**ANNA UNIVERSITY, CHENNAI**
**AFFILIATED INSTITUTIONS**
**REGULATIONS 2017**
**M.E. AEROSPACE TECHNOLOGY**
**CHOICE BASED CREDIT SYSTEM**

## PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) :

I. **PEO 1:** To acquire adequate knowledge both in practical and theoretical domains in the field of Aerospace Technology through post graduate education.

II. **PEO 2:** To train students to have successful technical and managerial career in aerospace industries and the allied management.

III. **PEO 3:** To guide students to learn and adapt new technology developments to contribute for the current needs of the Aerospace Technology.

IV. **PEO 4:** To prepare students to excel in aerospace technology with an academic environment aware of leadership and the life-long learning needed to meet out the changing industrial scenarios.

## PROGRAMME OUTCOMES (POs)

On successful completion of the programme,

1. Post Graduate will attain the skill to conduct experiments, to design, analyze and interpret data in the field of Aerospace technology.
2. Post Graduate will have the ability to design a system or a component to accomplish the design requirements with constraints exclusively meant for Aerospace Technology.
3. Post Graduate will excel with modern engineering tools and analyze problems within the domains of Aerospace Technology.
4. Post Graduate will acquire an understanding of professional and ethical responsibility with reference to their career in the field of Aerospace Technology and other allied professional fields.
5. Post Graduate will be able to communicate effectively in both verbal and written form.
6. Post Graduate will be trained towards developing and understanding the importance of design and development of launch vehicles from system integration point of view.
7. Post Graduate will develop confidence for self-education and understand the value of life-long learning.
8. Post Graduate will exhibit the awareness of contemporary issues focusing on the necessity to develop new materials, design and testing methods for the solution of problems related to aerospace industries.
9. Post Graduate will have a technological and communication base to get placement in aerospace industry and Research & Development organizations related to Aerospace Technology.
10. Post Graduate will be capable of doing doctoral studies and research in inter and multidisciplinary areas.

### Mapping of PEOs with POs

| Programme Educational Objectives | Programme Outcomes | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
| I | ✓ | ✓ | ✓ | ✓ | | | | ✓ | | ✓ |
| II | | | | ✓ | ✓ | ✓ | | ✓ | ✓ | |
| III | | ✓ | | ✓ | | ✓ | | ✓ | ✓ | |
| IV | | | ✓ | | | | ✓ | ✓ | | ✓ |

| | | | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR 1 | SEM 1 | Aerospace Structural Mechanics | ✓ | | | | | | ✓ | | ✓ | |
| | | Aerodynamics | | ✓ | ✓ | | | ✓ | | ✓ | | ✓ |
| | | Aircraft and Missile Propulsion | ✓ | | | | | | ✓ | | ✓ | |
| | | Rocketry and Space Mechanics | ✓ | | | | | ✓ | | | | ✓ |
| | | Aerospace Instrumentation | ✓ | | | | | | ✓ | | ✓ | |
| | | Advanced Mathematical Methods | ✓ | | | | | | ✓ | | ✓ | |
| | | Aerodynamics Laboratory | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | |
| | | Aerospace Propulsion Laboratory | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
| | | | | | | | | | | | | |
| | SEM 2 | Flight Mechanics | ✓ | | | | | | ✓ | | ✓ | |
| | | Finite Element Methods | ✓ | | | | | | ✓ | | ✓ | ✓ |
| | | Launch Vehicle Aerodynamics | ✓ | ✓ | | | | ✓ | ✓ | | | ✓ |
| | | Avionics | ✓ | ✓ | ✓ | | | ✓ | ✓ | | | ✓ |
| | | Professional Elective I | | | | | | | | | | |
| | | Professional Elective II | | | | | | | | | | |
| | | Structures laboratory | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | |
| | | Avionics Lab | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
| | | Technical Seminar | | | | ✓ | ✓ | | | ✓ | | |
| | | | | | | | | | | | | |
| YEAR 2 | SEM 3 | Chemical Rocket Technology | ✓ | ✓ | | | | ✓ | | | | ✓ |
| | | Professional Elective-III | | | | | | | | | | |
| | | Professional Elective-IV | | | | | | | | | | |
| | | Project work Phase I | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | |
| | | | | | | | | | | | | |
| | SEM 4 | Project work Phase II | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | |
| | | | | | | | | | | | | |
| | | **Semester II (Elective I & II)** | | | | | | | | | | |
| | | Aerospace Materials | | ✓ | ✓ | | | ✓ | | ✓ | ✓ | |
| | | Systems Engineering | ✓ | ✓ | | | | | ✓ | | | |
| | | Cryogenic Technology | | ✓ | ✓ | | | ✓ | | | | |
| | | Space Weapons and Warfare | | | | | | ✓ | | | ✓ | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **PROFESSIONAL ELECTIVES** | Computational Fluid Dynamics for Aerospace Applications | ✓ | ✓ | ✓ | | | ✓ | | ✓ | | ✓ |
| | Composite Materials and Structures | ✓ | ✓ | ✓ | | | ✓ | ✓ | | | ✓ |
| | Advanced Propulsion Systems | ✓ | ✓ | ✓ | | | ✓ | | | | |
| | Computational Heat Transfer | ✓ | ✓ | ✓ | | | ✓ | | ✓ | | ✓ |
| | Fatigue and Fracture Mechanics | ✓ | ✓ | ✓ | | | ✓ | | ✓ | | |
| | Structural Dynamics | ✓ | ✓ | ✓ | | | | | ✓ | | |
| | **Semester III (Elective III & IV)** | | | | | | | | | | |
| | Reliability and Quality Assurance | | | | ✓ | | | | ✓ | ✓ | |
| | Hypersonic Aerodynamics | ✓ | ✓ | ✓ | | | ✓ | | | | |
| | Missile Guidance and Control | ✓ | ✓ | | | | ✓ | | | | ✓ |
| | Transonic Aerodynamics | ✓ | ✓ | | | | ✓ | | | | ✓ |
| | Orbital Mechanics and Space Flight | | ✓ | | | | | ✓ | | ✓ | ✓ |
| | Digital Image Processing for Aerospace Applications | | ✓ | | | | | ✓ | | ✓ | ✓ |
| | Mathematical Modeling and Simulation | ✓ | ✓ | | | | | ✓ | | ✓ | ✓ |
| | High Speed Jet Flows | | ✓ | | | | | | | | ✓ |
| | | | | | | | | | | | |

