# HINDUSTAN INSTITUTE OF TECHNOLOGY AND SCIENCE

## SCHOOL OF AERONAUTCIAL SCIENCES

### M.TECH. AERONAUTICAL ENGINEERING

**CURRICULUM & SYLLABUS**
**2018-19**

**HINDUSTAN INSTITUTE OF TECHNOLOGY AND SCIENCE**
**DEPARTMENT OF AERONAUTICAL ENGINEERING**
**M.TECH. AERONAUTICAL ENGINEERING**

**CURRICULAM 2018-19**

**SEMESTER I**

| Sl. No. | Course Code | Course Title | L | T | P | C | TCH |
|---|---|---|---|---|---|---|---|
| **THEORY** | | | | | | | |
| **1** | AEA3701 | Aerodynamics[#] | 3 | 0 | 1 | 3 | 4 |
| **2** | AEA3702 | Flight Vehicle structures | 3 | 0 | 0 | 3 | 3 |
| **3** | MAA3702 | Advanced Engineering Mathematics | 3 | 0 | 0 | 3 | 3 |
| **4** | DE | Department Elective – I | 3 | 0 | 0 | 3 | 3 |
| **5** | DE | Department Elective – II | 3 | 0 | 0 | 3 | 3 |
| **6** | ZZZ3715 | Research Methodology & IPR* | 2 | 1 | 0 | 2 | 3 |
| **PRACTICAL** | | | | | | | |
| **7** | AEA3791 | Aircraft structures Lab | 0 | 0 | 4 | 2 | 4 |
| **8** | AEA3796 | Seminar | 0 | 0 | 3 | 2 | 3 |
| **Total** | | | | | | **21** | **26** |

[#] Theory integrated with lab *Compulsory course for all PG Program

**SEMESTER II**

| Sl. No. | Course Code | Course Title | L | T | P | C | TCH |
|---|---|---|---|---|---|---|---|
| **THEORY** | | | | | | | |
| **1** | AEA3703 | Composite Materials & Structures | 3 | 0 | 0 | 3 | 3 |
| **2** | AEA3704 | Aerospace Propulsion | 3 | 0 | 0 | 3 | 3 |
| **3** | AEA3705 | Flight Mechanics | 3 | 0 | 0 | 3 | 3 |
| **4** | DE | Department Elective – III | 3 | 0 | 0 | 3 | 3 |
| **5** | OE | Open elective | 3 | 0 | 0 | 3 | 3 |
| **PRACTICAL** | | | | | | | |
| **6** | AEA3792 | Propulsion lab | 0 | 0 | 4 | 2 | 4 |
| **7** | AEA3781 | Mini Project | 0 | 0 | 6 | 2 | 6 |
| **Total** | | | | | | **19** | **25** |

**SEMESTER III**

| Sl. No. | Course Code | Course Title | L | T | P | Credit | TCH |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| **1** | DE | Department Elective – IV# | 3 | 0 | 0 | 3 | 3 |
| **Practical** | | | | | | | |
| **2** | AEA3797 | Internship * | 0 | 0 | 3 | 2 | 3 |
| **3** | AEA3798 | Project Work-Phase I | 0 | 0 | 24 | 8 | 24 |
| **TOTAL** | | | | | | **13** | **30** |

* Internship to be undergone during vacation between 2nd or 3rd semesters
# Incorporation of MOOC to be offered for this course.

**SEMESTER IV**

| Sl. No. | Course Code | Course Title | L | T | P | Credit | TCH |
|---|---|---|---|---|---|---|---|
| **1** | AEA3799 | Project Work-Phase II | **0** | **0** | **24** | **12** | **24** |
| **TOTAL** | | | | | | **12** | **24** |

**Total No. of Credit = 65**

**Department Elective –I**

| Sl. No. | Course Code | Course Title | L | T | P | Credit | TCH |
|---|---|---|---|---|---|---|---|
| **1** | AEA3721 | Aircraft Design | 3 | 0 | 0 | 3 | 3 |
| **2** | AEA3722 | Theory of Vibrations | 3 | 0 | 0 | 3 | 3 |

**Department Elective –II**

| Sl. No. | Course Code | Course Title | L | T | P | Credit | TCH |
|---|---|---|---|---|---|---|---|
| **1** | AEA3723 | Experimental Stress Analysis | 3 | 0 | 0 | 3 | 3 |
| **2** | AEA3724 | Advanced Heat Transfer | 3 | 0 | 0 | 3 | 3 |

**Department Elective –III**

| Sl. No. | Course Code | Course Title | L | T | P | Credit | TCH |
|---|---|---|---|---|---|---|---|
| **1** | AEA3725 | Rocketry & Space Mechanics | 3 | 0 | 0 | 3 | 3 |
| **2** | AEA3726 | Hypersonic Aerodynamics | 3 | 0 | 0 | 3 | 3 |
| **3** | AEA3727 | Fatigue & Fracture Mechanics | 3 | 0 | 0 | 3 | 3 |
| **4** | AEA3728 | High Temperature Gas Dynamics | 3 | 0 | 0 | 3 | 3 |
| **5** | AEA3729 | Mechanics of Structural Impact | 3 | 0 | 0 | 3 | 3 |

**Department Elective –IV**

| Sl. No. | Course Code | Course Title | L | T | P | Credit | TCH |
|---|---|---|---|---|---|---|---|
| **1** | AEA3730 | Finite Element Methods | 3 | 0 | 0 | 3 | 3 |
| **2** | AEA3731 | Computational Fluid Dynamics | 3 | 0 | 0 | 3 | 3 |
| **3** | AEA3732 | Combustion Modeling | 3 | 0 | 0 | 3 | 3 |
| **4** | AEA3733 | Cryogenics | 3 | 0 | 0 | 3 | 3 |

## SEMESTER-I

| COURSE TITLE | AERODYNAMICS | | | | |
|---|---|---|---|---|---|
| COURSE CODE | AEA3701 | Credits | 3 | L-T-P-C | 3-0-0-3 |
| CIE | 100 Marks (50% weightage) | | ESE | 100 Marks (50% weightage) | |

**Prerequisites :** Fluid Mechanics

**AIM OF THE COURSE:** To understand the behavior of airflow over bodies with particular emphasis on airfoil sections in the incompressible flow regime

**OUTCOME OF THE COURSE:**

The student will

- Be able to understand the continuity, source, sink, pressure, velocity distributions with and without circulation with experiments
- Have a fundamental knowledge thin airfoil theory and its applications with experiments
- Understand the concept of lifting line theory, aspect ratio and taper ratio with experiments
- Know the flows. shock, expansion waves and small perturbation theory with experiments
- Have an understanding various types of wind tunnel and measurement system with experiments

**MODULE 1: REVIEW OF BASIC FLUID MECHANICS** **10 (8L + 2T)**

Continuity and Momentum equations, Point source and sink, Free and Forced Vortex, Uniform parallel flow, combination of basic flows, Pressure and Velocity Distributions On bodies with and without circulation in ideal and real fluid flows, Magnus effect

Lab : 1. Calibration of wind tunnel

Pressure distribution on 3-D bodies

**MODULE 2: AIRFOILS** **9 (8L + 1T)**

Conformal Transformation, Kutta condition, Karman – Treffz profiles, Thin aerofoil Theory and its applications.

Lab: 1. Pressure distribution over an aerofoil at different angles of attack

**MODULE 3: WING THEORY** **9 (8L + 1T)**

Vortex line, Horse shoe vortex, Biot and savart law, lifting line theory, effects of aspect Ratio, planform and taper ratio.

