehicle dynamics, Attitude control
CO5	Identify different types of materials used in rockets, missiles and acquire knowledge on rocket testing

Reference Books	
1.	**George P Sutton and Oscar Biblarz,' *Rocket Propulsion Element*', John Wiley and Sons Inc,7th edition,2010,ISBN-13: 978-8126525775**
2.	**Jack N Neilson, '*Missile Aerodynamics*', AIAA, 1st edition, 1988, ISBN-13: 978-0962062902**
3.	SS Chin, 'Missile *Configuration Design'*.
4.	Cornelisse, J.W., Schoyer H.F.R. and Wakker, K.F., *Rocket Propulsion and Space-Flight Dynamics*, Pitman, 1979,ISBN-13: 978-0273011415
5.	Turner, M.J.L., *Rocket and Spacecraft propulsion*, Springer, 3rd edition, 2010, ISBN-13: 978-3642088698.

Continuous Internal Evaluation (CIE):
Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Total marks: 50+50=100

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

CO3												
CO4												
CO5												

High-3, Medium-2, Low-1

Course Title	**Optimization techniques and probability theory**	Semester	V
Course Code	MVJ21AS554	**CIE**	50
Total No. of Contact Hours	40 L : T : P :: 3: 0 : 0	**SEE**	50
No. of Contact Hours/week	4	**Total**	100
Credits	3	**Exam. Duration**	3hrs

Course objective is to:

Ability to apply the theory of optimization methods and algorithms to develop and for solving various types of optimization problems

Ability to go in research by applying optimization techniques in problems of Engineering and Technology

Understand and apply probability distribution, sampling theory and joint probability distributions.

Module-1	L1, L2 & L3	8Hrs.

Linear Programming: Introduction to Linear Programming Problem (LPP): Prototype example, Assumptions of LPP, Formulation of LPP and Graphical method various examples. The simplex method, Two phase method and dual simplex method.

Self study topic: Big-M method

Application: Graphical solution procedure and algorithms to solve problems.

Web Link and Video Lectures:

1. https://www.youtube.com/watch?v=Hdd_TCIJS3Q&t=322s
2. https://www.youtube.com/watch?v=jn9PmuUvUws&t=673s
3. https://www.digimat.in/nptel/courses/video/111105100/L21.html

Module-2	L2, L3 & L4	8Hrs.

Unconstrained optimization Techniques:

Introduction, Direct search method-Random Search method, Univariate method, Decent methods-Gradient of a function, conjugate gradient method (Fletcher-Reeves method), Quasi-Newton

methods.

Self study topic: Secant method

Applications: Design of aerospace vehicles and aircraft vehicles.

Web Link and Video Lectures:

1. https://www.youtube.com/watch?v=RcXzyT8lk-w
2. https://www.youtube.com/watch?v=8kPUI5HoVxg
3. https://www.youtube.com/watch?v=dPQKltPBLfc

Module-3	L2, L3 & L4	8Hrs.

Constrained optimization Techniques:

Local maxima and minima for single and multi variables, Karush-Kuhn-Tucker conditions, Applications of the FONC, SONC, and SOSC conditions.

Self study topic: Lagrange multiplier method

Applications: Design of aerospace vehicles and aircraft vehicles.

Web Link and Video Lectures:

1. https://www.digimat.in/nptel/courses/video/111105100/L48.html

Module-4	L1, L2 & L3	8Hrs.

Probability Distributions: Random variables (discrete and continuous), probability mass/density functions. Binomial distribution, Poisson distribution. Exponential and normal distributions-problems.
Joint probability distribution: Joint Probability distribution for two discrete random variables, expectation, covariance, correlation coefficient.

Self study topic: Joint Probability distribution for two continuous random variables

Application: Finding correlation between random variables.

Web Link and Video Lectures:

1. http://nptel.ac.in/courses.php?disciplineID=111
2. http://www.class-central.com/subject/math(MOOCs)
3. http://academicearth.org/

Module-5	L1, L2& L3	8Hrs.

Sampling Theory: Sampling, Sampling distributions, standard error, test of hypothesis for means and proportions, confidence limits for means, student's t-distribution and Chi-square distribution.

Self study topic: confidence limits for probabilities.

Application: Testing the level of significance and the goodness of fit for large sample and small sample.

Web Link and Video Lectures:

1. http://nptel.ac.in/courses.php?disciplineID=111 2. http://www.class-central.com/subject/math(MOOCs) 3. http://academicearth.org/	
Course outcomes:	
CO1	Solve the mathematical formulation of linear programming problem.
CO2	Able to analyze external problems and functions and to establish mathematical models
CO3	Be able to model engineering minima/maxima problems as optimization problems
CO4	Develop probability distribution of discrete, continuous random variables and joint probability distribution occurring in digital signal processing, information theory and design engineering.
CO5	Demonstrate testing of hypothesis of sampling distributions.

Textbooks:	
1.	B.S. Grewal, "Higher Engineering Mathematics" Khanna Publishers, 43rd Edition, 2013.
2.	S. S. Rao John Wiley & Sons, "Engineering Optimization Theory and Practice", Fourth Edition, 2009.
Reference Books:	
1.	A. D. Belegundu and T.R. Chanrupatla, "Optimisation Concepts and Applications in Engineering", Cambridge University Press 2011.
2.	Joaquim R. R. A. Martins, Andrew Ning, "Engineering Design Optimization ", Cambridge University Press.

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

High-3, Medium-2, Low-1

Course Title	**ASTROPHYSICS & SPACE ENVIRONMENT**	**Semester**	**VI**
Course Code	**MVJ21AS555**	**CIE**	**50**
Total No. of Contact Hours	**40 L: T : P :: 3 :0 : 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 ofStellarAtmosphere.
- 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,luminosity, 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):

8. https://www.youtube.com/watch?v=MTY1Kje0yLg
9. https://www.youtube.com/watch?v=pj9cNnT7PJs
10. https://www.youtube.com/watch?v=itdYS9XF4a0

Module 2	**L1,L2**	10Hrs.

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):

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

Module 3	**L1,L2, L3**	10Hrs.

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**	10Hrs.

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**	10Hrs.

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):

3. https://www.youtube.com/watch?v=LIqPxnoprqY
4. https://www.youtube.com/watch?v=w_PWL0oZzOc
5. 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**
6.	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:

xix. 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.

xx. 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.

xxi. 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	**ENVIRONMENTAL STUDIES**	Semester	V
Course Code	MVJ21ENV56	**CIE**	50
Total No. of Contact Hours	20 L: T: P::1 : 0 :0	**SEE**	50
No. of Contact Hours/week	1	**Total**	100
Credits	1	**Exam. Duration**	3 Hrs.

Course objective is to:

- Relatetointerdisciplinaryapproachtocomplexenvironmentalproblemsusingbasictoolsofthenatural and social sciences including geo-systems, biology, chemistry, economics, political science and international processes; Study drinking water quality standards and to illustrate qualitative

analysis of water.

- Critically evaluate the science and policy ramifications of diverse energy portfolios on air and water quality, climate, weapons proliferation and societal stability..

Module 1	**L1,L2,**	04 Hrs.
Introduction to environmental studies, Multidisciplinary nature of environmental studies; Scope and importance; Concept of sustainability and sustainable development. **Ecosystems (Structure and Function):** Forest, Desert, Rivers, Ocean **Biodiversity:** Types, Hot spots; Threats and Conservation of biodiversity, Deforestation**.** **Video link:** https://nptel.ac.in/courses/127/106/127106004/		
Module 2	**L1,L2,L3,**	10 Hrs.
Advances in Energy Systems (Merits, Demerits, Global Status and Applications): Hydrogen, Solar, OTEC, Tidal and Wind. **Natural Resource Management (Concept and case-study):** Disaster Management, Sustainable Mining, Cloud Seeding, and Carbon Trading. **Video link:** https://nptel.ac.in/courses/121/106/121106014/		
Module 3	**L1,L2,L3**	10 Hrs.
Environmental Pollution (Sources, Impacts, Corrective and Preventive measures, Relevant Environmental Acts, Case-studies): SurfaceandGroundWaterPollution;Noisepollution;SoilPollutionand Air Pollution. **Waste Management & Public Health Aspects:** Bio-medical Waste; Solid waste; Hazardous waste; E-waste. **Video link**: • https://nptel.ac.in/courses/122/106/122106030/ • https://nptel.ac.in/courses/105/103/105103205/		
Module 4	**L1,L2,L3**	10 Hrs.
. **Global Environmental Concerns (Concept, policies, and case-studies**): Global Warming Climate Change; Acid Rain; Ozone Depletion; Fluoride problem In drinking water. **Video link:** • https://nptel.ac.in/courses/122/106/122106030/ • https://nptel.ac.in/courses/120108004/		
Module 5	**L1,L2**	10 Hrs.
Latest Developments in Environmental Pollution Mitigation Tools (Concept and Applications): G.I.S. & Remote Sensing, Environment Impact Assessment, Environmental Management Systems, ISO		

14001. **Video link:** • https://nptel.ac.in/courses/105/102/105102015/ https://nptel.ac.in/courses/120/108/120108004/

Course outcomes:	
Upon completion of the course, students will be able to:	
CO1	Describe the principles of ecology and environmental issues that apply to air, land, and water issueson a global scale.
CO2	Develop critical thinking and/or observation skills, and apply them to the analysis of a problem orquestion related to the environment.
CO3	Demonstrate ecology knowledge of a complex relationship between biotic and Abioticcomponents.
CO4	Apply their ecological knowledge to illustrate and graph a problem and describe the realities thatmanagers face when dealing with complex issues.

Reference Books:	
1.	Principals of Environmental Science and Engineering, Raman Siva kumar,Cengage learning, Singapur, 2nd Edition, 2005
2.	Environmental Science – working with the Earth G.Tyler Miller Jr. Thomson Brooks /Cole,11th Edition, 2006
3.	Textbook of Environmental and Ecology, Pratiba Singh, Anoop Singh&PiyushMalaviya ,ACME Learning Pvt. Ltd. New Delhi, 1st Edition.

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

High,3, Medium,2, Low,1

Course Title	**RESEARCH METHODOLOGY AND IPR**	**Semester**	**V**
Course Code	MVJ21XX57	**CIE**	**50**
Total No. of Contact Hours	**30 L: T: P: 1:2:0**	**SEE**	**50**
No. of Contact Hours/week	**1**	**Total**	**100**
Credits	**2**	**Exam. Duration**	**2Hrs.**

The course objective is to:

To give an overview of the research methodology and explain the technique of defining a research problem

• To explain the functions of the literature review in research.

• To explain carrying out a literature search, its review, developing theoretical and conceptual frameworks

and writing a review.

• To explain various research designs and their characteristics.

• To explain the details of sampling designs, measurement and scaling techniques and also different methods of data collections.

• To explain several parametric tests of hypotheses and Chi-square test.

• To explain the art of interpretation and the art of writing research reports.

• To explain various forms of the intellectual property, its relevance and business impact in the changing

global business environment.

• To discuss leading International Instruments concerning Intellectual Property Rights.

Module 1	**L1,L2**	10 Hrs.

Module-1

Research Methodology: Introduction, Meaning of Research, Objectives of Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Research Process, Criteria of Good Research.

Defining the Research Problem: Research Problem, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem,

Reviewing the literature: Place of the literature review in research, Review of the literature, searching the existing literature, reviewing the selected literature, developing a theoretical framework, Developing a conceptual framework, Writing about the literature reviewed.

Module 2	**L1,L2,**	10 Hrs.
Research Design: Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs. **Design of Sample Surveys:** Design of Sampling: Introduction, Sample Design, Sampling and Non-sampling Errors, Sample Survey versus Census Survey, Types of Sampling Designs. **Measurement and Scaling:** Qualitative and Quantitative Data, Classifications of Measurement Scales, Goodness of Measurement Scales, Sources of Error in Measurement, Techniques of Developing Measurement Tools, Scaling, Scale Classification Bases, Scaling Technics, Multidimensional Scaling, Deciding the Scale. **Data Collection**: Introduction, Experimental and Surveys, Collection of Primary Data, Collection of Secondary Data, Selection of Appropriate Method for Data Collection,		
Module 3	**L1,L2**	10 Hrs.
Intellectual Property: The Concept, Intellectual Property System in India, Development of TRIPS Complied Regime in India, Patents Act, 1970, Trade Mark Act, 1999,The Designs Act, 2000, The Geographical Indications of Goods (Registration and Protection) Act1999, Copyright Act,1957,The Protection of Plant Varieties and Farmers' Rights Act, 2001,The Semi-Conductor Integrated Circuits Layout Design Act, 2000, Trade Secrets, Utility Models, IPR and Biodiversity, The Convention on Biological Diversity (CBD) 1992, World Intellectual Property Organisation (WIPO),WIPO and WTO, Paris Convention for the Protection of Industrial Property, National Treatment, Right of Priority, Common Rules, Patents, Marks, Industrial Designs, Trade Names, Indications of Source, Unfair Competition, Patent Cooperation Treaty (PCT), Berne Convention for the Protection of Literary and Artistic Works, Basic Principles, Duration of Protection, Trade Related Aspects of Intellectual Property Rights(TRIPS) Agreement, Covered under TRIPS Agreement, Features of the Agreement, Protection of Intellectual Property under TRIPS, Copyright and Related Rights, Trademarks, Geographical indications, Industrial Designs, Patents, Patentable Subject Matter, Rights Conferred, Exceptions, Term of protection, Conditions on Patent Applicants, Process Patents, Other Use without Authorization of the Right Holder, Layout-Designs of Integrated Circuits,		

Course outcomes: Upon completion of the course, students will be able to:	
CO302.1	To explain the functions of the literature review in research.
CO302.2	• To explain carrying out a literature search, its review, developing theoretical and conceptual frameworks
CO302.3	and writing a review.
CO302.4	• To explain various research designs and their characteristics.
CO302.5	To explain the functions of the literature review in research.