**ANNA UNIVERSITY, CHENNAI**

**AFFILIATED INSTITUTIONS**

**REGULATIONS 2017**

**M.E AEROSPACE TECHNOLOGY**

**CHOICE BASED CREDIT SYSTEM**

**I TO IV SEMESTERS CURRICULUM AND SYLLABUS (FULL TIME)**

## SEMESTER - I

| SL. NO. | COURSE CODE | COURSE TITLE | CATEGORY | CONTACT PERIODS | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| **THEORY** | | | | | | | | |
| 1. | AS5101 | Aerospace Structural Mechanics | PC | 5 | 3 | 2 | 0 | 4 |
| 2. | AO5151 | Aerodynamics | PC | 3 | 3 | 0 | 0 | 3 |
| 3. | AS5102 | Aircraft and Missile Propulsion | PC | 3 | 3 | 0 | 0 | 3 |
| 4. | AO5071 | Rocketry and Space Mechanics | PC | 3 | 3 | 0 | 0 | 3 |
| 5. | AS5103 | Aerospace Instrumentation | PC | 3 | 3 | 0 | 0 | 3 |
| 6. | MA5151 | Advanced Mathematical Methods | FC | 4 | 4 | 0 | 0 | 4 |
| **PRACTICAL** | | | | | | | | |
| 7. | AO5161 | Aerodynamics Laboratory | PC | 4 | 0 | 0 | 4 | 2 |
| 8. | AS5112 | Aerospace Propulsion Laboratory | PC | 4 | 0 | 0 | 4 | 2 |
| | | | **TOTAL** | **29** | **19** | **2** | **8** | **24** |

| **SEMESTER II** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **SL. NO.** | **COURSE CODE** | **COURSE TITLE** | **CATEGORY** | **CONTACT PERIODS** | **L** | **T** | **P** | **C** |
| **THEORY** | | | | | | | | |
| 1. | AO5251 | Flight Mechanics | PC | 3 | 3 | 0 | 0 | 3 |
| 2. | AO5252 | Finite Element Methods | PC | 5 | 3 | 2 | 0 | 4 |
| 3. | AS5201 | Launch Vehicle Aerodynamics | PC | 3 | 3 | 0 | 0 | 3 |
| 4. | AO5092 | Avionics | PC | 3 | 3 | 0 | 0 | 3 |
| 5. | | Professional Elective I | PE | 3 | 3 | 0 | 0 | 3 |
| 6. | | Professional Elective II | PE | 3 | 3 | 0 | 0 | 3 |
| **PRACTICALS** | | | | | | | | |
| 7. | AO5261 | Structures Laboratory | PC | 4 | 0 | 0 | 4 | 2 |
| 8. | AS5211 | Avionics Lab | PC | 4 | 0 | 0 | 4 | 2 |
| 9. | AS5212 | Technical Seminar | EEC | 2 | 0 | 0 | 2 | 1 |
| | | | **TOTAL** | **30** | **18** | **2** | **10** | **24** |

| SEMESTER III | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SL. NO. | COURSE CODE | COURSE TITLE | CATEGORY | CONTACT PERIODS | L | T | P | C |
| **THEORY** | | | | | | | | |
| 1. | AS5301 | Chemical Rocket Technology | PC | 3 | 3 | 0 | 0 | 3 |
| 2. | | Professional Elective III | PE | 3 | 3 | 0 | 0 | 3 |
| 3. | | Professional Elective IV | PE | 3 | 3 | 0 | 0 | 3 |
| **PRACTICALS** | | | | | | | | |
| 4. | AS5311 | Project work Phase I | EEC | 12 | 0 | 0 | 12 | 6 |
| | | | **TOTAL** | **21** | **9** | **0** | **12** | **15** |

| SEMESTER IV | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SL. NO. | COURSE CODE | COURSE TITLE | CATEGORY | CONTACT PERIODS | L | T | P | C |
| **PRACTICAL** | | | | | | | | |
| 1 | AS5411 | Project work Phase II | EEC | 24 | 0 | 0 | 24 | 12 |
| | | | **TOTAL** | **24** | **0** | **0** | **24** | **12** |

**TOTAL NUMBER OF CREDITS = 75 PERIODS**

## FOUNDATION COURSES (FC)

| SL. NO. | COURSE CODE | COURSE TITLE | CATEGORY | CONTACT PERIODS | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| 1. | MA5151 | Advanced Mathematical Methods | FC | 4 | 4 | 0 | 0 | 4 |

## PROFESSIONAL CORE (PC)

| SL. NO. | COURSE CODE | COURSE TITLE | CATEGORY | CONTACT PERIODS | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| 1. | AS5101 | Aerospace Structural Mechanics | PC | 5 | 3 | 2 | 0 | 4 |
| 2. | AO5151 | Aerodynamics | PC | 3 | 3 | 0 | 0 | 3 |
| 3. | AS5102 | Aircraft and Missile Propulsion | PC | 3 | 3 | 0 | 0 | 3 |
| 4. | AO5071 | Rocketry and Space Mechanics | PC | 3 | 3 | 0 | 0 | 3 |
| 5. | AS5103 | Aerospace Instrumentation | PC | 3 | 3 | 0 | 0 | 3 |
| 6. | AO5161 | Aerodynamics Laboratory | PC | 4 | 0 | 0 | 4 | 2 |
| 7. | AS5112 | Aerospace Propulsion Laboratory | PC | 4 | 0 | 0 | 4 | 2 |
| 8. | AO5251 | Flight Mechanics | PC | 3 | 3 | 0 | 0 | 3 |
| 9. | AO5252 | Finite Element Methods | PC | 5 | 3 | 2 | 0 | 4 |
| 10. | AS5201 | Launch Vehicle Aerodynamics | PC | 3 | 3 | 0 | 0 | 3 |
| 11. | AO5092 | Avionics | PC | 3 | 3 | 0 | 0 | 3 |
| 12. | AO5261 | Structures Laboratory | PC | 4 | 0 | 0 | 4 | 2 |
| 13. | AS5211 | Avionics Laboratory | PC | 4 | 0 | 0 | 4 | 2 |
| 14. | AS5301 | Chemical Rocket Technology | PC | 3 | 3 | 0 | 0 | 3 |