Lab : 1. Drag measurements in Wind Tunnels

**MODULE 4: ELEMENTS OF COMPRESSIBLE FLOWS** **9 (8L + 1T)**

Isentropic flows – shock and expansion waves, compressibility effects on aerodynamic Coefficients, method of characteristics – small perturbation theory. Prandtl equation and Rankine – Hugonoit relation, Normal shock equations & Oblique shock equations, Rayleigh and Fanno Flow.

**MODULE 5: WIND TUNNELS** **8 (7L + 1T)**

Types of wind tunnels – Flow visualization processes – Measurements in wind tunnels, 6-component balance.

Lab : 1. Supersonic flow visualization with schlieren systems.

**TEXT BOOKS**

J.D. Anderson, “Fundamental of Aerodynamics”, McGraw-Hill Book Co., New York, 1985.

**REFERENCES**


1. E.L. Houghton and N.B. Carruthers, “Aerodynamics for Engineering Students”, Edward Arnold Publishers Ltd., London (First Indian Edition).
2. W.H. Rae and A. Pope, “Low speed Wind Tunnel Testing”, John Wiley Publications.
3. Shapiro, A.H., Dynamics & Thermodynamics of Compressible Fluid Flow, Ronald Press,
4. Zucrow, M.J., and Anderson, J.D., Elements of gas dynamics McGraw-Hill Book Co., New York.
5. Rathakrishnan.E., Gas Dynamics, Prentice Hall of India, 1995.


**TUTORIAL LINK**

1.https://nptel.ac.in/courses/101105059/

2.https://nptel.ac.in/syllabus/101106032/

| COURSE TITLE | FLIGHT VEHICLE STRUCTURES | | | | |
|---|---|---|---|---|---|
| COURSE CODE | AEA3702 | Credits | 3 | L-T-P-C | 3-0-0-3 |
| CIE | 100 Marks (50% weightage) | | ESE | 100 Marks (50% weightage) | |

**Prerequisites :** Solid Mechanics

**AIM OF THE COURSE:** To understand different types of beams and columns subjected to various types of loading and support conditions with particular emphasis on aircraft structural components.

**OUTCOME OF THE COURSE:**

The student will

- Be able to understand the stresses in unsymmetrical sections with experiments
- Have a fundamental knowledge monocoque and semimonocoque structure, Torsion and thin walled structure with experiments
- Understand the analysis of stiffened tubular structure, Analysis Multi cell, rings & frames revlent to aircraft structure
- Know the buckling and failures of thin walled structures
- Have an understanding of idealization of stiffened panels.
- Shear centre and shear flow of multi cell.

**MODULE 1: UNSYMMETRICAL BENDING** **9**

Stresses in beams of unsymmetrical sections, box beams.

**MODULE 2: AIRCRAFT STRUCTURE MONOCOQUE AND SEMI MONOCOQUE** **9**

Analysis of tubular, monocoque and semi-monocoque structures – Torsion and flexure of thin walled boxes – shear centre – Flexural axis and axis of twist.

**MODULE 3: ANALYSIS OF STIFFENED STRUCTURES** **9**

Idealisation and analysis of stiffened tubular structures – Study of open tubes – Analysis of multi cell tubes. Analysis of rings and frames – Applications to aircraft structures.

**MODULE 4: STABILITY PROBLEMS** **9**

Stability problems of thin walled structures – Flexural, torsional and local failures – Influence of eccentricity and in elasticity – Buckling of plates and sheet stringer combinations - crippling loads – Tension field theory

**MODULE 5: SHELLS** **9**

Idealization of stiffened shells, shear center, shear flow in thin walled multicell box beams, effect of taper

**TEXT BOOKS**

E.F. Bruhn, “Analysis and Design of Flight Vehicle Structures”, Tristate Offset Co.

**REFERENCES**


1. Megson, T.M.G; Aircraft Structures for Engineering Students, Edward Arnold.
2. Peery, D.J. and Azar, J.J., Aircraft Structures, 2nd Edition, McGraw-Hill, New York, 1993.
3. Stephen P. Tinnoshenko & S.woinowsky Krieger, Theory of Plates and Shells, 2nd Edition, McGraw-Hill, Singapore, 1990.


**TUTORIAL LINK**

1. https://nptel.ac.in/courses/101104069/21
2. https://nptel.ac.in/courses/101105022/

| COURSE TITLE | ADVANCED ENGINEERING MATHEMATICS | | | | |
|---|---|---|---|---|---|
| COURSE CODE | MAA3701 | Credits | 3 | L-T-P-C | 3-0-0-3 |
| CIE | 100 Marks (50% weightage) | | ESE | 100 Marks (50% weightage) | |

**Prerequisites : -**

**AIM OF THE COURSE:** To impart fundamental knowledge in various fields of Advanced Engineering Mathematics and its applications.

**OUTCOME OF THE COURSE:**

The student will

- Be able to understand the Functional dependent on functions of independent variables
- Have a fundamental knowledge of Laplace equations.
- Fourier transformation methods.
- Understand the concept Laplace equation and properties of Harmonic function
- Know the explicit and implicit methods with examples.
- Have an understanding of Tensor anaylsis

**MODULE 1: CALCULUS OF VARIATIONS** **9**

Concept of variation and its properties- Euler's Equation-Functional dependent on first and higher order derivatives - Functional dependent on functions of several independent variables- Isoperimetric problems – Direct Methods-Ritz and Kantorovich methods.

**MODULE 2: LAPLACE TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS** **9**

Laplace transform: Definitions, properties -Transform of error function, Bessel's function, Dirac Delta function, Unit Step functions – Convolution theorem – Inverse Laplace Transform: Complex inversion formula – Solutions to partial differential equations: Heat equation, Wave equation.

**MODULE 3: FOURIER TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS** **9**

Fourier transform: Definitions, properties – Transform of elementary functions, Dirac Delta function – Convolution theorem – Parseval's identity– Solutions to partial differential equations: Heat equation, Wave equation, Laplace and Poison's equations.

**MODULE 4: NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS** **9**

Solution of Laplace and Poisson equation on a rectangular region by Lieebmann's method – Diffusion equation by the explicit and Crank Nicolson – Implicit methods – Solution of wave equations by explicit scheme Cubic spline interpolation.

**MODULE 5: TENSOR ANALYSIS** **9**

Summation convention – contra variant and covariant vectors – contraction of vectors – inner product – quotient law – metric tensor – Christoffel symbols – covariant differentiation – gradient divergence and curl.

**REFERENCES**


1. Gupta, A.S. – Calculus of Variations with Applications, Prentice Hall of India(P) Ltd., New Delhi, 6th print, 2006
2. Sankar Rao, K. – Introduction to Partial Differential Equations, Prentice Hall of India(P) Ltd., New Delhi, 5th print, 2004
3. Spiegel, M.R – Theory and problems of Complex Variables with an Introduction to Conformal Mapping and Its applications, Schaum's outline series, Mc Graw Hill Book Co.
4. Grewal, B.S – Numerical Methods in Science and Engineering, Kanna Publications, New Delhi.
5. Ramanaiah, G.T – Tensor Analysis, S. Viswanathan (P) Ltd., New Delhi, 1990
6. Viswanadham. N and Narahari. Y, Performance Modeling of Automated Manufacturing Systems, Prentice-Hall, Inc. Upper Saddle River, NJ, USA,1992


**TUTORIAL LINK**

https://nptel.ac.in/downloads/111105035/

| COURSE TITLE | RESEARCH METHODOLOGY & IPR | | | | |
|---|---|---|---|---|---|
| COURSE CODE | ZZZ3715 | Credits | 3 | L-T-P-C | 3-0-0-3 |
| CIE | 100 Marks (50% weightage) | | ESE | 100 Marks (50% weightage) | |

**Prerequisites :** NA

**AIM OF THE COURSE:** To understand research problem and IPR role in research aspects.

**OUTCOME OF THE COURSE:**

At the end of this course, students will be able to

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals &nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

**MODULE 1: RESEARCH PROBLEM** **9**

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

**MODULE 2: ASSESSMENT AND METHODOLOGY** **9**

Effective literature studies approaches, analysis. Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

**MODULE 3: DATA ANALYSIS AND INTERPRETATION** **9**

Classification of Data, Methods of Data Collection, Sampling, Sampling techniques procedure and methods, Ethical considerations in research Data analysis, Statistical techniques and choosing an appropriate statistical technique, Hypothesis, Hypothesis testing, Data processing software (e.g. SPSS etc.), statistical inference, Interpretation of results.