Reference Books:	
1.	Research Methodology: Methods and Techniques C.R. Kothari, Gaurav Garg New Age International 4th Edition, 2018

2.	Research Methodology a step-by step guide for beginners. (For the topic Reviewing the literature under module 2) Ranjit Kumar SAGE Publications Ltd 3rd Edition, 2011
3.	Study Material (For the topic Intellectual Property under module 5) Professional Program Intellectual Property Rights, Law and Practice, The Institute of Company Secretaries of India, Statutory Body Under an Act of Parliament, September 2013

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:

xxii. 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.

xxiii. 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.

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

High,3, Medium,2, Low,1

Course Title	AEROSPACE SYSTEMS AND AVIONICS	Semester	VI
Course Code	MVJ21AS61	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 power distribution system and need for avionics.
2. Acquire knowledge of control and navigation systems
3. Gain knowledge of display technologies and avionics system architectures
4. Understand the Microprocessors and cockpit display technologies
5. Apprehend the functioning of data buses

Module 1Power Distribution System	L1, L2	10 Hrs.

Power Distribution System: Bus Bar, split bus bar system, special purpose cables. Electrical diagram and identification scheme. Circuit controlling devices. Power utilization-typical application to avionics. Introduction to integrated avionics and 5G systems.

Laboratory Sessions/ Experimental learning: Programming using microprocessor

Applications: Data Transfer, Communication

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

1. https://www.coursera.org/lecture/aeronautics/basics-X8Mvf

Module 2 Inertial Navigation &Electronic Flight Control System	L1, L2, L3,	10 Hrs.

Inertial Navigation System: Gyroscopic versus Inertial platform. Structure of stable platform. Inertial Navigation units. Inertial alignment. Inertial interface system. Importance of Compass swing. Navigation System in Aerospace Industries

Electronic Flight Control System: Fly-by-wire system: basic concept and features. Pitch and Roll rate: command and response. Control Laws. Frequency response of a typical FBW actuator. Avionics system architecture generations - Data buses: MILSTD-1553B, ARINC 429, AFDX/ARINC 664 - Fiber optic Data buses: IEEE STD 1393, MIL STD 1773.

Laboratory Sessions/ Experimental learning: Validation of truth tables for different logic circuits

Applications: Communication, Tracking **Video link / Additional online information (related to module if any)**: 1. https://www.coursera.org/lecture/aeronautics/basics-X8Mvf		
Module 3 Electronic Flight Instrument &Avionics Sub Systems	L1, L2, L3	10 Hrs.
Electronic Flight Instrument Systems: Display-units, presentation, failure, and annunciation. Display of air data. Typical avionics sub systems. Amplifier, oscillator, aircraft communication system, transmitter, receiver, antenna. **Modelling of Physical Systems**: Mathematical Models of Mechanical, Electrical, Thermal, Hydraulic Systems. **Laboratory Sessions/ Experimental learning**: Construct 7 segment display circuit using IC timer **Applications**: Attitude Estimation, Navigation, Control **Video link / Additional online information (related to module if any)**: 1. https://nptel.ac.in/courses/101/106/101106042/		
Module 4 Digital Systems & Flight Deck and Cockpits	L1, L2, L3	10 Hrs.
Principles of Digital Systems: Digital Computers, Microprocessors, Memories. **Flight Deck and Cockpits**: Control and display technologies CRT, LED, LCD, EL and plasma panel, Touch screen, Direct voice input (DVI)-Civil cockpit and military cockpit: MFDS, HUD, MFK, and HOTAS. **Laboratory Sessions/ Experimental learning**: Data transfer using ARINC420 data bus **Applications**: Position Estimation, Guidance, Control **Video link / Additional online information (related to module if any)**: 1. https://nptel.ac.in/courses/101/108/101108056/ 2. https://nptel.ac.in/courses/101/108/101108056/		
Module 5 Avionics Systems Integration	L1, L2, L3	10 Hrs.
Avionics Systems Integration: Avionics equipment fit. Electrical data bus system. Communication Systems, Navigation systems, Flight control systems, Radar, Electronic Warfare, and fire control system. Avionics system architecture, Data buses, MIL–STD1553B **Laboratory Sessions/ Experimental learning**: Data transfer using MIL-STD 1553B Data bus **Applications**: Navigation, Guidance, Control **Video link / Additional online information (related to module if any)**: 1. https://nptel.ac.in/courses/101/106/101106042/		
Course outcomes: Upon completion of the course, students will be able to:		

CO309.1.1	Analyse the power distribution system in avionics.
CO309.1.2	Apply the knowledge of control and navigation systems
CO309.1.3	Utilise the knowledge of display technologies and avionics system architectures
CO309.1.4	Evaluate the Microprocessors and cockpit display technologies
CO309.1.5	Analyse the functioning of data buses

Reference Books:	
1.	R.P.G. Collinson, Introduction to Avionics Systems, 3rd Edition, 2011, Springer.
2.	Ian Moir, Allan Seabridge and Malcolm Jukes, Civil Avionics Systems, 2nd Edition, 2003, Wiley.
3.	R. Cundy Dale, Introduction to Avionics, 2010, Pearson Education.

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:

- Question paper for the SEE consists of 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.
- 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.
- 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	3	2
CO2												2	1	
CO3	2	2	2									2		

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

High,3, Medium,2, Low,1

Course Title	**Aerospace Structural Analysis (+Aerospace Structures Lab)**	**Semester**	**VI**
Course Code	**MVJ21AS62**	**CIE**	**50**
Total No. of Contact Hours	**50 L: T : P :: 3:0:2**	**SEE**	**50**
No. of Contact Hours/week	**5**	**Total**	**100**
Credits	**4**	**Exam. Duration**	**3 Hrs.**

Course objective is to:

1. To describe about symmetrical and unsymmetrical sections
2. To Acquire the knowledge of Structural Idealization on open section tubes
3. To Acquire the knowledge of Structural Idealization on closed section tubes
4. To illustrate the different types of Buckling of Plates, Joints and Fitting
5. To Comprehend the stress analysis on Launch Vehicle and Spacecraft Structure

Module 1	**L1,L2, L3**	10 Hrs.

Introduction: Elementary theory of bending – Introduction to semi-Monocoque structures - Stresses in beams of symmetrical and unsymmetrical sections -Box beams – General formula for bending stresses-principal axes method – Neutral axis method.

Laboratory Sessions/ Experimental learning: Stress analysis on a flat plate using Ansys.

Applications: To differentiate and analyze the components of aircraft components.

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

11. https://swayam.gov.in/nd1_noc19_ae05/previewhttps://youtu.be/bQQMIy7Dlt0

12. https://nptel.ac.in/courses/101/101/101101079/

https:52/2013/AAE%20352%20Course%20Text%20Weisshaar%202011.pdf

Module 2	**L1,L2,L3**	10 Hrs.

Shear Flow: Shear stresses in beams – Shear flow in stiffened panels - Shear flow in thin-walled open tubes –Shear center – Shear flow in open sections with stiffeners.

Laboratory Sessions/ Experimental learning: Shear center and angle of twist in Aerospace Structures laboratory

Applications: To analyze shear flow in aircraft/spacecraft skin panels.

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

5. https://cosmolearning.org/courses/introduction-aerospace-structures/video-lectures/

6. https://ocw.tudelft.nl/course-lectures/shear-flow-thin-walled-section-2/ https://www.ae.msstate.edu/tupas/SA2/chA14.7_text.html		
Module 3	**L1,L2,L3**	10 Hrs.
Shear Flow Analyses: Shear flow in closed sections with stiffeners– Angle of twist - Shear flow in two flange and three flange box beams – Shear center - Shear flow in thin-walled closed tubes - Bredt-Batho theory - Torsional shear flow in multi cell tubes - Flexural shear flow in multi cell stiffened structures. **Laboratory Sessions/ Experimental learning:** Shear flow analyses for closed section in Ansys workbench. **Applications:** To analyze the shear flow in closed thin-walled section of the aircraft/spacecraft**.** **Video link / Additional online information (related to module if any):** 1. https://swayam.gov.in/nd1_noc19_ae05/previewhttps://youtu.be/bQQMIy7Dlt0 2. https://www.popsci.com/story/technology/best-aerospace-innovations-2019/ https://nptel.ac.in/courses/101/101/101101079/		
Module 4	**L1,L2,L3**	10 Hrs.
Failure concepts: Stability problems of thin-walled structures– Buckling of sheets under compression, shear, bending and combined loads - Crippling stresses by Needham's and Gerard's methods–Sheet stiffener panels- Effective width, Inter rivet and sheet wrinkling failures-Tension field web beams (Wagner's). **Laboratory Sessions/ Experimental learning:** Fatigue analysis can be analyzed using Ansys workbench. **Applications:** Used to predict the product life cycle management of aerospace components**.** **Video link / Additional online information (related to module if any):** 1. https://www.youtube.com/watch?v=3HE3A_vUZnw 2. https://www.youtube.com/watch?v=aivDhiLwu8E https://www.youtube.com/results?search_query=unsw+aerospace+structures		
Module 5	**L1,L2**	10Hrs.
Launch Vehicle and Spacecraft Structures: Launch vehicle structures – Loads and stresses, thin-walled pressure vessels, Buckling of beams, thin wall assumption. spacecraft - mini, microstructures, inflatable structures, flying effector, Nano tubing **Laboratory Sessions/ Experimental learning:** Fuselage Pressure Vessel experiment can be conducted using Ansys Workbench. **Applications:** Helps to analyze the stress in Aircraft components. **Video link / Additional online information (related to module if any):** 7. https://youtu.be/bQQMIy7Dlt0 8. https://nptel.ac.in/courses/101/101/101101079/		

Course outcomes:	
Upon completion of the course, students will be able to:	
CO303.1	Classify various types of load acting on an aircraft and Draw normal stress distribution.
CO303.2	Identify the shear flow distribution for open section structural member under torsion.
CO303.3	Investigate shear flow distribution for closed section structural member under torsion.
CO303.4	Solve different methods to find out buckling load for a given structural panel, Joints and Fittings
CO303.5	Examinethe stress distribution in Pressure Vessels and Spacecraft Structures

Reference Books:	
1.	Megson, T.H.G., AircraftStructures for Engineering Students, Edward Arnold,1995
2.	Perry D J & Azar J J , Aircraft Structures, 2nd edition, McGraw Hill N.Y.,1993
3.	BruhnE.F., Analysis and Design of Flight Vehicles Structures, Tri-Stateoffset Co.USA,1985
4.	T.H.G Megson Introduction to Aircraft Structural Analysis, Elsevier,2nd Edition,2014

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:

xxv. 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.

xxvi. 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.

xxvii. 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	2.6	2.2	1.6	2.4	1	0	0	0.6	1.4	0.2	3	1	1

CO2	3	2.6	2.2	1.6	2.4	1	0	0	0.6	1.4	0.2	3	1	1
CO3	3	2.6	2.2	1.6	2.4	1	0	0	0.6	1.4	0.2	3	1	1
CO4	3	2.6	2.2	1.6	2.4	1	0	0	0.6	1.4	0.2	3	1	1
CO5	3	2.6	2.2	1.6	2.4	1	0	0	0.6	1.4	0.2	3	1	1

High,3, Medium,2, Low,1

Course Title	**AEROSPACE STRUCTURES AND VIBRATION LAB**	**Semester**	VI

Course objective is to:

- Learn about the simply supported beam, cantilever beam.
- understand the Maxwell's theorem and Poisson ratio.
- Acquire the knowledge about buckling load, shear failure and shear center

Sl No	**Experiment Name**	**RBT Level**	**Hours**
1	Deflection of a Simply Supported Beam	L1,L2,L3	03
2	Deflectionofa 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 Column sand 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 FlexuralTesting of a Composite Material	L1,L2,L3	03

	Plate		
11	Determination of Natural Frequency and Mode Shapes of a Cantilever Beam for the Following Cases a) Constant cross section b) Varying cross section	L1,L2,L3	03
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 center.

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	**Aerospace Vehicle Design (+Design Modelling and Analysis Lab)**	Semester	VI
Course Code	**MVJ21AS63**	CIE	50
Total No. of Contact Hours	50 L: T:P:: 3 :0 :2	SEE	50
No. of Contact Hours/week	5	Total	100
Credits	4	Exam. Duration	3 Hrs.

Course objective is to:

1. Understand the concepts of launch vehicles.
2. Acquire the knowledge of Aerospace propulsion and re-entry vehicles.
3. Acquire the knowledge of Aerospace launch vehicle structure.

4. Illustrate the different types of vibration taking place in the launch vehicle.
5. Explore the future space technologies and its working principles.

Module 1	**L1,L2,L3**	**10 Hrs.**

Introduction to Launch Vehicle: Launch Vehicles Available, Launch Vehicle Capabilities Deciding, Which Launch Vehicle to Use. Characteristics of Spacecraft Necessary to Choose a Launch Vehicle Structures. Primary Structural Design Other Functional Divisions Mechanisms Used by the Other Subsystem. Materials forConstructing Spacecraft Manufacturing Techniques Applicable to the Structure.