## LIST OF ELECTIVES
### Semester II (Elective I & II)

| SL. NO. | COURSE CODE | COURSE TITLE | CATEGORY | CONTACT PERIODS | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| 1. | AS5001 | Aerospace Materials | PE | 3 | 3 | 0 | 0 | 3 |
| 2. | AS5091 | Systems Engineering | PE | 3 | 3 | 0 | 0 | 3 |
| 3. | AS5002 | Cryogenic Technology | PE | 3 | 3 | 0 | 0 | 3 |
| 4. | AS5003 | Space Weapons and Warfare | PE | 3 | 3 | 0 | 0 | 3 |
| 5. | AO5253 | Computational Fluid Dynamics for Aerospace Applications | PE | 3 | 3 | 0 | 0 | 3 |
| 6. | AO5254 | Composite Materials and Structures | PE | 3 | 3 | 0 | 0 | 3 |
| 7. | AO5073 | Advanced Propulsion Systems | PE | 3 | 3 | 0 | 0 | 3 |
| 8. | AO5072 | Computational Heat Transfer | PE | 3 | 3 | 0 | 0 | 3 |
| 9. | AO5074 | Fatigue and Fracture Mechanics | PE | 3 | 3 | 0 | 0 | 3 |
| 10. | AS5004 | Structural Dynamics | PE | 3 | 3 | 0 | 0 | 3 |

### Semester III (Elective III & IV)

| SL. NO. | COURSE CODE | COURSE TITLE | CATEGORY | CONTACT PERIODS | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| 1. | AS5005 | Reliability and Quality Assurance | PE | 3 | 3 | 0 | 0 | 3 |
| 2. | AO5091 | Hypersonic Aerodynamics | PE | 3 | 3 | 0 | 0 | 3 |
| 3. | AS5006 | Missile Guidance And Control | PE | 3 | 3 | 0 | 0 | 3 |
| 4. | AS5007 | Transonic Aerodynamics | PE | 3 | 3 | 0 | 0 | 3 |
| 5. | AS5008 | Orbital Mechanics and Space Flight | PE | 3 | 3 | 0 | 0 | 3 |
| 6. | AS5009 | Digital Image Processing For Aerospace Applications | PE | 3 | 3 | 0 | 0 | 3 |
| 7. | AS5010 | Mathematical Modeling and Simulation | PE | 3 | 3 | 0 | 0 | 3 |
| 8. | AO5075 | High Speed Jet Flows | PE | 3 | 3 | 0 | 0 | 3 |

### EMPLOYABILITY ENHANCEMENT COURSES (EEC)

| SL. NO. | COURSE CODE | COURSE TITLE | CATEGORY | CONTACT PERIODS | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| 1. | AS5212 | Technical Seminar | EEC | 2 | 0 | 0 | 2 | 1 |
| 2. | AS5311 | Project work Phase I | EEC | 12 | 0 | 0 | 12 | 6 |
| 3. | AS5411 | Project work Phase II | EEC | 24 | 0 | 0 | 24 | 12 |

**AS5101 AEROSPACE STRUCTURAL MECHANICS**

| L | T | P | C |
|---|---|---|---|
| 3 | 2 | 0 | 4 |

**OBJECTIVES:**

To make students learn important technical aspects on theory of bending, shear flow in open and closed sections, stability problems in structures with various modes of loading and also impart knowledge on how to analyze aircraft structural components under various forms of loading.

**UNIT I BENDING OF BEAMS 12+3**

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.

**UNIT II SHEAR FLOW IN OPEN SECTIONS 9+3**

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

**UNIT III SHEAR FLOW IN CLOSED SECTIONS 15+3**

Shear flow in closed sections with stiffeners– Angle of twist - Shear flow in two flange and three flange box beams – Shear centre - 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.

**UNIT IV STABILITY PROBLEMS 12+3**

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).

**UNIT V ANALYSIS OF AEROSPACE STRUCTURAL COMPONENTS 12+3**

Missile structures- satellite – mini, micro structures.

**TOTAL: 75 PERIODS**

**OUTCOME:**

Upon completion of the course, Students will get knowledge on different types of beams and columns subjected to various types of loading and support conditions and analysis of missile structures.

**REFERENCES**


1. E.F. Bruhn, "Analysis and Design of Flight Vehicle Structures", Tristate Offset Co., 1980.
2. Megson, T.M.G; Aircraft Structures for Engineering Students, Edward Arnold, 1995.
3. Peery, D.J. and Azar, J.J., Aircraft Structures, 2nd Edition, McGraw-Hill, New York, 1993.
4. Rivello, R.M., Theory and Analysis of Flight structures, McGraw-Hill, N.Y., 1993.
5. Stephen P. Tinnoshenko & S.woinowsky Krieger, Theory of Plates and Shells, 2nd Edition, McGraw-Hill, Singapore, 1990.


**AO5151 AERODYNAMICS**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**OBJECTIVES**

To introduce the students the fundamental concepts and topic related to aerodynamics of flight vehicles like fundamental forms of flow, aerodynamic coefficient, incompressible and compressible flow theories, viscous flow measurements and various configuration of aircraft and wings.

**UNIT I INTRODUCTION TO AERODYNAMICS 9**

Hot air balloon and aircrafts, Various types of airplanes, Wings and airfoils, lift and Drag, Centre of pressure and aerodynamic centre, Coefficient of pressure, moment coefficient, Continuity and Momentum equations, Point source and sink, doublet, 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

**UNIT II INCOMPRESSIBLE FLOW THEORY 9**

Conformal Transformation, Kutta condition, Karman – Trefftz profiles, Thin aerofoil Theory and its applications. Vortex line, Horse shoe vortex, Biot - Savart law, lifting line theory

**UNIT III COMPRESSIBLE FLOW THEORY 9**

Compressibility, Isentropic flow through nozzles, shocks and expansion waves, Rayleigh and Fanno Flow, Potential equation for compressible flow, small perturbation theory, Prandtl- Glauert Rule, Linearised supersonic flow, Method of characteristics

**UNIT IV AIRFOILS, WINGS AND AIRPLANE CONFIGURATION IN HIGH SPEED FLOWS 9**

Critical Mach number, Drag divergence Mach number, Shock stall, super critical airfoils, Transonic area rule, Swept wings (ASW and FSW), supersonic airfoils, wave drag, delta wings, Design considerations for supersonic airplanes

**UNIT V VISCOUS FLOW AND FLOW MEASUREMENTS 9**

Basics of viscous flow theory – Boundary Layer – Displacement, momentum and Energy Thickness – Laminar and Turbulent boundary layers – Boundary layer over flat plate – Blasius Solution Introduction to wind tunnel, Types of wind tunnel, Scale model, Important testing parameters, Calibration of test section, Measurement of force, moment and pressure, scale effect, Flow visualization techniques

**TOTAL : 45 PERIODS**

**OUTCOME:**

Upon completion of the course, students will understand the behaviour of airflow over bodies with particular emphasis on airfoil sections in the incompressible flow regime.