**MODULE 4: PATENT RIGHTS** **9**

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**MODULE 5: PATENT INFORMATION** **9**

Patent Rights: Scope of Patent Rights. Licensing and transfer of Technology. Patent information and databases. Geographical Indications.

**MODULE 6: IPR DEVELOPMENT** **9**

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

**REFERENCES**


1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science& engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
5. Mayall , "Industrial Design", McGraw Hill, 1992.
6. Niebel , "Product Design", McGraw Hill, 1974.
7. Asimov, "Introduction to Design", Prentice Hall, 1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", 2016.
9. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008
10. C. R. Kothari, Gaurav Garg, Research Methodology Methods and Techniques, New Age
11. International publishers, Third Edition. Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, 2nd Edition, SAGE, 2005
12. Business Research Methods – Donald Cooper & Pamela Schindler, TMGH, 9th edition
13. Creswell, John W. Research design: Qualitative, quantitative, and mixed methods, approaches. Sage publications, 2013.

| COURSE TITLE | AIRCRAFT STRUCTURES LAB | | | | |
|---|---|---|---|---|---|
| COURSE CODE | AEA3791 | CREDITS | 2 | L-T-P-C | 0-0-4-2 |
| CIE | 100 Marks (50% weightage) | | ESE | 100 Marks (50% weightage) | |

**Prerequisites :** - NA

**AIM OF THE COURSE:** To study experimentally the load deflection characteristics structural materials under different types of loads.

**OUTCOME OF THE COURSE:**

The students will be able to

- Be able to understand the behaviour of structural materials through experiments

**NAME OF THE EXPERIMENTS**

1. Stress Strain curve for various engineering materials.
2. Deflection of beams with various end conditions.
3. Verification of Maxwell's Reciprocal theorem & principle of superposition
4. Column – Testing
5. South – well's plot.
6. Unsymmetrical bending of beams
7. Shear centre location for open sections and closed section
8. Calibration of Photo- elastic materials
9. Stresses in circular discs and beams using photo elastic techniques
10. Vibrations of beams

## SEMESTER-II

| COURSE TITLE | COMPOSITE MATERIALS AND STRUCTURES | | | | |
|---|---|---|---|---|---|
| COURSE CODE | AEA3703 | CREDITS | 3 | L-T-P-C | 3-0-0-3 |
| CIE | 100 Marks (50% weightage) | | ESE | 100 Marks (50% weightage) | |

**Prerequisites :** NA

**AIM OF THE COURSE:** To understand the fabrication, analysis and design of composite materials & structures.

**OUTCOME OF THE COURSE:**

At the end of this course, students will be able to

- Be able to understand the need and types of composite material
- Have a fundamental knowledge of orthotropic, anisotropic material. Micromechanics and macro mechanics
- Know the governing equations, static, dynamic stability
- Analysis of composite plates
- Have an understanding of Netting analysis, failure criteria and sandwich construction
- To enable to understand manufacturing of fibers and processes.

**MODULE 1: CLASSIFICATION AND CHARACTERISTIC OF COMPOSITE MATERIALS** **9**

Need for the composite materials. Types of composite materials and their use in structures.

**MODULE 2: BASIC CONCEPTS** **9**

Hooke's law for orthotropic and anisotropic materials. Micromechanics and macro mechanics. Lamina stress-strain relations referred and principal material directions and arbitrary axes.

**MODULE 3: ANALYSIS OF LAMINATED COMPOSITES** **9**

Governing equations for anisotropic and orthotropic plates. Angle-ply and cross ply laminates. Static, dynamic and stability analysis for simpler cases of composite plates. Inter laminar stresses.

**MODULE 4: OTHER METHODS OF ANALYSIS AND FAILURE THEORY** **9**

Netting analysis, Failure criteria. Sandwich construction.

**MODULE 5: MANUFACTURING & FABRICATION PROCESSES** **9**

Manufacturing of glass, boron and carbon fibres. Open mould and closed mould processes.

**REFERENCES**


1. R.M. Jones, "Mechanics of composite materials", McGraw-Hill, Kogakusha Ltd., Tokyo,
2. L.R. Calcote, "Analysis of laminated structures", Van Nostrand Reinhold Co.,
3. G.Lubin, "Hand Book on Fibre glass and advanced plastic composites", Van Nostrand Co., New York,
4. B.D. Agarwal and L.J. Broutman, "Analysis and Performance of fiber composites", John-Wiley and Sons,


**E-BOOKS**

**COURSEWARE LINK**

**TUTORIAL LINK**

1. https://nptel.ac.in/courses/101104010/
2. https://nptel.ac.in/syllabus/101104010/

| COURSE TITLE | AEROSPACE PROPULSION | | | | |
|---|---|---|---|---|---|
| COURSE CODE | AEA3704 | CREDITS | 3 | L-T-P-C | 3-0-0-3 |
| CIE | 100 Marks (50% weightage) | | ESE | 100 Marks (50% weightage) | |

**Prerequisites :** Thermodynamics

**AIM OF THE COURSE:** To understand the principles of operation and design of aircraft and spacecraft power plants.

**OUTCOME OF THE COURSE:**

The student will

- Be able to understand the classification of power plants and differences jet engine and rocket engine
- Have a fundamental knowledge turbojet, turbo prop and turbo fan engines
- Understand the concept thermodynamic analysis components of jet engine. Ram jet and pulse jet application
- Know the reaction principle, thrust equation, propellants
- and rocket performance
- Have an understanding various types of supersonic combustors, Requirements for supersonic combustors, Performance estimation of supersonic combustors.

**MODULE 1: ELEMENTS OF AIRCRAFT PROPULSION** **9**

Classification of power plants based on methods of aircraft propulsion – jet and rocket propulsion – Differences between jet propulsion engines and rocket propulsion engines – Types and areas of applications – fundamental of aircraft piston engines.

**MODULE 2: INTRODUCTION TO GAS TURBINE ENGINES** **9**

Classification of air breathing engines – Principle of turbojet, turbo-prop, turbo-jet with reheat, by-pass and turbo fan concepts – Thrust augmentation in jet engines and its application to aircraft.

**MODULE 3: THERMODYNAMICS OF JET ENGINES** **9**

Thermodynamic analysis of jet engine – components of a jet engine – Compressor, combustion chamber, turbine and jet nozzle – their efficiencies – Introduction to ramjet, pulse jet and their application – Introduction to combustion and chemical kinetics.

**MODULE 4: RAMJET AND SCRAMJET PROPULSION** **9**

Ram jet -Operating principle – Sub critical, critical and supercritical operation – Combustion in ramjet engine – Ramjet performance - Fundamentals of hypersonic air birthing vehicles, Preliminary concepts in engine airframe integration, Various types of supersonic combustors, Requirements for supersonic combustors, Performance estimation of supersonic combustors.