Laboratory Sessions/ Experimental learning: Basic stress analysis on launch vehicle components can be analyzed using Ansys workbench.

Applications: Used in the launch vehicles design.

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

13. https://nptel.ac.in/noc/courses/noc21/SEM1/noc21-ae06/
14. https://www.youtube.com/watch?v=KbCR-ehWSIM
15. https://www.youtube.com/watch?v=pB1JP1ybxiE

Module 2	**L1,L2,L3,**	**10 Hrs.**

Propulsion: Rocket Propulsion Fundamentals, Ascent Flight Mechanics, Launch Vehicle selection, Entry flight Mechanics, Entry heating, entry vehicle design, Aero assisted orbit transfer.

Laboratory Sessions/ Experimental learning: Different types of nozzle analysis can be done using Ansys workbench.

Applications: Used in rocket and spacecraft engines.

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

2. https://nptel.ac.in/noc/courses/noc21/SEM1/noc21-ae06/
3. https://www.youtube.com/watch?v=5n92Px6hCvtg
4. https://www.youtube.com/watch?v=NDnyRPdhubs

Module 3	**L1,L2,L3**	**10 Hrs.**

Launch Vehicle structures: Loads on the vehicle structures, Stages, Motor case, Base shroud, Inter stages, Heat shield, Equipment Bay and their functions Modeling and Analysis Structures. Loads andStresses Thin-Walled Pressure Vessels Buckling of Beams Thin-Wall Assumption. Finite Element Analysis.

Laboratory Sessions/ Experimental learning: Static and dynamic analysis can be analyzed using Ansys workbench software.

Applications: Used in launch vehicle structural components.

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

7. https://nptel.ac.in/noc/courses/noc21/SEM1/noc21-ae06/
8. https://www.youtube.com/watch?v=cr-VTDrmPE8

9. https://www.youtube.com/watch?v=pB1JP1ybxiE

Module 4	**L1,L2,L3**	**10 Hrs.**

Vehicle Dynamics: Mode shape and frequencies of launch vehicles, Vibrations. Flexible Body Dynamics ofLiquid propellant in Moving containers Sloshing, POGO Orbital Vibration Mitigation Vibrations Aero elastic phenomenon of launch vehicles.

Laboratory Sessions/ Experimental learning: Vibrational analysis can be conducted using Ansys workbench.

Applications: Used to find the aeroelasticity(vibration) and to damp the vibration in the Launch vehicles.

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

3. https://nptel.ac.in/noc/courses/noc21/SEM1/noc21-ae06/
4. https://www.youtube.com/watch?v=HKfuuPymUP0
5. https://www.youtube.com/watch?v=b0vGbgdrIlA

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

Advanced Aerospace Technologies: Available Technologies, Available Launch Vehicles, New Technologies. Magnetically Inflated Cable System Flying Effector Nano tubing Example, Load and Deflection Nodal Analysis Example, Material Selection Analysis Example, Strained Example, Reaction Wheel Example, SpaceShuttle Landing Example, Vibrations Example.

Laboratory Sessions/ Experimental learning: Virtual experiments can be used to demonstrate the technologies.

Applications: Used in Aerospace vehicles.

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

9. https://nptel.ac.in/noc/courses/noc21/SEM1/noc21-ae06/
10. https://www.youtube.com/watch?v=744cYmaUZmg
11. https://www.youtube.com/watch?v=JmnBGrw2XsY

Course outcomes:

CO401.1	Classify the space mission analysis and design process.
CO401.2	Explain the working principle of rocket propulsion and re-entry mission.
CO401.3	Investigate the launch vehicle structural components for product lifecycle management.
CO401.4	Apply the concepts of space craft attitude control and instrumentation.
CO401.5	Summarize spacecraft configuration and advance technologies.

Reference Books:

1.	Space Vehicle Design M.D. Griffin,J.R. FrenchAIAA Series1 9 9 1.
2.	Spacecraft Systems Engineering P. Fortescue, J. stark, and G. Swinerd Wiley-Blackwell 4th revised edition,2011.
3.	Space Mission Analysis and designW.J. Larson andJ. R. Wertz.,Springer2nd edition,1992.
4.	Rocket and Spacecraft PropulsionM.J.L. TurnerSpringer3rd edition,2009.

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:

xxviii. 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.

xxix. 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.

xxx. 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	2	2	1	2	1	2	2	1	3	1	1
CO2	3	3	3	2	2	1	2	1	2	2	1	3	1	1
CO3	3	3	3	2	2	1	2	1	2	2	1	3	1	1
CO4	3	3	3	2	2	1	2	1	2	2	1	3	1	1
CO5	3	3	3	2	2	1	2	1	2	2	1	3	1	1

High,3, Medium,2, Low,1

Course Title	**DESIGN, MODELING AND ANALYSIS LAB**	**Semester**	VI

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 Aero foil Geometry, And Generation of Body Fitting Mesh.	L1,L2,L3	03
2	Modeling of Cambered Aero foil Geometry, And Generation of Body Fitting Mesh.	L1,L2,L3	03
3	Modeling of 2 D Incompressible and Inviscid Flow over an Aero foil. 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 Analysis of 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

Semester: VI		
INTRODUCTION OF AEROSPACE HISTORY		
Course Code:	**MVJ21AS641**	**CIE Marks:100**
Credits: 3	**L:T:P:S: 3:0:0:0**	**SEE Marks: 100**
Hours:	**40L**	**SEE Duration: 3 Hrs**
Course Learning Objectives: The students will be able to		
1	Understand basic principles of Aircraft and the history of space vehicles.	
2	Acquire the basic principles of flight.	
3	Learn the basic principle of Aircraft & Rocket propulsion.	
4	Understand the Aircraft Structures and Materials.	
5	Acquire the basics of Aircraft Instruments & systems.	

UNIT-I	
Introduction to Aircrafts: History of aviation, International Standard atmosphere, Atmosphere and its properties, Temperature, pressure and altitude relationships, Classification of aircrafts, V/STOL machines. 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.	**8 Hrs**

Laboratory Sessions/ Experimental learning: Ornithopter modelling, Paper plane. Applications: Environmental conditions Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101101079/	
UNIT-II	
Basic principles of flight: Significance of speed of sound, Propagation of sound, Mach number, subsonic, transonic, supersonic, hypersonic flows, Bernoulli's theorem, Aerodynamic forces and moments on an Airfoil, Lift and drag components, lift curve, drag curve, types of drag, factors affecting lift and drag; Centre of pressure and its significance, Aerodynamic centre, Aspect ratio, Airfoil nomenclature, Basic characteristics of airfoils, NACA nomenclature, Simple problems on lift and drag. Laboratory Sessions/ Experimental learning: Aerodynamics lab Applications: Aircraft Flow dynamics Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101104061/https://nptel.ac.in/courses/101101079/	**8 Hrs**
UNIT-III	
Aircraft Propulsion: Introduction, Classification, Piston Engine & its application, Brayton cycle, Principle of operation of Turboprop, turbojet and turbofan engines, Introduction to ramjets and scramjets; performance characteristics. **Rocket Propulsion:** Principles of operation of rocket, Classification of Rockets, Types of rockets and typical applications, Introduction to Space Exploration. Laboratory Sessions/ Experimental learning: Propulsion lab Applications: Aircraft engines Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101101079/	**8 Hrs**
UNIT-IV	
Aircraft and Spacecraft - Structures and Materials: Introduction- General types of construction, Monocoque, Semi-Monocoque and Geodesic structures. Typical wing and fuselage structure; Metallic and non-metallic materials for aircraft application. Use of aluminum alloy, titanium,	**8 Hrs**

stainless steel and composite materials. Materials selection for spacecraft application. Laboratory Sessions/ Experimental learning: Structures lab Applications: Material & Structural Dynamics of Aircraft Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101101079/	
UNIT-V	
Instrument: Instrument Displays, Introduction to Navigation Instruments, Basic Air data systems & Probes, Mach meter, Air speed indicator, Vertical speed indicator, Altimeter, Gyro based instruments, Introduction to spacecraft instruments. Inertial & GPS based sensors. **Systems:** Introduction to Hydraulic and pneumatic systems, Air Conditioning and Cockpit pressurization system, Generation and distribution of Electricity on board the airplane, Aircraft Fuel System, Fire Protection, Ice and Rain Protection System Laboratory Sessions/ Experimental learning: Instrumentation lab. Applications: Aircraft Instruments. Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101101079/	**8 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1	Differentiate the different concepts of aircrafts and spacecraft's in flight.
CO2	Describe the Principle of aviation and space flight.
CO3	Explain the Fundamentals of Rocket Propulsion and Aircraft Propulsion.
CO4	Apply the concepts of aircraft materials and structures.
CO5	Appreciate the complexities involved during development of flight vehicles systems.

Reference Books	
1.	John D. Anderson, "Introduction to Flight", McGraw-Hill Education, 8th edition, 2015, ISBN: 978-0078027673.

2.	Lalit Gupta and O P Sharma, Fundamentals of Flight Vol-I to Vol-IV, Himalayan Books. 2006, ISBN: 9788170020752
3.	Ian Moir, Allan Seabridge, "Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration", John Wiley & Sons, 3rd edition, 2011, ISBN: 9781119965206
4.	Sutton G.P., "Rocket Propulsion Elements", John Wiley, New York, 9th edition,2016,ISBN: 9781118753910

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	0	0	0	1	3	0	0	0	0	3

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

High-3, Medium-2, Low-1

Course Title	**INTRODUCTION TO MISSILES AND LAUNCH VEHICLES**	Semester	VI
Course Code	**MVJ21AS642**	**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**	10 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, spacecrafts, launching of satellites.

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

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

Module 2	**L1,L2,L3,**	10 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):

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

Module 3	**L1,L2,L3**	10 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**	10 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):

6. https://www.youtube.com/watch?v=L0SbCVyLNP8
7. https://www.youtube.com/watch?v=L0SbCVyLNP8
8. https://bps.space/tvc

Module 5	**L1,L2**	10 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):

12. https://nptel.ac.in/courses/101/104/101104078/
13. https://nptel.ac.in/content/storage2/101/104/101104078/MP4/mod11lec53.mp4
14. 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:

xxxi. 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.

xxxii. 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.

xxxiii. 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	**MVJ21AS643**	**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**	10Hrs.

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**	10Hrs.
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**	10Hrs.
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**	10Hrs.
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):**		

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

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

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):

1. https://www.youtube.com/watch?v=lsclmlNrpKM
2. 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	Analyze 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:
xxxiv. Question paper for the SEE consists of 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. xxxv. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students must answer five full questions. xxxvi. 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	**Introduction to Spacecraft & Satellite Technologies**	**Semester**	**VI**
Course Code	**MVJ21AS66**	**CIE**	**50**

Total No. of Contact Hours	**20 L : T : P :: 2 :0 : 0**	**SEE**	**50**
No. of Contact Hours/week	**2**	**Total**	**100**
Credits	**1**	**Exam. Duration**	**3 Hrs.**

The course objective is to:

1. Understand the basic concepts of space environment and its effects on space missions
2. Acquireknowledge of orbit mechanics and orbit manoeuvres.
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):

19. https://www.youtube.com/results?search_query=SPACE+FLIGHT+MECHANICS+NPTEL+
20. 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):

8. https://onlinecourses.nptel.ac.in/noc19_ph15/preview

9. https://www.youtube.com/watch?v=SfgEQUbnHyw **10.** https://www.youtube.com/watch?v=yD3_gZ_uXF4&t=67s		
Module 3	**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):** 10. https://www.youtube.com/results?search_query=Satellite+Attitude+Dynamics+nptel 11. https://www.youtube.com/watch?v=Q_P3S7t5lS4&list=PLbRMhDVUMngfOt5ATLzSIlqia0-IZbDI0		

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
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

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:

xxxvii. 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.

xxxviii. 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.

xxxix. 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

MVJ College of Engineering, Whitefield, Bangalore 560067

An Autonomous Institution, Affiliated to VTU, Belagavi

Scheme of Teaching and Examination

Outcome Based Education (OBE) and Choice Based Credit System (CBCS)

Effective from the academic year 2021-22

Department of Aerospace Engineering

Semester VII

Sl. No.	Course		Course Title	BoS	Teaching hrs./week				Examination				Credits
	Type	Code			Lecture L	Tutorial T	Practical P	Self-Study S	Duration Hrs.	CIE Marks	SEE Marks	Total Marks	
1	IPCC	MVJ21AS71	Space Flight Mechanics(+ Space Simulation Lab)		3	-	2	-	3	100	100	200	4
2	PEC	MVJ21AS72X	Professional Elective-II		3	-	-	-	3	50	50	100	3
3	PEC	MVJ21AS73X	Professional Elective-III		3	-	-	-	3	50	50	100	3
4	OEC	MVJ21AS74X	OEC 3		3	-	-	-	3	50	50	100	3
5	PRJ	MVJ21ASPR76	Project Phase I		-	-	4		3	50	50	100	2
6	AEC	MVJ21AS77	AEC (online minimum of 4 weeks duration)		1	-	-	-	2	50	50	100	1
Total					13	-	6			350	350	700	16

Course Code	Professional Elective-II	Course Code	Professional Elective-III
MVJ21AS721	Hypersonic Flows	MVJ21AS731	Atmospheric Flight Mechanics
MVJ21AS722/ MVJ21AE722	Composite Structures	MVJ21AS732/ MVJ21AE732	Reusable Launch Vehicles
MVJ21AS723	Cryogenics	MVJ21AS733/ MVJ21AE733	Artificial Intelligence and Robotics
MVJ21AS724	Spacecraft Launch Vehicles	MVJ21AS734	Satellite Design and Systems
MVJ21AS725/ MVJ21AE725	Control Engineering	MVJ21AS735/ MVJ21AE735	Guidance Navigation and Control

Course Code	Open Elective-III
MVJ21AS741	Spacecraft Navigation and Control
MVJ21AS742	Spacecraft Launch Vehicles
MVJ21AS743/ MVJ21AE743	Rockets & Missiles
MVJ21AS744	Aerospace Systems and Instrumentation
MVJ21AS745	Avionics

Course Title	**SPACE FLIGHT MECHANICS**	**Semester**	**VII**
Course Code	**MVJ21AS71**	**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:

6. Understand the basic concepts of space environment and its effects on space missions
7. Acquire knowledge of orbit mechanics and orbit maneuvers.
8. Gain knowledge of satellite injection and satellite attitude dynamics
9. Understand interplanetary trajectories and atmospheric re-entry problems.
10. 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 lifetime.