**REFERENCES**


1. E.L. Houghton and N.B. Caruthers, Aerodynamics for Engineering Students, Edward Arnold Publishers Ltd., London (First Indian Edition), 1988
2. J.D. Anderson, “Fundamentals of Aerodynamics”, McGraw-Hill Book Co., New York,1985.
3. Rathakrishnan.E., Gas Dynamics, Prentice Hall of India, 1995.
4. Shapiro, A.H., Dynamics & Thermodynamics of Compressible Fluid Flow, Ronald Press, 1982.
5. W.H. Rae and A. Pope, “Low speed Wind Tunnel Testing”, John Wiley Publications, 1984.
6. Zucrow, M.J., and Anderson, J.D., Elements of gas dynamics McGraw-Hill Book Co., New York, 1989.

**AS5102 AIRCRAFT AND MISSILE PROPULSION** **L T P C**
**3 0 0 3**

**UNIT I FUNDAMENTALS OF AIR-BREATHING PROPULSION 9**

Air breathing propulsion systems like Turbojet, turboprop and ducted fan – Thermodynamic cycles of these propulsion systems and evaluation of efficiency –Performance characteristics of the propulsion systems and operational limitations –twin spool systems.

**UNIT II RAMJET PROPULSION 9**

Basic operational principle of ramjet - Solid fuel and liquid fuelled ramjets – Preliminary performance calculations – Inlet and Diffuser design and performance estimation –combustor and nozzle design – air augmented rockets.

**UNIT III SCRAMJET PROPULSION 9**

Fundamental considerations of hypersonic air breathing propulsion – need for SCRAM Jet Propulsion - Preliminary concepts in engine airframe integration – calculation of propulsion flow path – Various types and requirements of supersonic combustors – endothermic fuels and cooling – Performance estimation of scramjet propulsion

**UNIT IV SOLID ROCKET PROPULSION 9**

Operating principle - Various subsystems of Solid rocket motor and their functions- selection of solid propellants - Propellant grain design- propellant burning rate laws- erosive burning – L * instability – internal ballistics of solid rocket motor – solid rocket as missile power plant .

**UNIT V LIQUID ROCKET PROPULSION 9**

Classification of liquid rocket engines – types of propellant feed systems used in liquid rockets - rocket thrust control – thrust chamber and injector design considerations – various types of liquids rocket injectors – thrust chamber cooling- propellant slosh- combustion instability – applications of liquid rockets.

**TOTAL : 45 PERIODS**

**OUTCOME:**

Upon completion of the course, students will understand the concept propulsion system using in aircraft and in missile and operation of ramjet and scramjet engines.

**REFERENCES**

1. Cumpsty, Jet propulsion, Cambridge University Press, 2003
2. G.C Oates, “Aerothermodynamics of Aircraft Engine Components “, AIAA Education. Series 1985.
3. G.P. Sutton, “Rocket Propulsion Elements”. John Wiley & Sons Inc., New York, 5 th Edition,1986.
4. Mathur and Sharma R.P. “Gas turbine, Jet and Rocket Propulsion standard publishers and Distributors Delhi, 1988.
5. William H. Heiser and David T. Pratt, Hypersonic Airbreathing propulsion.

**AO5071 ROCKETRY AND SPACE MECHANICS** **L T P C**
**3 0 0 3**

**OBJECTIVES**

- To familiarize the students on fundamental aspects of rocket propulsion, multi stating of rocket vehicle and spacecraft dynamics.

**UNIT I ORBITAL MECHANICS 9**

Description of solar system – Kepler's Laws of planetary motion – Newton's Law of Universal gravitation – Two body and Three-body problems – Jacobi's Integral, Librations points - Estimation of orbital and escape velocities

**UNIT II SATELLITE DYNAMICS 9**

Geosynchronous and geostationary satellites- factors determining life time of satellites – satellite perturbations – methods to calculate perturbations- Hohmann orbits – calculation of orbit parameters – Determination of satellite rectangular coordinates from orbital elements

**UNIT III ROCKET MOTION 10**

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.

**UNIT IV ROCKET AERODYNAMICS 9**

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

**UNIT V STAGING AND CONTROL OF ROCKET VEHICLES 8**

Need for multi-staging of rocket vehicles – multistage vehicle optimization – stage separation dynamics and separation techniques- aerodynamic and jet control methods of rocket vehicles - SITVC.

**TOTAL: 45 PERIODS**

**OUTCOME:**

Upon completion of the course, students will have an idea about solar system, basic concepts of orbital mechanics with particular emphasis on interplanetary trajectories.

**REFERENCES**


1. E.R. Parker, "Materials for Missiles and Spacecraft", McGraw-Hill Book Co., Inc., 1982.
2. G.P. Sutton, "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 5$^{th}$ Edition, 1986.
3. J.W. Cornelisse, "Rocket Propulsion and Space Dynamics", J.W. Freeman & Co., Ltd., London, 1982
4. Van de Kamp, "Elements of Astro-mechanics", Pitman Publishing Co., Ltd., London, 1980.


**AS5103 AEROSPACE INSTRUMENTATION**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**UNIT I MEASUREMENT SCIENCE AND AIR DATA INSTRUMENTS 9**

Instrumentation brief review- Functional elements of an instrument system –Transducers - classification - Static and dynamic characteristics- calibration - classification of aircraft instruments - Air data instruments-airspeed, altitude, Vertical speed indicators. Static Air temperature, Angle of attack measurement, Synchronous data transmission system.

**UNIT II GYROSCOPIC AND POWERPLANT INSTRUMENTS 9**

Gyroscope and its properties, gyro system, Gyro horizon, Direction gyro-direction indicator, Rate gyro-rate of turn and slip indicator, Turn coordinator, acceleration and turning errors. Pressure measurement, temperature measurement, engine power and control instruments-measurement of RPM, manifold pressure, torque, exhaust gas temperature, EPR, fuel flow, engine vibration, monitoring.