**MODULE 5: ROCKET AND ELECTRIC PROPULSION** **9**

Introduction to rocket propulsion – Reaction principle – Thrust equation – Classification of rockets based on propellants used – solid, liquid and hybrid – Comparison of these engines with special reference to rocket performance. electric propulsion – classification- electro thermal – electro static – electromagnetic thrusters- geometries of Ion thrusters- beam/plume characteristics – hall thruster

**REFERENCES**


1. G.C. Oates, “Aerothermodynamics of Aircraft Engine Components”, AIAA Education Series, Published by AIAA, New York.
2. G.C. Oates, “Aircraft Propulsion system technology & design”, AIAA Education Series.
3. G.P.Sutton, “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 8th Edition,2010.
4. H.Cohen, G.F.C.Rogers & H.I.H.Saravana muttoo, “Gas turbine theory”, Longman Co., ELBS Ed.
5. W.P.Gill, H.J.Smith & J.E. Ziurys, “Fundamentals of Internal Combustion Engines as applied to Reciprocating, Gas turbine & Jet Propulsion Power Plants”, Oxford & IBH Publishing Co.


**TUTORIAL LINK**

1. https://nptel.ac.in/courses/101106033/
2. https://nptel.ac.in/downloads/101101002/

| COURSE TITLE | FLIGHT MECHANICS | | | | |
|---|---|---|---|---|---|
| COURSE CODE | AEA3705 | CREDITS | 3 | L-T-P-C | 3-0-0-3 |
| CIE | 100 Marks (50% weightage) | | ESE | 100 Marks (50% weightage) | |

**Prerequisites :** NA

**AIM OF THE COURSE:** To understand the Aircraft stability & Performance

**OUTCOME OF THE COURSE:**

At the end of this course, students will be able to

- Be able to understand the different flight vehicles, altitude, True and indicated Air speed, Airplane and its functions
- Have a fundamental knowledge of drag, Reynold's number, drag polar and momentum theory
- Understand the performance parameters like range, endurance, Takeoff, landing and propellers and its types
- Have an understanding of static, dynamic, lateral , longitudinal and directional stability

**MODULE 1: INTRODUCTION TO PRINCIPLES OF FLIGHT** **9**

Physical properties and structure of the atmosphere, Temperature, pressure and altitude Relationship, Measurement of speed – True and Indicated Air speed, Components of an Airplane and their functions, Different types of flight vehicles.

**MODULE 2: DRAG OF BODIES** **9**

Types of Drag, effects of Reynold' number on skin friction and pressure drag, streamlined And bluff bodies, Drag reduction of airplanes, Momentum theory of finite wings, Drag polar

**MODULE 3: AIRCRAFT PERFORMANCE** **9**

Steady level flight conditions for minimum drag and minimum power required, Gliding and Climbing flight, Range and endurance, Take-off and landing, High left devices, Thrust Augmentation, Turning performance, V-n diagram, Froude momentum and black elements Theory of propellers, Fixed and Variable pitch propellers.

**MODULE 4: LONGITUDINAL STABILITY AND CONTROL** **9**

Degrees of freedom of a system, static and dynamic stability, static longitudinal stability, Contribution of individual components, neutral point, static margin, Hinge moment, Elevator control effectiveness, Power effects, elevator angle to trim, elevator angle per g, maneuver point, stick force gradient, aerodynamic balancing, Aircraft equations of motion, stability derivatives, stability quartic, Phugoid motion

**MODULE 5: LATERAL, DIRECTIONAL STABILITY AND CONTROL** **9**

Yaw and side slip, Dihedral effect, contribution of various components, lateral control, aileron control power, strip theory, aileron reversal, weather cock stability, directional control, rudder requirements, dorsal fin, One engine inoperative condition, Dutch roll, spiral and directional divergence, autorotation and spin.

**REFERENCES**


1. Houghton, E.L., and Caruthers, N.B., Aerodynamics for engineering students, Edward Arnold Publishers, 1988.
2. Perkins C.D., & Hage, R.E. Airplane performance, stability and control, Wiley Toppan,
3. Kuethe, A.M., and Chow, C.Y., Foundations of Aerodynamics, John Wiley & Sons, Clancey,L.J. Aerodynamics, Pitman, 1986.
4. Babister, A.W. Aircraft stability and response, Pergamon Press, 1980.
5. Nelson, R.C. Flight Stability & Automatic Control, McGraw-Hill, 1989.
6. McCormic, B.W., Aerodynamics, Aeronautics & Flight Mechanics John Wiley, 1995.


**TUTORIAL LINK**

1. https://onlinecourses.nptel.ac.in/noc18_ae06
2. https://nptel.ac.in/syllabus/101106042/

| COURSE TITLE | PROPULSION LAB | | | | |
|---|---|---|---|---|---|
| COURSE CODE | AEA3792 | Credits | 2 | L-T-P-C | 0-0-4-2 |
| CIE | 100 Marks (50% weightage) | | ESE | 100 Marks (50% weightage) | |

**Prerequisites :** - NA

**AIM OF THE COURSE:** To understand the Jet & Rocket propulsion system.

**OUTCOME OF THE COURSE:**

The student will be able to understand

- Cascade testing, Flow characteristics, Calorific value calculation & Rocket motor testing

**NAME OF THE EXPERIMENTS**

1. Cascade testing of a model of axial compressor blade row
2. Combustion performance studies in a jet engine combustion chamber
3. Determination of heat of combustion of aviation fuel
4. Characteristic plots of a free jet through a non-circular / circular orifice
5. Characteristic plots of a wall jet through a non-circular / circular orifice
6. Hybrid motor testing.

## DEPARTMENT ELECTIVE- I

| COURSE TITLE | EXPERIMENTAL STRESS ANALYSIS | | | | |
|---|---|---|---|---|---|
| COURSE CODE | AEA3723 | CREDITS | 3 | L-T-P-C | 3-0-0-3 |
| CIE | 100 Marks (50% weightage) | | ESE | 100 Marks (50% weightage) | |

**Prerequisites :** NA

**AIM OF THE COURSE:** To bring awareness on experimental method of finding the response of the structure to different types of load.

**OUTCOME OF THE COURSE:**

At the end of this course, students will be able to

- To Be able to understand the types and its operating methods
- Have a fundamental knowledge transducer for measurement of static and dynamic loads
- Understand the stress analysis of 2D and 3D photo elasticity, stress patterns and polar scope
- Be able to understand method, types or techniques and
- Moiré fringes
- Have an understanding modern techniques like C-Scan.
- Thermograph, Creep testing, optical sensor.

**MODULE 1: INTRODUCTION** **9**

Extensometers – Types – Mechanical, Electrical, Electronic and Optical – Review of bridge circuits.

**MODULE 2: STRAIN GAUGE TECHNIQUES** **9**

Strain gauge and transducers for measurement of static and dynamic loads – Instrumentation, measurement and recording systems.

**MODULE 3: PHOTO ELASTIC TECHNIQUES** **9**

Stress analysis by two and three dimensional photo elasticity – Interpretation of stress patterns – Typical applications – Description and users of reflection polariscope.

**MODULE 4: NON – DESTRUCTIVE TESTING** **9**

Fundamentals of NDT. Radiography, ultrasonic, Holography, Laser holography magnetic particle inspection, Fluorescent penetrant technique, Eddy current testing, Acoustic Emission Technique, Moire fringes —- Grid methods.

**MODULE 5: OTHER TECHNIQUES** **9**

Stress analysis by stress coat —Induction heating instrumentation, measurement and recording techniques – Creep testing. X-ray – applications. Fundamentals of brittle coating methods, Introduction to Moiré techniques, ultrasonic C- Scan, Thermograph, Fiber – optic Sensors.