Applications: Spacecraft

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

21. https://www.youtube.com/results?search_query=SPACE+FLIGHT+MECHANICS+NPTEL+
22. 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 Manoeuvres: 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, Bielliptic Transfer, Plane Changes, Combined Manoeuvres, Propulsion for Manoeuvres

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

Applications: Spacecraft

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

11. https://onlinecourses.nptel.ac.in/noc19_ph15/preview

12. https://www.youtube.com/watch?v=SfgEQUbnHyw

13. 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: PerformTorque free axisymmetric rigid body satellite attitude simulation.

Applications: Orbital Mechanics

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

12. https://www.youtube.com/results?search_query=Fundamentals+of+Orbit+Mechanics+NPTEL
13. https://www.youtube.com/watch?v=SNd5IrMjlC4&t=73s
14. 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 Re-entry: Introduction-Steep Ballistic Re-entry, Ballistic Orbital Re-entry, Skip Re-entry, "Double-Dip" Re-entry, Aero-braking, Lifting Body Re-entry.

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

Applications: Spacecraft (Re-entry)

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

9. https://www.youtube.com/results?search_query=Satellite+Attitude+Dynamics+nptel
10. 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):

15. https://www.youtube.com/results?search_query=Space+Mission+Operations+nptel
16. 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	Analyze 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.	Vandekamp, Elements of Astro mechanics, Pitman, 1979
4.	William E wiesel, 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:

xl. 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.

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

xlii. 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	**SPACE SIMULATION LAB**	**Semester**	VII

Course objective is to:

- Understand the Stability analysis of a system through MATLAB.
- Acquire the knowledge on Satellite orbit maneuvering.
- Get the ideas about the gyroscope capabilities

Sl No	**Experiment Name**	**RBT Level**	**Hours**
1	Draw Pole – Zero map of dynamics system model with plot customization option.	L1,L2,L3	03
2	Plot root locus for a given Transfer Function and find Gain and Phase Margins	L1,L2,L3	03
3	Plot root locus for a higher order system taking unity feedback.	L1,L2,L3	03
4	Draw Bode plot from a transfer function in MATLAB and find gain and phase margin.	L1,L2,L3	03

5	Demonstrate the effect of lead and lag phase compensations on close-loop performance of a linear system.	L1,L2,L3	03
6	Simulate a model space craft (space shuttle) landing with parachute deployed.	L1,L2,L3	03
7	Simulate Hohmann transfer orbit.	L1,L2,L3	03
8	Perform a planetary orbit simulation.	L1,L2,L3	03
9	Model and simulate RCS signature.	L1,L2,L3	03
10	Model a satellite motion and determine time period for its orbital motion.	L1,L2,L3	03
11	Perform trajectory simulation of a small atmospheric re-entry module.	L1,L2,L3	03
12	Perform 3-DOF Gyroscope experiment for System Identification.	L1,L2,L3	03
13	Perform 2- DOF Rotor System experiment for Coupled Dynamic Analysis	L1,L2,L3	03
14	Model and simulate a simple Magnetic Levitation system and validate with the experimental setup.	L1,L2,L3	03

Course outcomes:	
CO1	Determine system stability through MATLAB.
CO2	Simulate the Satellite orbit manoeuvring.
CO3	Analyses the gyroscope experiments

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	**HYPERSONIC FLOWS**	**Semester**	VII
Course Code	**MVJ21AS721**	**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 hypersonic flows.
2. Understand the surface inclination methods for inviscid hypersonic flows.
3. Learn the Approximate Methods For Inviscid Hypersonic Flows
4. Acquire the knowledge of viscous interactions in hypersonic flows.
5. Acquire knowledge on the Testing facilities & measurements of Hypersonic flows.

Module 1	**L1,L2,L3**	10Hrs.

Basics of Hypersonic Flows: Thin shock layers, entropy layers, low density and high-density flows, hypersonic flight paths hypersonic flight similarity parameters, shock wave and expansion wave relations of inviscid hypersonic flows.

Laboratory Sessions/ Experimental learning:

1.High speed flow analysis past blunt object in presence of a bow shock wave (DESIGN, MODELLING & ANALYSIS LAB)

Applications:

1.Investigation of the parameters of wake flow at high speeds

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

23. https://www.youtube.com/watch?v=C4W-FDPy0Fg
24. https://www.youtube.com/watch?v=sKqGQi9Qqu4

Module 2	**L1,L2,L3,**	10Hrs.

Surface Inclination Methods for Hypersonic Inviscid Flows: Local surface inclination methods, modified Newtonian Law, Newtonian theory – tangent wedge or tangent cone and shock expansion methods, Calculation of surface flow properties.

Laboratory Sessions/ Experimental learning:

1. Experimental analysis of Hypersonic flow over an Elliptic Cone.

Applications:

1. Obtain the total force and moment structure on the high-speed vehicle

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

14. https://www.youtube.com/watch?v=NKglmcjgm-s
15. https://www.youtube.com/watch?v=_ptNCs6XOvw

16. https://www.youtube.com/watch?v=b0dMl3mon6c

Module 3	**L1,L2,L3**	10Hrs.

Approximate Methods For Inviscid Hypersonic Flows: Approximate methods hypersonic small disturbance equation and theory, thin shock layer theory, blast wave theory, entropy effects, rotational method of characteristics, hypersonic shock wave shapes and correlations

Laboratory Sessions/ Experimental learning:

1. Experimental characterization of the hypersonic flow around a cuboid

Applications:

1. Design and operation of a practical hypersonic vehicle

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

15. https://www.youtube.com/watch?v=Mv70aK7NoEg
16. https://www.youtube.com/watch?v=IksdT7nLGck

Module 4	**L1,L2,L3**	10Hrs.

Viscous Interactions In Hypersonic Flows: Strong and weak viscous interactions, hypersonic shockwaves and boundary layer interactions, Estimation of hypersonic boundary layer transition, Role of similarity parameter for laminar viscous interactions in hypersonic viscous flow

Laboratory Sessions/ Experimental learning:

1. Grid generation on fore portion of a spacecraft model (DESIGN, MODELLING & ANALYSIS LAB).

Applications:

1. In**engine inlet & Inward-turning inlet of High speed vehicles.**

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

11. https://www.youtube.com/watch?v=K08Gc0tKWoA
12. https://www.youtube.com/watch?v=oUTzO6Ftenw
13. https://www.youtube.com/watch?v=hVeP_62SaCA
14. https://www.youtube.com/watch?v=RChlt5wdqBs

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

Hypersonic Flows: Testing facilities & Measurements: Hypersonic Test facilities-Hypersonic Wind Tunnel, Types of Hypersonic Wind Tunnel, Calibration, Hypersonic Flow Parameter estimation in Wind tunnel, Hypersonic Impulse Facilities, Shock Tunnel & its types, Other Hypersonic test facilities-Hot Shot tunnel & Launcher test facility, Heat transfer rate Measurement, Flow Visualization for High Speeds

Laboratory Sessions/ Experimental learning:

1.Experimental investigation on drag and heat flux reduction in supersonic/hypersonic flows:

Applications:

1. Design &Operation of a practical hypersonic vehicle

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

17. https://www.youtube.com/watch?v=5u5ZkCxkVuI
18. https://www.youtube.com/watch?v=T37O2xMpUEk
19. https://www.youtube.com/watch?v=_b692ujHtc
20. https://www.youtube.com/watch?v=rMBQfE7e_J0

Course outcomes:

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

CO404.2.1	Interpret the basics of Hypersonic flows
CO404.2.2	Analyse the surface inclination methods for inviscid hypersonic flows.
CO404.2.3	Evaluate the Approximate methods for inviscid hypersonic flows
CO404.2.4	Evaluate thehypersonic boundary layers & effects involved with hypersonic aerodynamic heating
CO404.2.5	Illustrate the hypersonic Flow Parameters & Hypersonic Testing facilities

Reference Books:

1.	John D Anderson Jr., Hypersonic & High Temperature Gas dynamics, AIAA series, 2nd revised edition,2006
2.	John D Anderson Jr., Modern Compressible flow & Historical perspective Hypersonic Series, McGraw Hill, 3rd edition, 2012.
3.	William H Heiser and David T Pratt, Hypersonic Air Breathing Propulsion, AIAA, 1994.
4.	John T. Bertin, Hypersonic Aerothermodynamics, AIAA Inc, 1994

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:

- 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.
- 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.
- 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,1

Course Title	**COMPOSITE STRUCTURES**	**Semester**	**VII**
Course Code	**MVJ20AS722/AE722**	**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 properties and advantages of composite materials compared to conventional materials.

2.Comprehend the properties of polymer matrix composites with fibre reinforcements and to learn the fabrication methods used in composites

3. Gain knowledge about the Micro and macro mechanical properties of composite lamina and laminates

4.Understand the failure theories for predicting the failure of a composite lamina

5. Learn the NDT and DT methods of Composites with Composite applications

Module 1	**L1,L2,L3**	10Hrs.

Introduction to Composite Materials

Definition, classification of composite materials, classification of reinforcement - particulate, short fibers, whiskers, long fibers composites. matrix materials – metals, ceramics, polymers (including thermoplastics and thermosets), Carbon-Carbon Composites

Metal Matrix Composites:

MMC with particulate and short fibre reinforcement, liquid and solid state processing of MMC – stir casting, squeeze casting. Properties of MMCs, Applications of Al, Mg, Ti based MMC

Laboratory Sessions/ Experimental learning:

Determination of various composite materials by different types of fibers with application

Applications: Aircraft structural Parts, Automobile Sector and Many Engineering fields

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

25. https://youtu.be/0kB0G6WKhKE?list=PLSGws_74K01-bdEEUElQ9-obrujIKGEhg – IIT Kanpur

Module 2	**L1,L2,L3,**	10Hrs.

Processing of Polymer Matrix Composites: Thermoset Polymers, Hand layup Process, Vacuum Bagging Process, Post Curing Process, Filament winding, **Resin Transfer Molding**, Pultrusion, Pulforming, Autoclave Process

Processing of Polymer Matrix Composites: Thermoplastic Polymers, Extrusion process, Injection Molding Process, Thermo-forming process.

Post Processing of Composites – Adhesive bonding, drilling, cutting processes.

Laboratory Sessions/ Experimental learning:

Preparation of Composite laminates by Hand layup method

Applications: Thermosets and Thermoplastics are used in Aircraft Construction, corrosive environment, Common applications include fans, grating, tanks, ducts, hoods, pumps and cabinets.

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

https://youtu.be/tP8JCX87DzI - IIT Roorkee

Module 3	**L1,L2,L3**	10Hrs.

Micro-Mechanical Behaviour of a Lamina

Determination of elastic constants-Rule of mixtures, transformation of coordinates, micro-mechanics-based analysis and experimental determination of material constants. **Ultimate Strengths of a Unidirectional Lamina**

Macro-Mechanical Behaviour of a Lamina:

Hooke's law for different types of materials, Number of elastic constants, Two - dimensional relationship of compliance and stiffness matrix. Global and local axis for angle lamina, Stress-Strain relations for lamina of arbitrary orientation, Numerical problems.

Laboratory Sessions/ Experimental learning:

Determination of Young's Modulus of a Composite beam

Applications: Basics of macro level elastic properties, Scales of analysis of composites. Unidirectional and Woven fibers

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

https://youtu.be/loyeZN5UQT8 - IIT Madras

Module 4	**L1,L2,L3**	10Hrs.

Failure Theory

Different Strengths of Composite Lamina, Failure of Composite, Tsai-Hill, Tsai-Wu, Max Stress and Max Strain theories

Classical plate theory- Stress and strain variation in a laminate- Resultant forces and moments- A B & D matrices- Strength analysis of a laminate.

Laboratory Sessions/ Experimental learning:

Evaluate the mechanical properties of a lamina and a laminate

Applications: Prediction of failure of composite, load analysis methodology.

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

https://youtu.be/6CLEWA2WNqM - IIT Madras

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

Inspection & Quality Control: Destructive & Non-Destructive Testing, Tensile, Compression, Flexural, Shear, Hardness; ultrasonic testing – A-B-C scan

Applications of Composites Materials

Automobile, Aircrafts, missiles, Space hardware, Electrical and electronics, marine, recreational and Sports equipment, future potential of composites.