**UNIT III AIRCRAFT COMPASS SYSTEMS & FLIGHT MANAGEMENT SYSTEM 9**

Direct reading compass, magnetic heading reference system-detector element, monitored gyroscope system, DGU, RMI, deviation compensator. FMS- Flight planning-flight path optimization-operational modes-4D flight management

**UNIT IV MISSILE INSTRUMENTATION 9**

Autopilots — Definitions, Types of Autopilots, Example Applications. Open-loop autopilots. Inertial instruments and feedback. Autopilot response, stability, and agility – Target tracker – missile tracker – guidance computer – beam riding – Active radar systems- gimballed gyrostabilized platform – fluid suspended gyro stabilized platform – solid state ring laser gyros.

**UNIT V FAULT DIAGNOSIS AND TESTING OF INSTRUMENTS 9**

System error analysis, fault diagnostics analysis for aerospace vehicles including case study. Autonomous instruments checkout and calibration built in test- ground test, In-flight test, core tests for sensors and actuators, environmental effects, performance evaluation.

**TOTAL: 45 PERIODS**

**OUTCOME:**

Upon completion of the course, the students will understand the available basic concepts of Flight instruments to the engineers and the necessary knowledge that are needed in understanding their significance and operation. The students will also have an exposure to various topics such as measurement concepts, air data sensors and measurements, Flight Management Systems, and other instruments pertaining to Gyroscopic measurements and Engine data measurements and will be able to deploy these skills effectively in understanding and analyzing the instrumentation methods in avionics engineering.

**REFERENCES:**

1. Doeblin.E.O, “Measurement Systems Application and Design”, McGraw-Hill, New York, 1999.
2. Harry.Stilz, “Aerospace Telemetry”, Vol I to IV, Prentice-Hall Space Technology Series.
3. Murthy, D.V.S., “Transducers and Measurements”, McGraw-Hill, 1995
4. Pallet, E.H.J. “Aircraft Instruments & Integrated systems”, Longman Scientific and Technical, McGraw-Hill, 1992.

| MA5151 | ADVANCED MATHEMATICAL METHODS | L | T | P | C |
|---|---|---|---|---|---|
| | | 4 | 0 | 0 | 4 |

**OBJECTIVES :**

The main objective of this course is to provide the student with a repertoire of mathematical methods that are essential to the solution of advanced problems encountered in the fields of applied physics and engineering. This course covers a broad spectrum of mathematical techniques such as Laplace Transform, Fourier Transform, Calculus of Variations, Conformal Mapping and Tensor Analysis. Application of these topics to the solution of problems in physics and engineering is stressed.

**UNIT I LAPLACE TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS 12**

Laplace transform : Definitions – Properties – Transform 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.

**UNIT II FOURIER TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS 12**

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 Poisson's equations.

**UNIT III CALCULUS OF VARIATIONS 12**

Concept of variation and its properties – Euler's equation – Functional dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Variational problems with moving boundaries – Isoperimetric problems – Direct methods – Ritz and Kantorovich methods.

**UNIT IV CONFORMAL MAPPING AND APPLICATIONS 12**

Introduction to conformal mappings and bilinear transformations – Schwarz Christoffel transformation – Transformation of boundaries in parametric form – Physical applications : Fluid flow and heat flow problems.

**UNIT V TENSOR ANALYSIS 12**

Summation convention – Contravariant and covariant vectors – Contraction of tensors – Inner product – Quotient law – Metric tensor – Christoffel symbols – Covariant differentiation – Gradient - Divergence and curl.

**TOTAL : 60 PERIODS**

**OUTCOMES :**

After completing this course, students should demonstrate competency in the following skills:

- Application of Laplace and Fourier transforms to initial value, initial–boundary value and boundary value problems in Partial Differential Equations.
- Maximizing and minimizing the functional that occur in various branches of Engineering Disciplines.
- Construct conformal mappings between various domains and use of conformal mapping in studying problems in physics and engineering particularly to fluid flow and heat flow problems.
- Understand tensor algebra and its applications in applied sciences and engineering and develops ability to solve mathematical problems involving tensors.
- Competently use tensor analysis as a tool in the field of applied sciences and related fields.

**REFERENCES :**


1. Andrews L.C. and Shivamoggi, B., "Integral Transforms for Engineers", Prentice Hall of India Pvt. Ltd., New Delhi, 2003.
2. Elsgolc, L.D., "Calculus of Variations", Dover Publications Inc., New York, 2007.
3. Mathews, J. H., and Howell, R.W., "Complex Analysis for Mathematics and Engineering", 5$^{th}$ Edition, Jones and Bartlett Publishers, 2006.
4. Kay, D. C., "Tensor Calculus", Schaum's Outline Series, Tata McGraw Hill Edition, 2014.
5. Naveen Kumar, "An Elementary Course on Variational Problems in Calculus ", Narosa Publishing House, 2005.
6. Saff, E.B and Snider, A.D, "Fundamentals of Complex Analysis with Applications in Engineering, Science and Mathematics", 3$^{rd}$ Edition, Pearson Education, New Delhi, 2014.
7. Sankara Rao, K., "Introduction to Partial Differential Equations", Prentice Hall of India Pvt. Ltd., New Delhi, 1997.
8. Spiegel, M.R., "Theory and Problems of Complex Variables and its Applications", Schaum's Outline Series, McGraw Hill Book Co., 1981.
9. Ramaniah. G. "Tensor Analysis", S. Viswanathan Pvt. Ltd., 1990.

**AO5161 AERODYNAMICS LABORATORY** **L T P C**
**0 0 4 2**

**LIST OF EXPERIMENTS**

1. Calibration of subsonic wind tunnel
2. Pressure distribution over a smooth and rough cylinders
3. Pressure distribution over a symmetric aerofoil section
4. Pressure distribution over a cambered aerofoil section
5. Force and moment measurements using wind tunnel balance
6. Pressure distribution over a wing of symmetric aerofoil section
7. Pressure distribution over a wing of cambered aerofoil section
8. Flow visualization studies in incompressible flows
9. Calibration of supersonic wind tunnel
10. Supersonic flow visualization studies

**TOTAL: 60 PERIODS**

**LABORATORY EQUIPMENTS REQUIREMENTS**

1. Subsonic wind tunnel
2. Rough and smooth cylinders
3. Symmetrical and Cambered aerofoil
4. Wind tunnel balance
5. Schlieren system
6. Pressure Transducers
7. Supersonic wind tunnel

**OUTCOME:**

Upon completion of the course, students will be in a position to use wind tunnel for pressure and force measurements on various models.

**AS5112 AEROSPACE PROPULSION LABORATORY** **L T P C**
**0 0 4 2**

**OUTCOME:**

Upon completion of the course, students will get practical experience on jets and pressure measurements on combustor.