**REFERENCES**


1. J.W. Dally and M.F. Riley, “Experimental Stress Analysis”, McGraw-Hill Book Co., New York, 1988.
2. P. Fordham, “Non-Destructive Testing Techniques” Business Publications, London, 1988.
3. M. Hetenyi, “Handbook of Experimental Stress Analysis”, John Wiley & Sons Inc., New York, 1980.
4. G.S. Holister, “Experimental Stress Analysis, Principles and Methods”, Cambridge University Press, 1987.
5. A.J. Durelli and V.J. Parks, “Moire Analysis of Strain”, Prentice Hall Inc., Englewood Cliffs, New Jersey,


**E-BOOKS**

**COURSEWARE LINK**

**TUTORIAL LINK**

| COURSE TITLE | THEORY OF VIBRATIONS | | | | |
|---|---|---|---|---|---|
| COURSE CODE | AEA3722 | CREDITS | 3 | L-T-P-C | 3-0-0-3 |
| CIE | 100 Marks (50% weightage) | | ESE | 100 Marks (50% weightage) | |

**Prerequisites** : NA

**AIM OF THE COURSE:** To introduce the students, natural modes of vibration, principles of dynamics and energy and approximate methods for aerospace structures.

**OUTCOME OF THE COURSE:**

At the end of this course, students will be able to
To study the effect of periodic and aperiodic forces on mechanical systems with matrix approach and also to get the natural characteristics of large sized problems using approximate methods.

**MODULE 1: INTRODUCTION** **9**

Simple harmonic motion, definition of terminologies, Review of Newton's, Laws, D'Alembert's principle, Energy methods.

**MODULE 2: SINGLE DEGREE OF FREEDOM SYSTEMS** **9**

Free vibrations free damped vibrations, forced excitations with and without damping, support excitation, vibration measuring instruments.

**MODULE 3: MULTI-DEGREE OF FREEDOM SYSTEMS** **9**

Two degrees of freedom systems, Static and dynamic couplings, vibration absorber, Principle coordinates, Principal modes, orthogonality conditions. Hamilton's Principle, Lagrangean equation and applications. Vibrations of elastic bodies, String or stretched cord, Longitudinal vibration, Lateral vibration, Torsional vibration. Approximate methods for calculating natural frequencies.

**MODULE 4: ELEMENTS OF AERO-ELASTICITY** **9**

Aero elastic problems – Collar's triangle of courses – Wing divergence – Aileron control reversal – Flutter.

**MODULE 5: SOLUTION METHOD** **9**

Computational technique in vibration, Vibrating string, General method, Beam element, Global matrices, Transformation of matrices, Equation of motion of complete system, Consistent and Lombard mass.

**REFERENCES**


1. Timoshenko.S, "Vibration Problems in Engineering", John Wiley & Sons, Inc., 1987.
2. Meirovitch, L, Elements of Vibration Analysis", McGraw-Hill Inc., 1986.
3. F.S. Rse., I.F. Morse and R.T. Hinkle, "Mechanical Vibrations", Prentice-Hall of India, 1985.
4. Fung, Y.C, "An Introduction to the Theory of Aero elasticity", John Wiley & Sons Inc., New York, 1985.5. Rao.J.S. and Gupta.K, "Theory and Practice of Mechanical Vibrations", Wiley Eastern Ltd., New Dehli, 1999.


**E-BOOKS**

**COURSEWARE LINK**

**TUTORIAL LINK**

1. https://nptel.ac.in/courses/112103111/

| COURSE TITLE | ROCKETRY AND SPACE MECHANICS | | | | |
|---|---|---|---|---|---|
| COURSE CODE | AEA 625 | CREDITS | 3 | L-T-P-C | 3-0-0-3 |
| CIE | 100 Marks (50% weightage) | | ESE | 100 Marks (50% weightage) | |

**Prerequisites :** NA

**AIM OF THE COURSE**

To introduce basic concepts of design and trajectory estimation of rocket , missiles and basic concepts of orbital Mechanics

**LEARNING OUTCOME OF THE COURSE**

The student will

- Be able to understand solar system, Keplers, Newton's law of motion, escape velocity, Geosynchronous, geostationary satellites
- Be able to understand principle of rocket and its stages, thrust equation, one and two dimensional rocket motions
- Understand the loads, drag, performances at different altitudes, types of nozzles and launching problems
- Be able to understand materials used and special coatings and ablative materials
- Satellite injections, orbit transfer, orbit deviation due to injection error, general perturbation approach

**MODULE 1: ORBITAL MECHANICS AND SATELLITE DYNAMICS** **9**

Description of solar system – Keplers Laws of planetary motion – Newton's Law of Universal gravitation – Two body and Three-body problems – Jacobis Integral, Librations points – Estimator of orbital and escape velocities – geosynchronous and geostationary satellites life time – satellite perturbations – Hohmann orbits – calculation of orbit parameters.

**MODLE 2: ROCKET MOTION** **9**

Principle of operation of rocket motor - thrust equation – one dimensional and two dimensional rocket motions in free space and homogeneous gravitational fields – Description of vertical, inclined and gravity turn trajectories determinations of range and altitude – simple approximations to burnout velocity – staging of rockets.

**MODULE 3: ROCKET AERODYNAMICS** **9**

Description of various loads experienced by a rocket passing through atmosphere – drag estimation – wave drag, skin friction drag, and base pressure drag – Boat-tailing in missiles – performance at various altitudes – conical and bell shaped nozzles – adapted nozzles – rocket dispersion – launching problems.

**MODULE 4: MATERIALS FOR SPACECRAFT AND MISSILES** **9**

Selections of materials for spacecraft and missiles – special requirements of materials to perform under adverse conditions – ablative materials.

**MODULE 5: SATELLITE INJECTION AND SATELLITE ORBIT PERTURBATIONS** **9**

General Aspects of satellite Injections – Satellite Orbit Transfer –Various Cases – Orbit Deviations Due to Injection Errors – Special and General Perturbations – Cowell's Method – Encke's Method – Method of vibrations of Orbital Elements – General Perturbations Approach.

**REFERENCES**


1. G.P. Sutton, "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 5th Edition, 1986.
2. J.W. Cornelisse, "Rocket Propulsion and Space Dynamics", J.W. Freeman & Co., Ltd., London.
3. Van de Kamp, "Elements of astromechanics", Pitman Publishing Co., Ltd., London.
4. E.R. Parker, "Materials for Missiles and Spacecraft", McGraw-Hill Book Co., Inc.


**MOOC**

https://ecourses.ou.edu/cgi-bin/ebook.cgi?topic=me

| COURSE TITLE | FATIGUE AND FRACTURE MECHANICS | | | | |
|---|---|---|---|---|---|
| COURSE CODE | AEA3727 | CREDITS | 3 | L-T-P-C | 3-0-0-3 |
| CIE | 100 Marks (50% weightage) | | ESE | 100 Marks (50% weightage) | |

**Prerequisites : NA**

**AIM OF THE COURSE**

To understand the basic characteristics of fatigue and creep mechanisms in the aircraft structures.

**LEARNING OUTCOME OF THE COURSE**

At the end of this course, students should be capable of

1. Become familiar with definitions
2. Analyze for cumulative damage
3. Analyze for crack initiation & crack growth
4. Analyze for strength of cracked bodies
5. Analyze damage tolerant structures

**MODULE 1: FATIGUE OF STRUCTURES** **9**

S.N. curves - Endurance limit - Effect of mean stress - Goodman, Gerber and Soderberg relations and diagrams - Notches and stress concentrations - Neuber's stress concentration factors - plastic stress concentration factors - S-N curves for typical notched geometries.

**MODLE 2: STATISTICAL ASPECTS OF FATIGUE BEHAVIOUR** **9**

Low cycle and high cycle fatigue - Coffin-Manson's relation - Transition life - Cyclic Strain hardening and softening - Analysis of load histories - Cycle counting techniques - Cumulative damage - Miner's theory - other theories.