Laboratory Sessions/ Experimental learning:

Determination of Defects in a composite by NDT Methods

Applications: NDT- DT Methods, Composites in Aerospace sector

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

https://youtu.be/ZMJ7O4vs-Q8 - IIT Kanpur

Course outcomes:	
Upon completion of the course, students will be able to:	
CO305.2.1	Compare the properties and select material for the given application.
CO305.2.2	Analyse the properties of polymer matrix composites and Fabrication of Composite materials
CO305.2.3	Apply constitutive equations of *composite* materials and understand mechanical behaviour at *micro and macro* levels.
CO305.2.4	Design and failure *analysis* for manufacturing *composite* materials and Determine stresses and strains relation in composites materials.
CO305.2.5	Carry out various inspections in accordance with the established procedures and differentiate various defect types and select the appropriate **NDT** methods for better evaluation

Reference Books:	
1.	K.K Chawla, Composite Materials- Science and Engineering, IV edition, Springer International Publishing, 2019: ISBN: 978-3-030-28983-6
2.	Autar Kaw, Mechanics of Composites, II edition, Taylor & Francis Group CRC Press. 2006, ISBN:978-0-8493-1343-1
3.	R M Jones,Mechanics of Composite Materials, 2nd Edition, Taylor & Francis, 2015; ISBN:978-1560327127
4.	Ajay Kapadia**,** Non-Destructive Testing of Composite Materials, National Composites Network, Best Practices Guide, TWI Publications, 2006.

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:

xliii. 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.

xliv. 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.

xlv. 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	1	2	1	2	2	1	2	2	2	2	2	1	1
CO2	3	1	3	2	2	2	2	2	2	2	2	2	1	1
CO3	3	3	3	3	2	2	1	2	2	2	1	1	1	1
CO4	3	3	3	3	2	2	1	2	2	2	1	1	1	1
CO5	3	1	3	2	2	2	2	2	2	2	2	1	1	1

High,3, Medium,2, Low,1

Course Title	**CRYOGENICS**	Semester	VII
Course Code	**MVJ20AS723**	**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. Study the basics of cryogenic technology and applications
2. Learn the properties of cryogenic materials and their process
3. Understand the techniques of cryogenic insulation
4. Acquire knowledge on storage and instrumentation of cryogenic liquids
5. Learn the basics of cryogenic equipment

Module 1-Introduction to cryogenic Engineering	**L1,L2,L3**	10Hrs.

Thermo-Physical and Fluid Dynamics Properties of Liquid and Gas Hydrogen, Thermo-Physical and Fluid Dynamics Properties of Liquid and Gas Helium, Liquefaction System of Hydrogen and Helium Gases, Refrigeration and Liquefaction Principles, Joule Thomson Effect and Inversion Curve, Adiabatic and Isenthalpic Expansion and Their Comparison

Applications: Aerospace and chemical Industry **Video link / Additional online information (related to module if any):** 26. https://nptel.ac.in/courses/112/101/112101004/		
Module 2 – Properties	**L1,L2,L3,**	10Hrs.
Cryogenic Fluids, Solids at Cryogenic Temperatures, Superconductivity, Recuperative–Linde–Hampson, Claude, Cascade, Heylandt, Kapitza, Collins, Simon, Regenerative – Sterling Cycle and Refrigerator, Slovay Refrigerator, Gifford-Mcmahon Refrigerator, Vulilleumier Refrigerator, Pulse Tube Refrigerator, Liquefaction of Natural Gas **Applications:** Aerospace and chemical Industry **Video link / Additional online information (related to module if any):** **17.** https://youtu.be/fmwo0_qS_Ww **18.** https://youtu.be/JQG2m9jSkws		
Module 3 -Cryogenic Insulation	**L1,L2,L3**	10Hrs.
Vacuum Insulation, Evacuated Porous Insulation, Gas Filled Powders and Fibrous Materials, Solid Foams, Multilayer Insulation, Liquid and Vapor Shields, Composite Insulations **Applications:** Aerospace and chemical Industry **Video link / Additional online information (related to module if any):** 17. https://youtu.be/2_MIGplFQX8 18. https://youtu.be/2PVnn3_w3MQ		
Module 4 – Storage and instrumentation of cryogenic liquids	**L1,L2,L3**	10Hrs.
Design Considerations of Storage Vessel-Dewar Vessels- Industrial Storage Vessels, Storage of Cryogenic Fluids in Space, Transfer Systems and Lines for Cryogenic Liquids, Cryogenic Valves and Transfer Lines, Two Phase System in Transfer Systems, Cool-Down of Storage and Transfer Systems, Measurement of Strain , Pressure , Flow, Liquid Level and Temperature in Cryogenic Environment, Cryostats **Applications:** Aerospace and chemical Industry **Video link / Additional online information (related to module if any):** 15. https://youtu.be/snMwYxlyUfc 16. https://youtu.be/jIoGlPsOdjg		
Module 5 – Cryogenic Equipment	**L1,L2,L3**	10Hrs.
Cryogenic Heat Exchangers, Recuperative and Regenerative, Variables Affecting Heat Exchangers and System Performance, Cryogenic Compressors, Pumps, Expanders, Turbo Altimators, Effect of Component		

Inefficiencies, System Optimization, Magneto-Caloric Refrigerator, 3He-4He Dilution Refrigerator, Cryopumping, Cryogenic Engineering Application in Energy, Aeronautics, Space, Industry, Biology, Preservation Application of Cryogenic Engineering in Transport

Applications:

Aerospace and chemical Industry

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

21. https://youtu.be/wZae17GUFe8

Course outcomes:

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

CO403.2.1	Analyze cryogenic technology and its applications
CO403.2.2	Apply the properties of cryogenic materials and their process
CO403.2.3	Demonstrate the different cryogenic insulation methods
CO403.2.4	Apply the knowledge of storage and instrumentation of cryogenic liquids
CO403.2.5	Evaluate cryogenic equipment for their application

Reference Books:

1.	Flynn T. Cryogenic Engineering revised and expanded. CRC Press; 2004 Nov 30.
2.	Weisend, J. G. Handbook of cryogenic engineering. Vol. 325. Philadelphia: Taylor & Francis, 1998.
3.	Barron, Randall F. "Cryogenic systems." Monographs on cryogenics (1985).
4.	Timmerhaus, Klaus D., and Richard P. Reed, eds. Cryogenic engineering: fifty years of progress. Springer Science & Business Media, 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:

- Question paper for the SEE consists of 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.
- Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students must answer five full questions.
- 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			1						1	3	1
CO2	3	3	2			1						1	3	1
CO3	3	3	2			1						1	3	1
CO4	3	3	2			1						1	3	1
CO5	3	3	2			1						1	3	1

High,3, Medium,2, Low,1

Course Title	**SPACECRAFT LAUNCH VEHICLES**	Semester	VII
Course Code	**MVJ21AS724**	**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 knowledge of the environment and mission design
2. Understand the Trajectory of Rockets.
3. Acquire knowledge of orbital mechanics
4. Understand the atmospheric entry and spacecraft control.
5. Comprehend the configuration, design and communication of spacecraft launch vehicles

Module 1	**L1,L2,L3**	10 Hrs.

Environment and Mission Design

Earth environment, launch environment, atmosphere, space and upper atmosphere; earth-bound orbits, lunar and deep space missions, advanced missions, launch vehicle selection, launching and deployment.

Laboratory Sessions/ Experimental learning:

Visualize the impact of perturbances and dispersion on mission trajectories.

Applications:

Designing spacecrafts based on mission requirements and conditions.

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

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

Module 2	**L1,L2,L3**	10 Hrs.

Trajectory of a Rocket

Mass ratio and propellant mass fraction; equation of motion of an ideal rocket; motion of a rocket in a gravitational field; simplified vertical trajectory; burn-out velocity and burn-out height; step-rockets; ideal mission velocity and losses; effect of launch angle; factors causing dispersion of rockets in flight; dispersion of finned rockets; stability of flight.

Laboratory Sessions/ Experimental learning:

To calculate thrust profile for different solid grain structures.

Applications:

Selection of solid and liquid 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):

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

Module 3	**L1,L2,L3**	10 Hrs.

Astrodynamics

Orbits and trajectories, Kepler's laws, orbital velocity and periods, eccentric elliptical orbits; effect of injection conditions, effect of earth's rotation, perturbation analysis; parking orbit, transfer trajectory, impulsive shot; rendezvous; recent interplanetary missions

Laboratory Sessions/ Experimental learning:

Role of multi staging in performance of launch vehicles.

Applications:

Designing orbital transfer, launch of satellites, interplanetary missions, space exploration.

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

- https://www.youtube.com/watch?v=9oymZGQwiNk&t=1s
- https://www.youtube.com/watch?v=A4vBfVr1bcw
- https://www.teachengineering.org/lessons/view/cub_rockets_lesson01

Module 4	**L1,L2,L3**	10 Hrs.

Atmospheric Entry, Attitude Determination and Control

Entry flight mechanics, entry heating, entry vehicle design, aero-assisted orbit transfer; concepts and terminology of attitude determination, rotational dynamics, rigid body dynamics, disturbance torques, passive attitude control, active control, attitude determination, system design considerations.

Laboratory Sessions/ Experimental learning:

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

Applications:

Design of Rockets and Missiles, aerodynamic controls, reentry body design configurations.

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 5	**L1,L2**	10 Hrs.

Configuration, Structural Design, and Communications

Design drivers and concepts, mass properties, structural loads; power sources, design drivers and practice, command subsystems, redundancy and autonomy, radio communications, tracking.

Laboratory Sessions/ Experimental learning:

To determine the ignition delay of shellac igniter at various Voltage and Current level by using igniter testing apparatus.

Applications:

Design of electrical circuits, power transmission system, design of drivers and controlling sectors, designing of communication system.

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

- https://www.youtube.com/watch?v=dt4Ce8gQPns
- https://www.youtube.com/watch?v=Tu5VCcx25So
- http://sa-nitk.vlabs.ac.in/exp1/index.html

Course outcomes:

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

CO405.3.1	Analyse the environment and mission design
CO405.3.2	Evaluate the Trajectory of Rockets.
CO405.3.3	Illustrate the orbits and orbital mechanics
CO405.3.4	Analyse the atmospheric entry and spacecraft control

CO405.3.5	Describe the configuration, design and communication of spacecraft launch vehicles

Reference Books:	
1.	M.D. Griffin and J.R. French, Space Vehicle Design. 2nd Edition, AIAA Education Series (2004).
2.	J.W. Cornelisse, H.F.R. Schöyer, and K.F. Wakkar. Rocket Propulsion and Spacecraft Dynamics. 1st Edition, Pitman (1979).
3.	E. Stuhlinger and G. Mesmer. Space Science and Engineering. 1st Edition, McGraw-Hill, New York (1965).
4.	W.N. Hess. Space Science. 1st Edition, Blackie and Son (1965).

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:

- Question paper for the SEE consists of 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.
- Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students must answer five full questions.
- 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			1						1	3	1
CO2	3	3	2			1						1	3	1
CO3	3	3	2			1						1	3	1
CO4	3	3	2			1						1	3	1
CO5	3	3	2			1						1	3	1

High,3, Medium,2, Low,1

Course Title	**CONTROL ENGINEERING**	Semester	VII
Course Code	**MVJ21AS725**	**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 basic concepts of control systems and mathematical models.
2. Acquire knowledge of block diagrams and signal flow graphs.
3. Gain knowledge of stability analysis in Laplace domain through various techniques
4. Apprehend the frequency response specifications and polar plots
5. Understand the requirement for controller and compensation gain.

Module 1	**L1,L2,L3**	10Hrs.

Introduction to Control Systems and Mathematical Models Introduction: Concept of controls, Open loop and closed loop systems with examples, Concepts of feedback and basic structure of feedback control system, requirements of an ideal control system.

Mathematical Models: Transfer function models of mechanical systems, electrical circuits, DC and AC motors in control systems, Analogous systems: Force voltage and Force current analogy.

Laboratory Sessions/ Experimental learning:

1. Draw pole zero plot for open and closed loop system for a given transfer function

Applications:

1. Aircraft Controls

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

27. https://in.mathworks.com/videos/understanding-control-systems-part-1-open-loop-control-systems-123419.html
28. https://in.mathworks.com/videos/understanding-control-systems-part-2-feedback-control-systems-123501.html
29. https://nptel.ac.in/courses/108/102/108102043/

Module 2	**L1,L2,L3,**	10Hrs.

Block Diagrams and Signal Flow Graphs: Transfer functions definition and its properties, block representation of control systems and terminologies, block diagram algebra and reduction of block diagrams, Signal flow graph method, Mason's gain formula and its applications.

Transient and Steady State Response Analysis: Introduction, type and order of systems, time response specifications, first order and second order system response to step, ramp and impulse inputs, concepts of time constant and its importance.

Laboratory Sessions/ Experimental learning:

1. Study the behaviour of second order system with impulse, step and ramp input

Applications:

1. simplifies complex control system
2. Analyse the steady and transient behaviour of a system

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

19. https://nptel.ac.in/courses/108/102/108102043/

20. https://in.mathworks.com/videos/simscape-multibody-overview-117986.html?s_tid=srchtitle

Module 3	**L1,L2,L3**	10Hrs.

System stability analysis using Routh's – Hurwitz Criterion Root Locus Plots Definition of root loci, General rules for constructing root loci, Analysis using root locus plots, Determination of desired gain, limit gain, gain margin and conditional stability.