**LIST OF EXPERIMENTS**

1. Total pressure measurements along the jet axis of a circular supersonic jet
2. Total pressure measurements along the jet axis of a non circular supersonic jet
3. Performance studies of a hybrid rocket propulsion system
4. Cold flow studies of a wake region behind flame holders
5. Wall pressure measurements of a non circular combustor
6. Wall pressure measurements of a subsonic diffuser
7. Ignition delay measurements of a solid propellant
8. Wall pressure measurements of an isolator of a supersonic combustor (cold flow studies)
9. DSC and TGA studies on HTPB
10. Cascade testing of compressor blades.

**TOTAL: 60 PERIODS**

**LABORATORY EQUIPMENTS REQUIREMENTS**

1. Jet facility with compressor and storage tank
2. Multitube manometer
3. Wind tunnel
4. Pressure transducer with pressure indicator (0 to 5 bar) or DSA pressure scanner
5. Conical flame holder
6. Compressor blade set
7. Circular and non-circular combustors.
8. Bomb calorimeter

**AO5251** **FLIGHT MECHANICS** **L T P C**
**3 0 0 3**

**OBJECTIVES**

- To impart knowledge to students on aircraft performance in level, climbing, gliding and accelerated flight modes and also various aspects of stability and control in longitudinal, lateral and directional modes.

**UNIT I PRINCIPLES OF FLIGHT 9**

Physical properties and structure of the atmosphere, International Standard Atmosphere, Temperature, pressure and altitude relationship, Measurement of speed – True, Indicated and Equivalent air speed, Streamlined and bluff bodies, Various Types of drag in airplanes, Drag polar, Methods of drag reduction of airplanes.

**UNIT II AIRCRAFT PERFORMANCE IN LEVEL, CLIMBING AND GLIDING FLIGHTS 8**

Straight and level flight, Thrust required and available, Power required and available, Effect of altitude on thrust and power, Conditions for minimum drag and minimum power required, Gliding and Climbing flight, Range and Endurance.

**UNIT III ACCELERATED FLIGHT 9**

Take-off and landing performance, Turning performance, horizontal and vertical turn, Pull up and pull Down, maximum turn rate, V-n diagram with FAR regulations.

**UNIT IV LONGITUDINAL STABILITY AND CONTROL 10**

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

**UNIT V 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

**TOTAL: 45 PERIODS**

**OUTCOME:**

Upon completion of the course, students will understand the static, dynamic longitudinal, directional and lateral stability and control of airplane, effect of maneuvers.

**REFERENCES**


1. Babister, A.W. Aircraft stability and response, Pergamon Press, 1980.
2. Clancey,L.J. Aerodynamics, Pitman, 1986.
3. Houghton, E.L., and Caruthers, N.B., Aerodynamics for engineering students, Edward Arnold Publishers, 1988.
4. Kuethe, A.M., and Chow, C.Y., Foundations of Aerodynamics, John Wiley & Sons, 1982.
5. McCormic, B.W., Aerodynamics, Aeronautics & Flight Mechanics John Wiley, 1995.
6. Nelson, R.C. Flight Stability & Automatic Control, McGraw-Hill, 1989.
7. Perkins C.D., & Hage, R.E. Airplane performance, stability and control, Wiley Toppan, 1974.

**AO5252** **FINITE ELEMENT METHODS** **L T P C**
**3 2 0 4**

**OBJECTIVES:**

- To make students learn using Finite element techniques to solve problems related to discrete, continuum and isoparametric elements. And also to introduce solution schemes for static, dynamic and stability problems.

**UNIT I INTRODUCTION 12**

Review of various approximate methods – Rayleigh-Ritz, Galerkin and Finite Difference Methods - Stiffness and flexibility matrices for simple cases - Basic concepts of finite element method - Formulation of governing equations and convergence criteria.

**UNIT II DISCRETE ELEMENTS 14**

Structural analysis of bar and beam elements for static and dynamic loadings. Bar of varying section – Temperature effects

Program Development and use of software package for application of bar and beam elements for static, dynamic and stability analysis.

**UNIT III CONTINUUM ELEMENTS 14**

Plane stress, Plane strain and Axisymmetric problems – CST Element – LST Element. Consistent and lumped load vectors. Use of local co-ordinates. Numerical integration. Application to heat transfer problems.

Solution for 2-D problems (static analysis and heat transfer) using software packages.

**UNIT IV ISOPARAMETRIC ELEMENTS 12**

Definition and use of different forms of 2-D and 3-D elements. - Formulation of element stiffness matrix and load vector.

Solution for 2-D problems (static analysis and heat transfer) using software packages.

**UNIT V SOLUTION SCHEMES 8**

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

**TOTAL: 75 PERIODS**

**OUTCOME:**

Upon completion of the course, students will learn the concept of numerical analysis of structural components

**REFERENCES**


1. C.S. Krishnamurthy, “Finite Elements Analysis”, Tata McGraw-Hill, 1987.
2. K.J. Bathe and E.L. Wilson, “Numerical Methods in Finite Elements Analysis”, Prentice Hall of India Ltd., 1983.
3. Robert D. Cook, David S. Malkus, Michael E. Plesha and Robert J. Witt “Concepts and Applications of Finite Element Analysis”, 4th Edition, John Wiley & Sons, 2002.
4. S.S.Rao, “Finite Element Method in Engineering”, Butterworth, Heinemann Publishing, 3rd Edition, 1998
5. Segerlind,L.J. “Applied Finite Element Analysis”, Second Edition, John Wiley and Sons Inc., New York, 1984.
6. Tirupathi R. Chandrupatla and Ashok D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall, 2002

**AS5201 LAUNCH VEHICLE AERODYNAMICS**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**OBJECTIVE:**

- To impart knowledge to students on basic launch vehicle configurations and preliminary drag estimation. The objective is also to introduce slender and blunt body aerodynamics, aerodynamic aspects of launching phase.

**UNIT I BASICS OF HIGH SPEED AERODYNAMICS 9**

Compressible flows-Isentropic relations-mathematical relations of flow properties across shock and expansion waves-fundamentals of Hypersonic Aerodynamics

**UNIT II BOUNDARY LAYER THEORY 9**

Basics of boundary layer theory-compressible boundary layer-shock shear layer interaction-Aerodynamic heating-heat transfer effects

**UNIT III LAUNCH VEHICLE CONFIGURATIONS AND DRAG ESTIMATION 9**

Types of Rockets and missiles-various configurations-components-forces on the vehicle during atmospheric flight-nose cone design and drag estimation

**UNIT IV AERODYNAMICS OF SLENDER AND BLUNT BODIES 9**

Aerodynamics of slender and blunt bodies, wing-body interference effects-Asymmetric flow separation and vortex shedding-unsteady flow characteristics of launch vehicles- determination of aero elastic effects.