**MODULE 3: PHYSICAL ASPECTS OF FATIGUE** **9**

Phase in fatigue life - Crack initiation - Crack growth - Final fracture - Dislocations - Fatigue fracture surfaces.

**MODULE 4: FRACTURE MECHANICS** **9**

Strength of cracked bodies - potential energy and surface energy - Griffith's theory - Irwin - Orwin extension of Griffith's theory to ductile materials - Stress analysis of cracked bodies - Effect of thickness on fracture toughness - Stress intensity factors for typical geometries.

**MODULE 5: FATIGUE DESIGN AND TESTING** **9**

Safe life and fail safe design philosophies - Importance of Fracture Mechanics in aerospace structure - Application to composite materials and structures.

**TEXT BOOKS**


1. Prasanth Kumar - "Elements of fracture mechanics" - Wheeter publication, 1999.
2. Barrois W, Ripely, E.L., "Fatigue of aircraft structure", Pergamon press. Oxford, 1913.


**REFERENCES**


1. Sin, C.G., "Mechanics of fracture" Vol. I, Sijthoff and w Noordhoff International Publishing Co., Netherlands, 1919.
2. Knott, J.F., "Fundamentals of Fracture Mechanics", Buterworth& Co., Ltd., London, 1913.


**E-BOOKS**

**MOOC**

https://ecourses.ou.edu/cgi-bin/ebook.cgi?topic=me

| COURSE TITLE | MECHANICS OF STRUCTURAL IMPACT | | | | |
|---|---|---|---|---|---|
| COURSE CODE | AEA3729 | CREDITS | 3 | L-T-P-C | 3-0-0-3 |
| CIE | 100 Marks (50% weightage) | | ESE | 100 Marks (50% weightage) | |

**Prerequisites :** SOLID MECHANICS

**AIM OF THE COURSE**

To provide student with a fundamental knowledge of impact mechanics and model the basic structural impact mechanics problems.

**MODULE 1: INTRODUCTION TO STRUCTURAL IMPACT** **9L**

Introduction to Structural Impact, Rigid Body Impact Mechanics, Coefficient of Restitution, Oblique Impact, One Dimensional Impact Mechanics of Deformable Bodies,1-D Wave Propagation in Solids Induced by Impact.

**MODULE 2: MULTI DIMENTIONAL STRUCTURAL IMPACT MECHANICS** **9L**

Analysis of Stress, Mohr's Circles, Octahedral Stress, Decomposition Into Hydrostatic and Pure States, Equation of motion of body in Cartesian, Cylindrical, Spherical coordinates, Analysis of Strain, Linearized Stress Strain Relations, Wave propagation in infinite and semi-infinite media

**MODULE 3: MODELLING OF DEFORMATION/FAILURE** **9L**

Constitutive models for material deformation and plasticity, Isotropic and Kinematic Hardening, Thermo Elastic Plastic, Power law, Johnson-Cook , Zerilli – Amstrong,,Steinberg-Guinan, Constitutive models for composites, Failure and damage models

**MODULE 4: EXPRIMENTAL IMPACT MECHANICS** **9L**

Quasi-static material test, Pendulum Impact Test, Split-Hopkinson's Bar Test, Taylor Cylinder Test, Drop Impact Test, Drop Weight Impact Test

**MODULE5: COMPUTATIONAL IMPACT MECHANICS** **9L**

Principles of numerical formulations, Classical continuum methods, Particle based Methods, Meshless Methods, Numerical Integration Methods, and Contact Impact Considerations.

**TEXT BOOKS**


1. C. Lakshmana Rao, V.Narayanamurthy, K. R. Y. Simha, Applied Impact Mechanics,2016 Print ISBN:9781119241805
2. W.J.Stronge, Impact Mechanics, Cambridge University Press January 2010 doi.org/10.1017/CBO9780511626432
3. Norman Jones Structural Impact,February 2012,isbn: 9781139200493


**REFERENCES**


1. Stefan Hiermaier, Structures Under Crash and Impact: Continuum Mechanics,2010
2. Tod A. Laursen, Computational Contact and Impact Mechanics: Springer Publications 2014
3. C. A. Brebbia, Advances in Dynamics and Impact Mechanics,2003


**E-BOOKS**

1. onlinelibrary.wiley.com/doi/book/10.1002/9781119241829
2. books.google.co.in/books/about/Impact_Mechanics.html?id=nHgcS0bfZ28C&redir_esc=y
3. http://admin.cambridge.org/academic/subjects/engineering/solid-mechanics-and-materials/structural-impact-2nd-edition

**MOOC**

https://onlinecourses.nptel.ac.in/noc17_ce25

https://www.mooc-list.com/course/engineering-mechanics-coursera

**OBJECTIVES OF THE COURSE**

The course should enable the students to understand

- Wave propagation and damage in metallic and composite structures due to Impact
- Constitutive models for modeling structural impact problems for metallic and composites
- Experimental techniques used for structural impact problems
- Computationally estimate the structural damage due to impact

| **LEARNING OUTCOME OF THE COURSE** |
| --- |
| At the end of this course, students should be capable of<br>• Calculate the stress wave propagation in structures using 1D and multi-dimensional approach for structural impact problems<br>• Using the appropriate constitutive model for modeling metal plasticity, composite damage<br>• Using various experimental techniques used for impact damage assessment<br>• Calculating the structural impact damage using numerical techniques |

| COURSE TITLE | CRYOGENIC PROPULSION | | | | |
|---|---|---|---|---|---|
| COURSE CODE | AEA3733 | CREDITS | 3 | L-T-P-C | 3-0-0-3 |
| AEC | 100 Marks (50% weightage) | | ESE | 100 Marks (50% weightage) | |

**Prerequisites :** HEAT TRANSFER and AERO ENGINEERING THERMODYNAMICS

**AIM OF THE COURSE**

To study the engineering concept of cryogenic and its application in various field.

**LEARNING OUTCOME OF THE COURSE**

At the end of this course, students should be capable of

- Understand the background of cryogenic technology and its applications.
- Understand the properties of cryogenic materials and their production.
- Understand the different methods used for cryogenic insulation.
- Understand the technique for storing cryogenics.
- Understand the different cryogenic equipment's and their applications.

**MODULE 1:INTRODUCTION TO CRYOGENIC ENGINEERING** **9**

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

**MODULE 2: PROPERTIES** **9**

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

**MODULE 3: CRYOGENIC INSULATION** **9**

Vacuum insulation, Evacuated porous insulation, Gas filled Powders and fibrous materials, Solid foams, Multilayer insulation, Liquid and vapour Shields, Composite insulations.

**MODULE 4: STORAGE AND INSTRUMENTATION OF CRYOGENIC LIQUIDS** **9**

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

**MODULE 5: CRYOGENIC EQUIPMENT** **9**

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

**TEXT BOOKS**

1.T.M. Flynn, Marcel Dekker., Cryogenic Engineering,

**REFERENCES**


1. Bose and P. Sengupta, "Cryogenics: Applications and Progress", Tata McGraw Hill.
2. J.G. Weisend II, Taylor and Francis, "Handbook of Cryogenic Engineering",
3. R.Barron,"Cryogenic Systems", Oxford University Press.
4. K.D.Timmerhaus and T.M. Flynn, "Cryogenic Process Engineering", Plenum Press.
5. G.G.Haselden,"Cryogenic Fundamentals", Academic Press.
6. C.A.Bailey,"Advanced Cryogenics", PlenumPress.
7. R.W. Vance and W.M. Duke , "Applied Cryogenic Engineering", John Wiley & sons.