Frequency Response Analysis Using Bode Plots: Bode attenuation diagrams for first and second order systems, Simplified Bode diagrams, Stability analysis using Bode plots and determination of phase margin and gain margin and gain

Laboratory Sessions/ Experimental learning:

1. Analyse the stability using root locus plot for a dynamic system
2. Analyse the stability using bode plot for transfer function

Applications:

1. Stability Analysis of a SISO system
2. Effect of gain in stability of a system
3. Effect of frequency in stability of a system

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

19. https://in.mathworks.com/videos/control-system-design-with-control-system-tuning-app-68749.html?s_tid=srchtitle
20. https://nptel.ac.in/courses/108/102/108102043/

Module 4	**L1,L2,L3**	10Hrs.

Frequency Response Specification and Analysis using Polar plots: Specification: Frequency response definition, frequency response specifications and its relationship with time response specifications.

Analysis: Polar plots, Nyquist stability criterion, Stability analysis, Relative stability concepts, Gain margin and phase margin, M&N circles.

Laboratory Sessions/ Experimental learning:

1. Plot Polar plot for a transfer function

2. Determine gain and phase margin from nyquist plot

Applications:

1. Determine stability of an aircraft

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

17. https://in.mathworks.com/videos/control-systems-in-practice-part-10-nichols-chart-nyquist-diagram-and-bode-plot-1607596350472.html?s_tid=srchtitle
18. https://nptel.ac.in/courses/108/102/108102043/

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

Feedback control systems: Types of controllers – Proportional, Integral, Derivative controllers, Proportional – Integral, Proportional – Integral – Derivative controllers; Compensation methods – Series and feedback compensation, Lead, Lag and Lead-Lag Compensators.

State Variable Characteristics of Linear Systems: Introduction to concepts of states and state variable representation of linear systems, Advantages and Disadvantages over conventional transfer function representation, state equations of linear continuous data system. Matrix representation of state equations, Solution of state equation, State transition matrix and its properties, controllability and observability, Kalman and Gilberts test.

Laboratory Sessions/ Experimental learning:

1. Design PID controller for non linear system

Applications:

2. Autopilot design for lateral directional motion
3. Provide suitable controller for non linear or complex system.

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

22. https://in.mathworks.com/videos/pid-control-made-easy-81646.html?s_tid=srchtitle
23. https://nptel.ac.in/courses/108/102/108102043/

Course outcomes:

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

CO403.3.1	Apply the concepts of control models
CO403.3.2	Generate block diagrams and signal flow graphs
CO403.3.3	Perform the stability analysis in Laplace domain through various techniques
CO403.3.4	Evaluate the frequency response specifications and Nyquist criteria
CO403.3.5	Determine controller and compensation gain for feedback control system

Reference Books:	
1.	U.A. Bakshi and V.U. Bakshi, "Control Engineering", Technical Publications
2.	A. NagoorKani, "Control Systems Engineering", RBA Publications, 2014
3.	Katsuhiko Ogatta, "Modern Control Engineering ", Pearson Education, 2004
4.	N.S. Nise, "Control Systems Engineering", Wiley, 6th Edition,2012

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:

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

High,3, Medium,2, Low,1

Course Title	**ATMOSPHERIC FLIGHT MECHANICS**	**Semester**	**VII**
Course Code	**MVJ21AS731**	**CIE**	**50**

Total No. of Contact Hours	**40 L: T : P :: 3 :0 : 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**	10 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):

30. 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,**	10 Hrs.

Static Longitudinal Stability and Control-Stick free

Introduction, Hinge moment parameters, Control surface floating characteristics and aerodynamic balance, Estimation of hinge moment parameters, The trim 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**	10 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 engine in operative 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**	10 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**	10Hrs.

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.	BernardEtkin, 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:

xlvi. 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.

xlvii. 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.

xlviii. 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	**REUSABLE LAUNCH VEHICLE AND SPACE OPERATIONS**	Semester	VII
Course Code	**MVJ21AS732/ MVJ21AE732**	**CIE**	50
Total No. of Contact Hours	40 L: T:P: 3 :0 :0	**SEE**	50
No. of Contact Hours/week	4	**Total**	100
Credits	3	**Exam. Duration**	3 Hrs.

The course objective is to:

1. Learn thelaunch vehicle dynamics and stage separation techniques
2. Understand the basics of reusable launch vehicles
3. Study the primary structure of the reusable launch vehicles
4. Acquire knowledge on the operation of re-entry vehicles and its applications
5. Comprehend knowledge on mission and flight dynamics operations

Module 1: Launch Vehicle Dynamics	**L1,L2,L3**	10Hrs.

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

Laboratory Sessions/ Experimental learning:

Simulation of the mission profile of a launch vehicle using simulation software

Applications:

Aerospace Industry

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

1. https://youtu.be/Pqi6dMrtB0E

Module 2:Introduction to Reusable Launch Vehicle	**L1,L2,L3,**	10Hrs.

Understanding the Development of Reusable Launch Vehicles -Recent History and CurrentPrograms – Technical challenges - Economic Considerations - Legal and Policy Issues - Threat Considerations, Reusable Launch Vehicle Missions and Applications, Military Utility of Reusable Launch Vehicles,

Commercial Utility of Reusable Launch Vehicles, fully and partially reusable launch systems -lift-off stages, orbital insertion stages, Reusable orbiter. Introduction to space shuttle, docking in space.

Laboratory Sessions/ Experimental learning:

Simulation of the mission profile of a reusable launch vehicle using simulation software

Applications:

Aerospace Industry

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

1. https://youtu.be/BZmf5H6wpeM
2. https://youtu.be/a_T4QayqtI4
3. https://youtu.be/XSHegOVw1n0n

Module 3: Primary Vehicle Structure	**L1,L2,L3**	10Hrs.

Introduction, Components of Major Structures, Reusable Cryogenic Tank System- Al-Li cryogenic tanks- LOX Tank- LH2 Tank- Organic-Matrix Composite Tanks, Thermal Protection System, propulsion- Existing AND New Engines-Engine Performance- Throttling- Revolutionary Reusable Technology Turbopump (RRTT) and Other Advanced Turbopump- Health Monitoring-High reliability Sensors

Laboratory Sessions/ Experimental learning:

Case study on RLV-TD

Applications:

Aerospace Industry

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

1. https://www.youtube.com/watch?v=Wn5HxXKQOjw

Module 4 : Reentry Mission	**L1,L2,L3**	10Hrs.

Operating environment and reentry system design guidelines

Reentry flight environment- system design process - system mission management,

Re-entry Dynamics and Re-entry Vehicle Configurations

Re-entry Dynamics, Ballistic Bodies Re-entry, Influence of Re-entry Flight Path Angle, Influence of Vehicle Lift on the Re-entry System, Skipping Trajectory Reentry System, Range Capabilities and Reentry Foot-Print, Winged-Reentry Vehicles

Laboratory Sessions/ Experimental learning:

Thermal Simulation of Reentry heat shield using simulation software.

Applications:

Aerospace industry

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

1. https://youtu.be/hLHo9ZM3Bis

Module 5: Space operations	**L1,L2**	10Hrs.

Overview Space Segment

The Space Environment, Space Systems Objectives and Requirements, Design Drivers and Trade-offs, Fundamentals of Space Communications

Mission Operations

Mission Operations Preparation, Mission Operations Execution, Flight Experience

Flight Dynamic Operations

Orbital Dynamics, Attitude Dynamics, mission planning, mission planning for unmanned systems, Mission Planning for Human Spaceflight Missions

Laboratory Sessions/ Experimental learning:

Flow Simulation of Reentry heat shield using simulation software

Applications:

Aerospace industry

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

19. https://youtu.be/RJzyB_qEWyU
20. https://www.youtube.com/watch?v=Pqi6dMrtB0E

Course outcomes:

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

CO402.1	Evaluate the launch vehicle dynamics and stage separation techniques
CO402.2	Explain the basics of reusable launch vehicle
CO402.3	Configure reusable launch vehicle
CO402.4	Analyse Re-entry vehicle dynamics and configurations
CO402.5	Analyse the mission and flight dynamics operations

Reference Books:

1.	Ward, J.E., Reusable launch vehicles and space operations. 2000.
2.	Suresh, B. and K. Sivan, Integrated design for space transportation system. 2015: Springer.
3.	Council, N.R., Reusable launch vehicle: Technology development and test program. 1996: National Academies Press.

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:
- 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. - 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. - 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	3								1	3	1
CO2	3	3	1									1	3	1
CO3	3	3	2	2								1	3	1
CO4	3	3	2	3								1	3	1
CO5	3	3	2	3								1	3	1

High,3, Medium,2, Low,1

Course Title	**ARTIFICIAL INTELLIGENCE AND ROBOTICS**	**Semester**	**VII**
Course Code	**MVJ21AS733/AE733**	**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 basic techniques of artificial intelligence 2. Understand Non-monotonic reasoning and statistical reasoning 3. Introduce the electronics and software aspects in the design of robots 4. Introduce the latest state of the art robots

5. Understand the usage of AI in Robots		
Module 1Introduction to AI	**L1,L2,L3**	10 Hrs.
Computerized reasoning - Artificial Intelligence (AI) - characteristics of an AI problem – Problem representation in AI - State space representation - problem reduction-Concept of small talk programming **Laboratory Sessions/ Experimental learning:** Compare the theoretical solution to the forward kinematics problem with a physical implementation on the robot. **Applications:** Design, Supply chain management, Prediction of in-service damages **Video link / Additional online information (related to module if any):** 31. https://nptel.ac.in/courses/106/102/106102220/		
Module 2Search Process &Knowledge Representation	**L1, L2, L3,**	10 Hrs.
Search Process:AI and search process - Brute force search techniques - Depth first - Breadth first search techniques - Hill climbing - Best first search - AND/OR graphs - A* algorithm - Constraint satisfaction. **Knowledge Representation:** Logic, Propositional logic - Tautology - Contradiction - Normal forms - Predicate logic - Rules of inference - Resolution - Unification algorithm -Production rules - Semantic networks - Frames – Scripts - Conceptual dependency. **Laboratory Sessions/ Experimental learning:** Derive and implement a solution to the inverse kinematics problem for the robot **Applications:** Predictive Maintenance, Flight performance Optimization, Reverse Engineering **Video link / Additional online information (related to module if any):** **21.** https://nptel.ac.in/courses/106/102/106102220/		
Module 3 Introduction to Robotics	**L1, L2, L3**	10 Hrs.
Scope of Robots: The scope of industrial Robots - Definition of an industrial robot - Need for industrial robots. **Robot Components:** Fundamentals of Robot Technology - Automation and Robotics - Robot anatomy - Work volume- Precision of movement - End effectors - Sensors **Laboratory Sessions/ Experimental learning:** Controlling the robots using the programming language **Applications:** Quality control, Smart Factory Building, Repetitive work management **Video link / Additional online information (related to module if any):** 21. https://nptel.ac.in/courses/112/105/112105249/		
Module 4Future Trends in Robots	**L1, L2, L3**	10 Hrs.
Telepresence robot - Autonomous mobile robots - Walker Robots – Solar ball Robot – Under water bots – Aerobots - Advanced robotics in Space - Specific features of space robotics systems – long term technical developments - Next generation robots. **Laboratory Sessions/ Experimental learning:** Integrate computer vision and control of the robot **Applications:** Training, Smart Repairs Management		

Video link / Additional online information (related to module if any): 21. https://nptel.ac.in/courses/112/105/112105249/		
Module 5AI in Robotics	**L1, L2**	10 Hrs.
Robotic perception, localization – mapping- configuring space - planning uncertain movements - dynamics and control of movement, Ethics and risks of artificial intelligence in robotics. **Laboratory Sessions/ Experimental learning:** Integrate forward and inverse kinematics and computer vision to control the robot. **Applications:** AI Autopilot in commercial flights, Knowledge-Based Engineering **Video link / Additional online information (related to module if any):** 24. https://nptel.ac.in/courses/106/102/106102220/		

Course outcomes: Upon completion of the course, students will be able to:	
CO404.3.1	Apply the basic techniques of artificial intelligence
CO404.3.2	Compare and contrast non-monotonic reasoning and statistical reasoning
CO404.3.3	Design and develop robotic based systems
CO404.3.4	Develop automatic solution for replacing humans in life threatening area
CO404.3.5	Interpret basic AI algorithms in Robotics

Reference Books:	
1.	Elaine Rich And Kevin Knight,Artificial Intelligence, Tata Mcgraw-Hill, 3rdedition,2008.
2.	Barry Leatham - Jones, Elements of industrial Robotics, Pitman Publishing, 1987
3.	J. M. Selig, Introductory Robotics, Prentice Hall, 1992
4.	David Jefferis, Artificial Intelligence: Robotics and Machine Evolution, Crabtree Publishing Company, 1992

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:

- 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.
- 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.
- 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
CO1	2	2	-	-	-	-	-	-	-	-	-	-
CO2	3	3	-	-	3	-	-	-	-	-	-	-
CO3	-	-	-	-	-	3	-	-	-	-	-	-
CO4	-	-	3	-	-	2	3	-	-	-	-	3
CO5	3	3	3	-	3	-	2	-	-	-	-	3

High,3, Medium,2, Low,1

Course Title	Satellite Design and Systems	Semester	VII
Course Code	MVJ21AS734	**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:

6. Understand the basics of navigation and control.
7. Gain knowledge of orbit mechanics and orbit determination
8. Acquire knowledge of the launch phase and maneuver.
9. Comprehend Spacecraft control
10. Understand the optimization techniques for trajectory planning

Module 1	**L1,L2,L3**	10 Hrs.