**UNIT V AERODYNAMIC ASPECTS OF LAUNCHING PHASE 9**

Booster separation-cross wind effects-specific considerations in missile launching-missile integration and separation-methods of evaluation and determination- Stability and Control Characteristics of Launch Vehicle Configuration- Wind tunnel tests – Comparison with CFD Analysis.

**TOTAL: 45 PERIODS**

**OUTCOME:**

Upon completion of the course, Students will learn the concept of high speed aerodynamics and configurations of launch vehicles.

**REFERENCES:**


1. Anderson Jr., D., – “Modern compressible flows”, McGraw-Hill Book Co., New York 1999.
2. Anderson, J.D., “Fundamentals of Aerodynamics”, McGraw-Hill Book Co., New York, 1985.
3. Anderson, J.D., “Hypersonic and High Temperature Gas Dynamics”, AIAA Education Series.
4. Charles D.Brown, “Spacecraft Mission Design”, AIAA Education Series, Published by AIAA, 1998
5. Chin SS, Missile Configuration Design, Mc Graw Hill, New York, 1961.
6. Elements of Space Technology for Aerospace Engineers”, Meyer Rudolph X, Academic Press, 1999
7. Nielson, Jack N, Stever, Gutford, “Missile Aerodynamics”, Mc Graw Hill, New York, 1960.

**AO5092** **AVIONICS** **L T P C**
**3 0 0 3**

**OBJECTIVES:**

- To introduce the basic of avionics and its need for civil and military aircrafts
- To impart knowledge about the avionic architecture and various avionics data buses
- To gain more knowledge on various avionics subsystems

**UNIT I INTRODUCTION TO AVIONICS 9**

Need for avionics in civil and military aircraft and space systems – integrated avionics and weapon systems – typical avionics subsystems, design, technologies – Introduction to digital computer and memories.

**UNIT II DIGITAL AVIONICS ARCHITECTURE 9**

Avionics system architecture – data buses – MIL-STD-1553B – ARINC – 420, ARINC-429 – ARINC – 629.

**UNIT III FLIGHT DECKS AND COCKPITS 9**

Control and display technologies: CRT, LED, LCD, EL and plasma panel – Touch screen – Direct voice input (DVI) – Civil and Military Cockpits: MFDS, HUD, MFK, HOTAS.

**UNIT IV INTRODUCTION TO NAVIGATION SYSTEMS 9**

Radio navigation – ADF, DME, VOR, LORAN, DECCA, OMEGA, TACAN, ILS, MLS, Hyperbolic navigation systems, Ground Control Approach Systems. Dead reckoning navigation systems, Doppler navigational and inertial navigation– Inertial Navigation Systems (INS) – INS block diagram – Satellite navigation systems – Traffic Alert and Collision Avoidance System (TCAS), GPS.

**UNIT V AIR DATA SYSTEMS AND AUTO PILOT 9**

Air data quantities – Altitude, Air speed, Vertical speed, Mach meter, Total air temperature, Mach warning, Altitude warning – Auto pilot – Basic principles, Longitudinal and lateral auto pilot.

**TOTAL: 45 PERIODS**

**OUTCOMES**:

- To introduce the basic of avionics and its need for civil and military aircrafts
- To impart knowledge about the avionic architecture and various avionics data buses
- To gain more knowledge on various avionics subsystems

**REFERENCES:**


1. Albert Helfrick.D., "Principles of Avionics", Avionics Communications Inc., 2004
2. Collinson.R.P.G. "Introduction to Avionics", Chapman and Hall, 1996.
3. Middleton, D.H., Ed., "Avionics systems, Longman Scientific and Technical", Longman Group UK Ltd., England, 1989.
4. Spitzer, C.R. "Digital Avionics Systems", Prentice-Hall, Englewood Cliffs, N.J., U.S.A. 1993.
5. Spitzer. C.R. "The Avionics Hand Book", CRC Press, 2000
6. Pallet.E.H.J. "Aircraft Instruments and Integrated Systems", Longman Scientific.

**AO5261** **STRUCTURES LABORATORY** **L T P C**
**0 0 4 2**

**OBJECTIVES:**

- To impart practical knowledge to the students on calibration of photoelastic materials determination of elastic constant for composite lamina, unsymmetrical bending of beams, determination of shear centre locations for closed and open sections and experimental studies.

**LIST OF EXPERIMENTS**

1. Constant strength Beams
2. Buckling of columns
3. Unsymmetrical Bending of Beams
4. Shear Centre Location for Open Section
5. Shear Centre Location for Closed Section
6. Flexibility Matrix for Cantilever Beam
7. Combined Loading
8. Calibration of Photo Elastic Materials
9. Stresses in Circular Disc Under Diametrical Compression – Photo Elastic Method
10. Vibration of Beams with Different Support Conditions
11. Fabrication and Determination of elastic constants of a composite laminate.
12. Wagner beam

**NOTE**: Any TEN experiments will be conducted out of 12.

**TOTAL: 60 PERIODS**

**LABORATORY EQUIPMENTS REQUIREMENTS**

1. Constant strength beam setup
2. Column setup
3. Unsymmetrical Bending setup
4. Experimental setup for location of shear centre (open & close section)
5. Cantilever beam setup
6. Experimental setup for bending and torsional loads
7. Diffuser transmission type Polaris cope with accessories
8. Experimental setup for vibration of beams
9. Universal Testing Machine
10. Wagner beam setup

**OUTCOME:**

Upon completion of the course, Students will acquire experimental knowledge on the unsymmetrical bending of beams, finding the location of shear centre, obtaining the stresses in circular discs and beams using photo-elastic techniques, calibration of photo – elastic materials.

**AS5211 AVIONICS LABORATORY L T P C**
**0 0 4 2**

**LIST OF EXPERIMENTS**

1. Addition/Subtraction of 8 bit and 16 bit data for control surface deflection.
2. Sorting of Data in Ascending & Descending order for voting mechanism.
3. Sum of a given series with and without carry for identifying flap data.
4. Greatest in a given series & Multi-byte addition in BCD mode.
5. Addition/Subtraction of binary numbers using adder and Subtractor circuits.
6. Multiplexer & Demultiplexer Circuits
7. Encoder and Decoder circuits.
8. Stability analysis using Root locus, Bode plot techniques.
9. Design of lead, lag and lead –lag compensator for aircraft dynamics.
10. Performance Improvement of Aircraft Dynamics by Pole placement technique.