**E-BOOKS**

www.onlinelibrary.wiley.com/doi/10.1002/vipr.19980100419/full

| COURSE TITLE | COMPUTATIONAL FLUID DYNAMICS | | | | |
|---|---|---|---|---|---|
| COURSE CODE | AEA3731 | CREDITS | 3 | L-T-P-C | 3-0-0-3 |
| CIE | 100 Marks (50% weightage) | | ESE | 100 Marks (50% weightage) | |

**Prerequisites :** Fluid Mechanics and Machinery Numerical Methods

**AIM OF THE COURSE**

Give the student a working knowledge of a variety of computational techniques that can be used for solving engineering problems.

**LEARNING OUTCOME OF THE COURSE**

At the end of this course, students should be capable of

1. Describe the flow phenomena in a flow field with correspondence with elliptic, parabolic and hyperbolic equations. Clearly understand the steps involved in source and vortex panel methods. Clearly understand steps involved in grid generation methods.
2. Describe the upwind concept and its effects in a given flow. Can understand the discretization of a flow model for analysis
3. Can clearly understand the weighed variational formulae and Galerkin method for finite element technique
4. Know the numerical finite volume methods (Runge Kutta method, Lax Wendroff method) in computational analysis
5. Able to solve the complex flow field problems with suitable turbulence models with detailed understanding of its physics.

**MODULE 1: FUNDAMENTAL CONCEPTS** **9**

Introduction - Basic Equations of Fluid Dynamics -. Mathematical properties of Fluid Dynamics Equations - Elliptic, Parabolic and Hyperbolic equations- Initial and Boundary conditions - Well posed- ill Posed problems - discretization of partial Differential Equations – Structured and Unstructured Grids-Grids and equation transformations - - Implicit and Explicit schemes -Source panel method - Vortex panel method

**MODULE 2 : DISCRETIZATION** **9**

Implicit time dependent methods for in viscid and viscous compressible flows - Concept of numerical dissipation --Stability properties of explicit and implicit methods - Conservative upwind discretization for Hyperbolic systems - Further advantages of upwind differencing.

**MODULE 3:FINITE ELEMENT TECHNIQUES** **9**

Finite Element Techniques in Computational Fluid Dynamics; introduction - Strong and Weak Formulations of a Boundary Value Problem - Strong formulation - Weighted Residual Formulation - Galerkin Formulation - Weak Formulation - Variational Formulation -

**MODULE 4: FINITE VOLUME TECHNIQUES** **9**

Finite Volume Techniques - Cell Centered Formulation - Lax – Wendroff Time Stepping - Runge - Kutta Time Stepping - Multi - stage Time Stepping - Accuracy -. Cell Vertex Formulation - Multistage Time Stepping - FDM -like Finite Volume Techniques - Central and Up-wind Type Discretization –

**MODULE 5: FLOW FIELD ANALYSIS AND TURBULENCE MODELS** **9**

Pressure and Velocity corrections - Pressure Correction equation, SIMPLE algorithm and its variants – PISO Algorithms Turbulence models, mixing length model, Two equation (k-Є) models – High and low Reynolds number models.

**TEXT BOOKS**

1. Computational Fluid Mechanics and Heat Transfer, R.H. Pletcher, J.C. Tannehil, and D.A.

Anderson, 3rd Edition, Taylor & Francis, 2013, ISBN 1-56032-046-X
2. H. Malalasekara and W. Versteeg , "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", 2nd Ed., Pearson Education, 2010.

**REFERENCES**

1. J. D. Anderson, "Computational Fluid Dynamics: The Basics with Applications", 2nd Ed., McGraw Hill Education, 2012
2. John F. Wendt (Editor), "Computational Fluid Dynamics: An Introduction", (Von Karman Institute Book) 3rd ed. 2009 Edition
3. K. Muralidhar and T. Sundararajan (Editors), "Computational Fluid Flow and Heat Transfer", 3rd Ed., Narosa Publishing House, 2009
4. Klaus A. Hoffmann and Steve T. Chiang, "Computational Fluid Dynamics for Engineers", Vols. I, II and III, 4th Ed., Engineering Education System, P. O. Box 20071, Wichita, KS, USA, 2000
5. SedatBiringen and Chuen-Yen Chow, "An Introduction to Computational Fluid Mechanics by Example", 2nd Ed., John Wiley and Sons, New York, 2011
6. C. A. J. Fletcher, "Computational Techniques for Fluid Dynamics", Vols. I and II, 2nd Ed., Springer-Verlag, Berlin, 1990

**E-BOOKS**

1. https://books.google.co.in/books?isbn=3540850562
2. https://books.google.co.in/books?isbn=0070016852
3. https://books.google.co.in/books?isbn=0081012446
4. https://books.google.co.in/books?isbn=1139446835

**MOOC**

1. https://nptel.ac.in/courses/112105045
2. www.engr.uky.edu/~acfd/me691-lctr-nts.pdf

**COURSEWARE LINK**

**OBJECTIVES OF THE COURSE**

The course should enable the students to understand and calculate:

- Understand the basic flow equations, characteristics of mathematical models for a given flow. Know the importance and significance of panel methods and grid generation
- Understand the importance of discretization, upwind differencing and implicit explicit solutions
- Familiarize with Finite Element Techniques (FEM) in Computational Fluid Dynamics (CFD)
- Familiarize with Finite Volume Techniques (FVM) in Computational Fluid Dynamics (CFD)
- To create confidence to solve complex problems in the field of fluid flow and heat transfer. Know the importance and significance of Turbulence models

| COURSE TITLE | HIGH TEMPERATURE GAS DYNAMICS (COMMON TO AERONAUTICAL AND AEROSPACE) | | | | |
|---|---|---|---|---|---|
| COURSE CODE | AEA3728 | CREDITS | 3 | L-T-P-C | 3-0-0-3 |
| CIE | 100 Marks (50% weightage) | | ESE | 100 Marks (50% weightage) | |

**Prerequisites :** NIL

**AIM OF THE COURSE**

To provide the student with fundamental knowledge and understanding in High Temperature Gas Dynamics.

**LEARNING OUTCOME OF THE COURSE**

At the end of this course, students should be capable of

- acquiring comprehensive knowledge on high temperature gas dynamics.
- applying various approaches of high temperature gas dynamics
- carrying out calculations in high temperature flows in aerospace field.

**MODULE 1: INTRODUCTION** **8**

Importance of High-Temperature Flows, Nature of High-Temperature Flows, Chemical Effects in Air: The Velocity-Altitude Map, Thermodynamics of Chemically Reacting Gases, Kinetic theory of gases, Definition of Real Gases and Perfect Gases, Various Forms of the Perfect-Gas Equation of State, Collision Frequency and Mean Free Path, Velocity and Speed Distribution Functions, Classification of Gases, First Law of Thermodynamics, Second Law of Thermodynamics, Calculation of Entropy, Gibbs Free Energy, Heat of Reaction.

**MODULE 2: STATISTICAL THERMODYNAMICS** **10**

Introduction, Microstates & Macrostates, Boltzmann Distribution, Evaluation of Thermodynamic Properties in Terms of the Partition Function, Evaluation of the Partition Function in terms of T and V, Thermodynamic Properties for a Single Chemical Species, Calculation of the Equilibrium Constant, Chemical Equilibrium, Calculation of the Equilibrium Composition or High-Temperature Air, Thermodynamic Properties of an Equilibrium Chemically Reacting Gas, Equilibrium Properties of High-Temperature Air.