Introduction to Navigation and control: concept of guidance, navigation and control. Attitude determination, orbit determination.

Space sensors for Navigation: Space based RADAR sensor, Passive microwave sensors, Infrared sensors, GPS.

Laboratory Sessions/ Experimental learning:

Study the effect of actuation command in six degree of freedom simulation environment using MATLAB.

Applications:

Autonomous system, surveillance and tracking.

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

1. NPTEL- Guidance and Navigation

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

Module 2	**L1,L2,L3**	10 Hrs.

Orbital Mechanics:

The Two-Body Problem, Orbital Elements and Reference Axes, Time in Orbit, Lambert's Time of Flight Theorem.

Orbit Determination:

Introduction, **First Estimates of Orbits,** Refinement of Orbits, Sequential Estimation.

Laboratory Sessions/ Experimental learning:

Calculate the trajectory for a spacecraft using MATLAB

Applications:

Attitude and orbit determination

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

2. NPTEL- Rocket propulsion

https://www.youtube.com/watch?v=gPdZlfRQWeE&ab_channel=NPTELIITGuwahati

Module 3	**L1,L2,L3**	10 Hrs.

Launch Phase:

Introduction, Equations of Motion, Gravitational Forces, Rocket Thrust, Aerodynamic Forces, Final Orbital Elements. In flight guidance.

Orbit Manoeuvre:

Co-planar Transfer Manoeuvre, Injection into an Interplanetary Orbit, Plane Change to inject into a Geostationary Orbit. Mid-course Manoeuvre, Gravity Assist Manoeuvre.

Laboratory Sessions/ Experimental learning:

Calculate the spacecraft trajectory for a spacecraft using MATLAB

Applications:

Flight plan for spacecraft, thrust determination

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

1. NPTEL- Determining Orbit

https://www.youtube.com/watch?v=gPdZlfRQWeE&ab_channel=NPTELIITGuwahati

Module 4	**L1,L2,L3**	10 Hrs.

Control of Spacecraft:

Attitude and orbit Control of spacecraft. Spacecraft parameters for dynamic analysis. Roll autopilot. Acceleration command and root locus.

Laboratory Sessions/ Experimental learning:

Autopilot design for a spacecraft using MATLAB

Applications:

Autopilot design

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

1. NPTEL- Guidance and Navigation

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

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

Optimization:

Optimal Low-Thrust Rendezvous Using Equinoctial Orbit Elements, Optimal Low-Thrust Transfer Using Variable Bounded Thrust, Minimum-Time Low-Thrust Rendezvous and Transfer Using EpochMean Longitude Formulation, Trajectory Optimization Using Eccentric Longitude Formulation

Laboratory Sessions/ Experimental learning:

Design Minimum-Time Low-Thrust Rendezvous and Transfer Using EpochMean Longitude Formulation

Applications:

Determine relative stability of an Aircraft

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

1. NPTEL- Guidance and Navigation

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

Course outcomes:

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

CO405.2.1	Apply the concept of navigation and control in spacecraft.
CO405.2.2	Analyse orbit mechanics and orbit determination
CO405.2.3	Evaluate launch phase and manoeuvre
CO405.2.4	Analyse attitude and orbit control of spacecraft
CO405.2.5	Compute the optimization techniques for trajectory planning

Reference Books:

1.	Mohamed M AbidSpacecraft Sensors,Wiley, 2005.
2.	Dr. Maxwell Noton, R.E., Spacecraft Navigationand Guidance,Springer-Verlag London, 1998
3.	J.R. Wertz, Spacecraft Attitude Determination and Control, Springer, 1978
4.	Jean Albert Kéchichian, Applied Nonsingular Astrodynamics: Optimal Low-Thrust Orbit Transfer, Cambridge Aerospace Series, 2018

Course Title	**GUIDANCE NAVIGATION & CONTROL**	**Semester**	**VII**
Course Code	**MVJ21AS735**	**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 Guidance and Navigation.

2. Gain knowledge of the various types of guidance and control systems

3. Comprehend the control system for missiles

4.Acquire knowledge of the missile guidance performance

5. Understand the requirement for integrating flight and fire control system.

Module 1	**L1,L2,L3**	10Hrs.

Guidance, Navigation and Control Introduction: Concepts of navigation, guidance and control. Introduction to basic principles. Air data information.

Radar Systems: Principle of working of radar. MTI and Pulse Doppler radar. Moving target detector. Limitation of MTI performance. MTI from a moving platform (AMTI).

Laboratory Sessions/ Experimental learning:

1. Analyse the flight instruments of aircraft for given flight condition using MATLAB

Applications: Guidance system for aircraft, Target detection

Video link / Additional online information:

https://nptel.ac.in/courses/101/104/101104062/ - IIT Kanpur

Module 2	**L1,L2,L3,**	10Hrs.

Target Detection and Tracking with Radar: Mono pulse tracking. Conical scan and sequential lobbing. Automatic tracking with surveillance radar (ADT). Detection avoidance techniques.

Other Guidance Systems: Gyros and stabilised platforms. Inertial guidance and Laser based guidance. Components of Inertial Navigation System. Imaging Infrared guidance. GPS, SATcom.

Laboratory Sessions/ Experimental learning:

1. Calculate the position and velocity of an target for given doppler shift using MATLAB.

Applications: Target detection and tracking

Video link / Additional online information:

https://nptel.ac.in/courses/101/104/101104062/ -IIT Kanpur

Module 3	**L1,L2,L3**	10Hrs.
Transfer Functions: Input-output Transfer function. Basic altitude reference. Concepts of Open loop and Close Loop, Root Locus plot. **Missile Control System:** Guided missile concept. Roll stabilisation. Control of aerodynamic missile. Missile parameters for dynamic analysis. Missile autopilot schematics. Acceleration command and root locus. **Laboratory Sessions/ Experimental learning:** **1.** Determine stability of a system using Root locus plot. **Applications:** Stability of a system, Missile autopilot design **Video link / Additional online information:** https://nptel.ac.in/courses/101/104/101104062/ - IIT Kanpur		
Module 4	**L1,L2,L3**	10Hrs.
Missile Guidance: Proportional navigation guidance; command guidance. Comparison of guidance system performance. Bank to turn missile guidance. **Laboratory Sessions/ Experimental learning:** 1. Draw a missile trajectory to hit a slow-moving target using Proportional guidance **Applications:** Guidance system for missiles **Video link / Additional online information:** https://nptel.ac.in/courses/101/104/101104062/- IIT Kanpur		
Module 5	**L1,L2**	10Hrs.
Integrated Flight/Fire Control System: Principal of missile launch from aircraft, Director fire control system. Tracking control laws. Longitudinal flight control system. Lateral flight control system. Rate of change of Euler angle, Auto Pilot. **Laboratory Sessions/ Experimental learning:** **1.** Draw a missile trajectory to hit a combat aircraft using Command guidance. **Applications:** Simulation of dynamic modes and performance parameters for Aircraft design **Video link / Additional online information:** https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-885j-aircraft-systems-engineering-fall-2005/video-lectures/lecture-16/ - MIT		

Course outcomes:

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

CO404.3.1	Apply the concept of guidance and navigation to design guidance system for aircraft.
CO404.3.2	Apply knowledge of the various types of guidance and control systems
CO404.3.3	Evaluate control of missile
CO404.3.4	Analyse missile guidance performance

CO404.3.5	Analyse integrated flight and fire control system

Reference Books:	
1.	P.T. Kabamba and A.R. Girard, Fundamentals of Aerospace Navigation and Guidance, Cambridge Aerospace Series, 2014
2.	John H Blakelock,Automatic control of Aircraft & Missiles`, Wile –Inter Science Publication, 2nd edition, May 1990.
3.	Merrilh I. Skolnik,`Introduction to Radar Systems`, 3rd edition, Tata Mc Graw Hill, 2001.
4.	George M. Siouris**,** Missile Guidance and Control Systems, Springer, 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:

xlix. Question paper for the SEE consists of 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.

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

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

High,3, Medium,2, Low,1

Course Title	SPACECRAFT NAVIGATION AND CONTROL	Semester	VII
Course Code	MVJ21AS741	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:

11. Understand the basics of navigation and control.
12. Gain knowledge of orbit mechanics and orbit determination
13. Acquire knowledge of the launch phase and maneuver.
14. Comprehend Spacecraft control
15. Understand the optimization techniques for trajectory planning

Module 1	**L1,L2,L3**	10 Hrs.

Introduction to Navigation and control: concept of guidance, navigation and control. Attitude determination, orbit determination.

Space sensors for Navigation: Space based RADAR sensor, Passive microwave sensors, Infrared sensors, GPS.

Laboratory Sessions/ Experimental learning:

Study the effect of actuation command in six degree of freedom simulation environment using MATLAB.

Applications:

Autonomous system, surveillance and tracking.

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

2. NPTEL- Guidance and Navigation

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

Module 2	**L1,L2,L3**	10 Hrs.

Orbital Mechanics:

The Two-Body Problem, Orbital Elements and Reference Axes, Time in Orbit, Lambert's Time of Flight Theorem.

Orbit Determination:

Introduction, **First Estimates of Orbits,** Refinement of Orbits, Sequential Estimation.

Laboratory Sessions/ Experimental learning:

Calculate the trajectory for a spacecraft using MATLAB

Applications:

Attitude and orbit determination

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

3. NPTEL- Rocket propulsion

https://www.youtube.com/watch?v=gPdZlfRQWeE&ab_channel=NPTELIITGuwahati		
Module 3	**L1,L2,L3**	10 Hrs.
Launch Phase: **Introduction,** Equations of Motion, Gravitational Forces, Rocket Thrust, Aerodynamic Forces, Final Orbital Elements. In flight guidance. **Orbit Manoeuvre:** Co-planar Transfer Manoeuvre, Injection into an Interplanetary Orbit, Plane Change to inject into a Geostationary Orbit. Mid-course Manoeuvre, Gravity Assist Manoeuvre. **Laboratory Sessions/ Experimental learning:** Calculate the spacecraft trajectory for a spacecraft using MATLAB **Applications:** Flight plan for spacecraft, thrust determination **Video link / Additional online information (related to module if any):** 2. NPTEL- Determining Orbit https://www.youtube.com/watch?v=gPdZlfRQWeE&ab_channel=NPTELIITGuwahati		
Module 4	**L1,L2,L3**	10 Hrs.
Control of Spacecraft: Attitude and orbit Control of spacecraft. Spacecraft parameters for dynamic analysis. Roll autopilot. Acceleration command and root locus. **Laboratory Sessions/ Experimental learning:** Autopilot design for a spacecraft using MATLAB **Applications:** Autopilot design **Video link / Additional online information (related to module if any):** 2. NPTEL- Guidance and Navigation https://nptel.ac.in/courses/101/104/101104062/		
Module 5	**L1,L2**	10 Hrs.
Optimization: Optimal Low-Thrust Rendezvous Using Equinoctial Orbit Elements, Optimal Low-Thrust Transfer Using Variable Bounded Thrust, Minimum-Time Low-Thrust Rendezvous and Transfer Using EpochMean Longitude Formulation, Trajectory Optimization Using Eccentric Longitude Formulation **Laboratory Sessions/ Experimental learning:** Design Minimum-Time Low-Thrust Rendezvous and Transfer Using EpochMean Longitude Formulation **Applications:** Determine relative stability of an Aircraft		

Video link / Additional online information (related to module if any):	
2. NPTEL- Guidance and Navigation https://nptel.ac.in/courses/101/104/101104062/	
Course outcomes: Upon completion of the course, students will be able to:	
CO405.2.1	Apply the concept of navigation and control in spacecraft.
CO405.2.2	Analyse orbit mechanics and orbit determination
CO405.2.3	Evaluate launch phase and manoeuvre
CO405.2.4	Analyse attitude and orbit control of spacecraft
CO405.2.5	Compute the optimization techniques for trajectory planning

Reference Books:	
1.	Mohamed M AbidSpacecraft Sensors,Wiley, 2005.
2.	Dr. Maxwell Noton, R.E., Spacecraft NavigationandGuidance,Springer-Verlag London, 1998
3.	J.R. Wertz, Spacecraft Attitude Determination and Control, Springer, 1978
4.	Jean Albert Kéchichian, Applied Nonsingular Astrodynamics: Optimal Low-Thrust Orbit Transfer, Cambridge Aerospace Series, 2018

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:
- 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. - 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. - 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	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	SPACECRAFT LAUNCH VEHICLES	Semester	VII
Course Code	MVJ21AS742	**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:

6. Gain knowledge of the environment and mission design
7. Understand the Trajectory of Rockets.
8. Acquire knowledge of orbital mechanics
9. Understand the atmospheric entry and spacecraft control
10. Comprehend the configuration, design and communication of spacecraft launch vehicles

Module 1	**L1,L2,L3**	10 Hrs.

Environment and Mission Design

Earth environment, launch environment, atmosphere, space and upper atmosphere; earth-bound orbits, lunar and deep space missions, advanced missions, launch vehicle selection, launching and deployment.

Laboratory Sessions/ Experimental learning:

Visualize the impact of perturbances and dispersion on mission trajectories.

Applications:

Designing spacecrafts based on mission requirements and conditions.