**MODULE 3: INVISCID HIGH TEMPERATURE EQUILIBRIUM AND NON-EQUILIBRIUM FLOWS** **10**

Introduction, Governing Equations for Inviscid High-Temperature Equilibrium Flow, Equilibrium Normal and Oblique Shock-Wave Flows, Equilibrium Quasi-One-Dimensional Nozzle Flows, Frozen and Equilibrium Flows: The Distinction, Equilibrium and Frozen Specific Heats, Equilibrium Speed of Sound, Equilibrium Conical Flow, Equilibrium Blunt-Body Flows.

Governing Equations for Inviscid, non-equilibrium flows, Non-equilibrium Normal and Oblique Shock-Wave Flows.

**MODULE 4:TRANSPORT PROPERTIES IN HIGH TEMPERATURE GASES** **8**

Introduction, Definition of Transport Phenomena, Transport Coefficients, Mechanism of Diffusion, Energy Transport by Thermal Conduction and Diffusion: Total Thermal Conductivity, Transport Properties for High-Temperature Air.

**MODULE 5: VISCOUS HIGH TEMPERATURE FLOWS** **9**

Introduction, Governing Equations for Chemically Reacting Viscous Flow, Alternate Forms of the Energy Equation, Boundary-Layer Equations for a Chemically Reacting Gas, Boundary Conditions: Catalytic Walls, Boundary-Layer Solutions: Stagnation-Point Heat Transfer for a Dissociating Gas, Parabolized Navier-Stokes Solutions to Chemically Reacting Flows.

**REFERENCES**

John D. Anderson Jr., “Hypersonic and High-Temperature Gas Dynamics”,
2nd Edition, AIAA Education Series, 2006.

Tarit K. Bose, “High Temperature Gas Dynamics”, 2nd Edition, Springer, 2014.

| COURSE TITLE | HYPERSONIC AERODYNAMICS | | | | |
|---|---|---|---|---|---|
| COURSE CODE | AEA3728 | CREDITS | 3 | L-T-P-C | 3-0-0-3 |
| CIE | 100 Marks (50% weightage) | | ESE | 100 Marks (50% weightage) | |

**Prerequisites : NIL**

**AIM OF THE COURSE**

To prepare the students for futuristic design of aerospace vehicles and give them a capability to work out on the technical aspect of the high-speed vehicles in the hypersonic range.

**LEARNING OUTCOME OF THE COURSE**

At the end of this course, students should be capable of

- Differentiate the hypersonic regime from other non-hypersonic high-speed regimes.
- Use simple solution methods viz. local surface inclination method, shock and expansion wave method and approximate method and solve simple inviscid hypersonic flow problems.
- Understand and work out with the viscous flow in the hypersonic regime and will be able to solve simple problems in the same.
- Understand and conceptualize the viscous interaction with the hypersonic flow and differentiate the weak and strong interactions.
- Analyse and work out with the heat transfer related problems in the hypersonic regime.

**MODULE 1 : FUNDAMENTALS OF HYPERSONIC AERODYNAMICS** **9**

Introduction to hypersonic aerodynamics– differences between hypersonic aerodynamics and supersonic aerodynamics – concept of thin shock layer and entropy layers – hypersonic flight paths – hypersonic similarity parameters - Shock wave and expansion wave relations of inviscid hypersonic flows

**MODULE 2: SIMPLE SOLUTION METHODS FOR HYPERSONIC INVISCID FLOWS** **9**

Local surface inclination method – Newtonian theory – modified Newtonian law

Tangent wedge and tangent cone and shock expansion methods

Approximate methods – hypersonic small disturbance theory – thin shock layer theory

**MODULE 3: VISCOUS HYPERSONIC FLOW THEORY** **9**

Boundary layer equation for hypersonic flow – hypersonic boundary layers – self similar and non-self-similar layers – solution methods for non-self-similar boundary layers Aerodynamic heating

**MODULE 4: VISCOUS INTERACTION IN HYPERSONIC FLOWS** **9**

Introduction to the concept of viscous interaction in hypersonic flows – Strong and weak interactions – hypersonic viscous interaction similar parameter - Introduction to shock wave layer interactions

**MODULE 5: HEAT TRANSFER PROBLEMS IN AEROSPACE ENGINEERING** **9**

Nature of the high temperature flows – chemical effects in air – real and perfect gases – Gibb's free energy and entropy Chemically reacting mixtures – recombination and dissociations

**Text Book**

John D. Anderson Jr., *"Hypersonic and High Temperature Gas Dynamics,"* McGraw Hill Series, New York, 1996.

**REFERENCES**


1. William, H. D., "*Viscous Hypersonic Flow – Theory of Reacting and Hypersonic Boundary Layers*," Dover Publications Inc. Mineola, New York, 2017.
2. Murthy, T. K. S., "Computational Methods in Hypersonic Aerodynamics," Springer, New Delhi, 1992 edition.
3. Dr. Mukarram Hussain, "*Hypersonic Aerodynamic Performances of Asymmetric Re-Entry Vehicles*," LAP Lambert Academic Publishing, Saarbrücken, Germany, 2011.
4. John D. Anderson Jr., *"Modern Compressible Flow with Historical Perspective"*. McGraw Hill Publishing Company, New York, 1996.
5. John T. Bertin, *"Hypersonic Aerothermodynamics"*, published by AIAA Inc.,

| COURSE TITLE | FINITE ELEMENT METHODS | | | | |
|---|---|---|---|---|---|
| COURSE CODE | AEA3730 | Credits | 3 | L-T-P-C | 3-0-0-3 |
| CIE | 100 Marks (50% weightage) | | ESE | 100 Marks (50% weightage) | |

**Prerequisites : NIL**

**AIM OF THE COURSE**

To introduce the concept of Numerical analysis of structural components

**LEARNING OUTCOME OF THE COURSE**

At the end of this course, students should be capable of

1. Be able to understand stiffness and flexibility matrices.
2. Be able to understand bar & beam elements with computer aided engineering
3. Understand the applications of plane stress-strain and axi- symmetric problems
4. Know the 2D, 3D elements with reference to Aircraft structural parts wing, fuselage and turbine
5. Have an understanding static, dynamic problems and computer engineering software

**MODULE 1 : INTRODUCTION** **9**

Review of various approximate methods in structural analysis. Stiffness and flexibility matrices for simple cases. Basic concepts of finite element method. Formulation of governing equations and convergence criteria.

**MODULE 2: DISCRETE ELEMENTS** **9**

Use of bar and beam elements in structural analysis. Computer implementation of procedure for these elements.

**MODULE 3: CONTINUUM ELEMENTS** **9**

Different forms of 2-D elements and their applications for plane stress, plane strain and axi- symmetric problems. Consistent and lumped formulation. Use of local co-ordinates. Numerical integration.

**MODULE 4: ISOPARAMETRIC ELEMENTS** **9**

Definition and use of different forms of 2-D and 3-D elements. Computer implementation of formulation of these elements for the analysis of typical aircraft structural parts like, wing, fuselage, turbine blades.

**MODULE 5: SOLUTION SCHEMES** **9**

Different methods of solution of simultaneous equations governing static, dynamics and stability problems. General purpose Software packages.

**REFERENCES**


1. L.J. Segerlind, “Applied Finite Element Analysis”, Second Edition, John Wiley and Sons Inc., New York, 1984.
2. K.J. Bathe and E.L. Wilson, “Numerical Methods in Finite Elements Analysis”, Prentice Hall of India Ltd., 1983.
3. R.D. Cook, “Concepts and Applications of Finite Element Analysis”, 3rd Edition, John Wiley & Sons, 1989.
4. C.S. Krishnamurthy, “Finite Elements Analysis”, Tata McGraw-Hill, 1987.
5. V.Ramamurthi, “Computer Aided Design in Mechanical Engineering”, Tata McGraw-Hill.


**E-BOOKS**

**MOOC**

**COURSEWARE LINK**