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

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

Module 2	**L1,L2,L3**	10 Hrs.

Trajectory of a Rocket

Mass ratio and propellant mass fraction; equation of motion of an ideal rocket; motion of a rocket in a gravitational field; simplified vertical trajectory; burn-out velocity and burn-out height; step-rockets; ideal mission velocity and losses; effect of launch angle; factors causing dispersion of rockets in flight; dispersion of finned rockets; stability of flight.

Laboratory Sessions/ Experimental learning:

To calculate thrust profile for different solid grain structures.

Applications:

Selection of solid and liquid 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):

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

Module 3	**L1,L2,L3**	10 Hrs.

Astrodynamics

Orbits and trajectories, Kepler's laws, orbital velocity and periods, eccentric elliptical orbits; effect of injection conditions, effect of earth's rotation, perturbation analysis; parking orbit, transfer trajectory, impulsive shot; rendezvous; recent interplanetary missions

Laboratory Sessions/ Experimental learning:

Role of multi staging in performance of launch vehicles.

Applications:

Designing orbital transfer, launch of satellites, interplanetary missions, space exploration.

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

- https://www.youtube.com/watch?v=9oymZGQwiNk&t=1s
- https://www.youtube.com/watch?v=A4vBfVr1bcw
- https://www.teachengineering.org/lessons/view/cub_rockets_lesson01

Module 4	**L1,L2,L3**	10 Hrs.

Atmospheric Entry, Attitude Determination and Control

Entry flight mechanics, entry heating, entry vehicle design, aero-assisted orbit transfer; concepts and terminology of attitude determination, rotational dynamics, rigid body dynamics, disturbance torques, passive attitude control, active control, attitude determination, system design considerations.

Laboratory Sessions/ Experimental learning:

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

Applications:

Design of Rockets and Missiles, aerodynamic controls, reentry body design configurations.

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 5	**L1,L2**	10 Hrs.

Configuration, Structural Design, and Communications

Design drivers and concepts, mass properties, structural loads; power sources, design drivers and practice, command subsystems, redundancy and autonomy, radio communications, tracking.

Laboratory Sessions/ Experimental learning:

To determine the ignition delay of shellac igniter at various Voltage and Current level by using igniter testing apparatus.

Applications:

Design of electrical circuits, power transmission system, design of drivers and controlling sectors, designing of communication system.

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

- https://www.youtube.com/watch?v=dt4Ce8gQPns
- https://www.youtube.com/watch?v=Tu5VCcx25So
- http://sa-nitk.vlabs.ac.in/exp1/index.html

Course outcomes:

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

CO405.3.1	Analysethe environment and mission design
CO405.3.2	Evaluate the Trajectory of Rockets.
CO405.3.3	Illustrate the orbits and orbital mechanics
CO405.3.4	Analyse the atmospheric entry and spacecraft control
CO405.3.5	Describe the configuration, design and communication of spacecraft launch vehicles

Reference Books:

1.	M.D. Griffin and J.R. French, Space Vehicle Design. 2nd Edition, AIAA Education Series (2004).
2.	J.W. Cornelisse, H.F.R. Schöyer, and K.F. Wakkar. Rocket Propulsion and Spacecraft Dynamics. 1st Edition, Pitman (1979).

3.	E. Stuhlinger and G. Mesmer. Space Science and Engineering. 1st Edition, McGraw-Hill, New York (1965).
4.	W.N. Hess. Space Science. 1st Edition, Blackie and Son (1965).

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:
- Question paper for the SEE consists of 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. - Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students must answer five full questions. - 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			1						1	3	1
CO2	3	3	2			1						1	3	1
CO3	3	3	2			1						1	3	1
CO4	3	3	2			1						1	3	1
CO5	3	3	2			1						1	3	1

High,3, Medium,2, Low,1

Semester: VII		
Rockets & Missiles		
Course Code:	**MVJ21AS743/ MVJ21AE743**	**CIE Marks:100**
Credits: L:T:P:S: 3:1:0:0		**SEE Marks: 100**
Hours: 40 Hours		**SEE Duration: 3 Hrs**
Course Learning Objectives: The students will be able to		

1	Basics of Rockets and Missiles is an elective course offered in 5th semester Aeronautical Engineering curriculum.
2	This subject covers extensively regarding design and analysis of rockets and missiles.
3	The different types of Airframe components, types of propulsion system, and types of guidance systems are also covered in this subject.
4	This subject will make student to understand advanced problems facing in launch vehicles and missiles.
5	

UNIT-I	
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. **Applications**: **Web Link and Video Lectures:** https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-512-rocket-propulsion-fall-2005/ https://www.isro.gov.in/launchers	**8 Hrs**
UNIT-II	
SOLID AND LIQUID ROCKET MOTOR SYSTEMS **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 **Applications**: **Web Link and Video Lectures:** https://www.esa.int/Our_Activities/Space_Transportation/Launch_vehicles/Ariane_5 https://www.nasa.gov/centers/glenn/about/history/lvpo.html	**8 Hrs**
UNIT-III	
MODULE 3: AERODYNAMICS OF ROCKETS AND MISSILES **Liquid Propellant Rocket Motor Systems:** Liquid propellants, types, composition, properties, performance. Propellant tanks, feed systems, pressurization, turbo-pumps, and valves and feed lines, injectors, starting and	**8 Hrs**

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 **Applications**: **Web Link and Video Lectures:** https://www.nasa.gov/connect/ebooks/aeronautics_ebooks_archive_1.html	
UNIT-IV	
LAUNCH VEHICLE DYNAMICS & ATTITUDE CONTROL OF ROCKETS **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.Λ **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 **Applications** **Web Link and Video Lectures:** http://nptel.ac.in/courses/101104019/	**8 Hrs**
UNIT-V	
ROCKET TESTING AND MATERIALS **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 atypical space launch vehicle launch procedure. **Materials:** Criteria for selection of materials for rockets and missiles, requirements for choice of materials for propellant tanks, liners, insulators, inhibitors, at cryogenic temperatures, requirements of materials at extremely high temperatures, requirements of materials for Thermal protection and for pressure vessels. **Applications**: **Web Link and Video Lectures:** http://nptel.ac.in/courses/101105030/33	**8 Hrs**

Course Outcomes: After completing the course, the students will be able to

CO1	Identify the types of space launch vehicles and missiles.
CO2	Distinguish the solid and liquid propellant motors.
CO3	Classify different types of missiles, understand missile aerodynamics.
CO4	Acquire the knowledge on launch vehicle dynamics, Attitude control
CO5	Identify different types of materials used in rockets, missiles and acquire knowledge on rocket testing

Reference Books	
3.	**George P Sutton and Oscar Biblarz,' *Rocket Propulsion Element*', John Wiley and Sons Inc,7th edition,2010,ISBN-13: 978-8126525775**
4.	**Jack N Neilson, '*Missile Aerodynamics*', AIAA, 1st edition, 1988, ISBN-13: 978-0962062902.**
3.	SS Chin, 'Missile *Configuration Design'*.
4.	Cornelisse, J.W., Schoyer H.F.R. and Wakker, K.F., *Rocket Propulsion and Space-Flight Dynamics*, Pitman, 1979,ISBN-13: 978-0273011415
5.	Turner, M.J.L., *Rocket and Spacecraft propulsion*, Springer, 3rd edition, 2010, ISBN-13: 978-3642088698.

Continuous Internal Evaluation (CIE):
Theory for 50 Marks
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Total marks: 50+50=100

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

CO2												
CO3												
CO4												
CO5												

High-3, Medium-2, Low-1

Course Title	**Aerospace Systems and Instrumentation**	**Semester**	**VIi**
Course Code	**MVJ21AS744**	**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 satellite mission and the space environment
2. Gain knowledge of the Attitude and Orbit Control Systems of spacecraft
3. Gain the knowledge of power generation andEnergy storage systems for spacecraft
4. Learn the various power converters and power distribution systems
5. Understand the spacecraft propulsion system and thermal control systems

Module 1	**L1,L2,**	10Hrs.

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):

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

Module 2	**L1,L2,L3,**	10Hrs.

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):

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

Module 3	**L1,L2,L3**	10Hrs.

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):

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

Module 4	**L1,L2,L3**	10Hrs.

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**	10Hrs.

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:
lii. 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. liii. 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. liv. 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	**AVIONICS**	**Semester**	**VII**
Course Code	**MVJ21AS745**	**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:

6. Understand the power distribution system and need for avionics.
7. Acquire knowledge of control and navigation systems
8. Gain knowledge of display technologies and avionics system architectures
9. Understand the Microprocessors and cockpit display technologies
10. Apprehend the functioning of data buses

Module 1Power Distribution System	**L1,L2**	10 Hrs.

Power Distribution System: Bus Bar, split bus bar system, special purpose cables. Electrical diagram and identification scheme. Circuit controlling devices. Power utilization-typical application to avionics. Need for Avionics in civil and military aircraft.

Laboratory Sessions/ Experimental learning: Programming using microprocessor.

Applications: Data Transfer, Communication

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

2. https://www.coursera.org/lecture/aeronautics/basics-X8Mvf

Module 2Inertial Navigation &Electronic Flight Control System	**L1,L2,L3,**	10 Hrs.

Inertial Navigation System: Gyroscopic versus Inertial platform. Structure of stable platform. Inertial Navigation units. Inertial alignment. Inertial interface system. Importance of Compass swing.

Electronic Flight Control System: Fly-by-wire system: basic concept and features. Pitch and Roll rate: command and response. Control Laws. Frequency response of a typical FBW actuator. Cooper Harper scale. Redundancy and failure survival. Common mode of failures and effects analysis.

Laboratory Sessions/ Experimental learning: Validation of truth tables for different logic circuits

Applications: Communication, Tracking

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

2. https://www.coursera.org/lecture/aeronautics/basics-X8Mvf

Module 3Electronic Flight Instrument &Avionics Sub Systems	**L1,L2,L3**	10 Hrs.

Electronic Flight Instrument Systems: Display-units, presentation, failure, and annunciation. Display of air data.

Introduction to Avionics Sub Systems and Electronic Circuits: Typical avionics sub systems. Amplifier, oscillator, aircraft communication system, transmitter, receiver, antenna.

Laboratory Sessions/ Experimental learning: Construct 7 segment display circuit using IC timer

Applications: Attitude Estimation, Navigation, Control

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

2. https://nptel.ac.in/courses/101/106/101106042/

Module 4Digital Systems& Flight Deck and Cockpits	**L1,L2,L3**	10 Hrs.

Principles of Digital Systems: Digital Computers, Microprocessors, Memories.

Flight Deck and Cockpits: Control and display technologies CRT, LED, LCD, EL and plasma panel, Touch screen, Direct voice input (DVI)-Civil cockpit and military cockpit: MFDS, HUD, MFK, and HOTAS.

Laboratory Sessions/ Experimental learning: Data transfer using ARINC420 data bus.

Applications: Position Estimation, Guidance, Control

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

3. https://nptel.ac.in/courses/101/108/101108056/
4. https://nptel.ac.in/courses/101/108/101108056/

Module 5Avionics Systems Integration	**L1,L2,L3**	10 Hrs.

Avionics Systems Integration: Avionics equipment fit. Electrical data bus system. Communication Systems, Navigation systems, Flight control systems, Radar, Electronic Warfare, and fire control system. Avionics system architecture, Data buses, MIL–STD1553B

Laboratory Sessions/ Experimental learning: Data transfer using MIL-STD 1553B Data bus

Applications: Navigation, Guidance, Control

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

2. https://nptel.ac.in/courses/101/106/101106042/

Course outcomes:

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

CO404.1.1	Analyse the power distribution system in avionics.
CO404.1.2	Apply the knowledge of control and navigation systems
CO404.1.3	Utilise the knowledge of display technologies and avionics system architectures
CO404.1.4	Evaluate the Microprocessors and cockpit display technologies
CO404.1.5	Analyse the functioning of data buses

Reference Books:

1.	R.P.G. Collinson, Introduction to Avionics Systems, 3rd Edition, 2011, Springer.
2.	Ian Moir, Allan Seabridge and Malcolm Jukes, Civil Avionics Systems, 2nd Edition, 2003, Wiley.
3.	R. Cundy Dale, Introduction to Avionics, 2010, Pearson Education.

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:

- 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.
- 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.
- 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	3	2
CO2												2	1	
CO3	2	2	2									2		
CO4	3	3	2			2	2					3	2	1
CO5	3	3	3			2	2					3	3	3

High,3, Medium,2, Low,1

MVJ College of Engineering, Whitefield, Bangalore 560067

An Autonomous Institution, Affiliated to VTU, Belagavi

Scheme of Teaching and Examination

Outcome Based Education (OBE) and Choice Based Credit System (CBCS)

Effective from the academic year 2021-22

Department of Aerospace Engineering

Semester VIII

Sl. No.	Course		Course Title	BoS	Teaching hrs./week				Examination				Credits
	Type	Code			Lecture L	Tutorial T	Practical P	Self-Study S	Duration Hrs.	CIE Marks	SEE Marks	Total Marks	
1	PRJ	MVJ21XXP81	Project Phase II	AE	-	-	-	-	3	50	50	100	10
2	INT	MVJ21XXINT82	Research / Industrial Internship	AE	-	-	-	-	3	50	50	100	05
3	Seminar	MVJ21XXS83	Seminar	AE	-	-	-	-	3	50	50	100	01
Total					-	-		-		150	150	300	16