Note: **= If MATLAB software is not available, the mathematical & graphical analysis of the experiment has to be done.

**TOTAL: 60 PERIODS**

**LIST OF EQUIPMENTS**

1. Microprocessor 8085 Kit
2. Adder/Subtractor Binary bits Kit
3. Encoder Kit
4. Decoder Kit
5. Multiplexer Kit
6. Demultiplexer Kit
7. computers
8. Regulated power supply
9. MATLAB software

**OBJECTIVE**:

This laboratory is to train students, to study about basic digital electronics circuits, various microprocessor applications in Control surface, Displays fault tolerant computers, to study the stability analysis and design using MATLAB.

**AS5301 CHEMICAL ROCKET TECHNOLOGY L T P C**
**3 0 0 3**

**OBJECTIVE:**

- To impart knowledge to the students on solid, liquid and hybrid rocket propulsion. And also the testing and safety procedures for rockets.

**UNIT I SOLID ROCKET PROPULSION 9**

Various subsystems of Solid rocket motor and their functions- Propellant grain design- erosive burning – L* instability – internal ballistics of solid rocket motor – types of ignites - igniter design considerations – special problems of solid rocket nozzles.

**UNIT II LIQUID ROCKET PROPULSION 12**

Classification of liquid rocket engines – rocket thrust control – thrust chamber and injector design considerations – various types of liquids rocket injectors – thrust chamber cooling- cryogenic rocket propulsion – problems peculiar to cryogenic engines- propellant slosh- combustion instability.

**UNIT III HYBRID ROCKET PROPULSION 8**

Standard and reverse hybrid propulsion systems – applications – current status and limitations – combustion mechanism – propellant system selection – internal ballistics of hybrid rocket systems.

**UNIT IV PROPELLANT TECHNOLOGY 8**

Selection criteria for solid and liquid rocket propellants – calculation of adiabatic flame temperature – assessment of rocket performance- selections of propellant formulation – determination of propellant burn rate and factors influencing the burn rate – solid propellant processing

**UNIT V TESTING AND SAFETY 8**

Static testing of rocket – instrumentation required – thrust Vs time – pressure Vs time diagrams – specific impulse calculation – safety procedures for testing of rockets and solid propellants –ignition delay testing.

**TOTAL: 45 PERIODS**

**OUTCOME:**

Upon completion of this course, students acquire knowledge in depth about chemical rocket propulsion

**REFERENCES**


1. Cornelisse., J.W., " Rocket Propulsion and space Dynamics" J.W.Freemav & Co. Ltd., London, 1982.
2. G.C Oates, "Aerothermodynamics of Aircraft Engine Components ", AIAA Education. Series 1985.
3. G.P. Sutton, "Rocket Propulsion Elements". John Wiley & Sons Inc., New York, 5th Edition, 1986.
4. Mathur and Sharma R.P. "Gas turbine, Jet and Rocket Propulsion standard publishers and Distributors Delhi, 1988.


| AS5001 | AEROSPACE MATERIALS | L T P C |
|---|---|---|
| | | 3 0 0 3 |

**OBJECTIVE:**

- To impart knowledge to the students on mechanical behaviour, corrosion & heat treatment of aerospace materials and also to expose them to applications of ceramic & composites and high temperature characterization.

**UNIT I ELEMENTS OF AEROSPACE MATERIALS 9**

Structure of solid materials – Atomic structure of materials – Crystal structure – Miller indices – Density – Packing factor – Space lattices – X-ray diffraction – Imperfection in crystals – general requirements of materials for aerospace applications

**UNIT II MECHANICAL BEHAVIOUR OF MATERIALS 9**

Linear and non linear elastic properties – Yielding, strain hardening, fracture, Bauchinger's effect – Notch effect testing and flaw detection of materials and components – Comparative study of metals, ceramics plastics and composites.

**UNIT III CORROSION & HEAT TREATMENT OF METALS AND ALLOYS 10**

Types of corrosion – Effect of corrosion on mechanical properties – Stress corrosion cracking – Corrosion resistance materials used for space vehicles, Heat treatment of carbon steels – aluminium alloys, magnesium alloys and titanium alloys – Effect of alloying treatment, heat resistance alloys – tool and die steels, magnetic alloys, powder metallurgy.

**UNIT IV CERAMICS AND COMPOSITES 9**

Introduction – physical metallurgy – modern ceramic materials – cermets - cutting tools – glass ceramic –production of semi fabricated forms - Plastics and rubber – Carbon/Carbon composites, Fabrication processes involved in metal matrix composites - shape memory alloys – applications in aerospace vehicle design

**UNIT V HIGH TEMPERATURE MATERIALS CHARACTERIZATION 8**

Classification, production and characteristics – Methods and testing – Determination of mechanical and thermal properties of materials at elevated temperatures – Application of these materials in Thermal protection systems of Aerospace vehicles – super alloys – High temperature material characterization.

**OUTCOME:**

Upon completion of this course, students will understand the advanced concepts of aerospace materials to the engineers and to provide the necessary mathematical knowledge that are needed in understanding their significance and operation. The students will have an exposure on various topics such elements of aerospace materials, mechanical behavior of materials, ceramics and composites and will be able to deploy these skills effectively in the understanding of aerospace materials.

**TOTAL: 45 PERIODS**

**REFERENCES**


1. Martin, J.W., Engineering Materials, Their properties and Applications, Wykedham Publications (London) Ltd., 1987.
2. Raghavan.V., Materials Science and Engineering, Prentice Hall of India, New Delhi, 1993.
3. Titterton.G., Aircraft Materials and Processes, V Edition, Pitman Publishing Co., 1995.
4. Van Vlack.L.H., Materials Science for Engineers, Addison Wesley, 1985.


| AS5091 | SYSTEMS ENGINEERING | L T P C |
|---|---|---|
| | | 3 0 0 3 |

**UNIT I INTRODUCTION TO SYSTEM ENGINEERING 9**

Overview, Systems definition and concepts, Conceptual system design, Systems thinking and Systems Engineering.

**UNIT II DESIGN AND DEVELOPMENT 9**

Detail Design Requirements, The Evolution of Detail Design, Design Data, Information, and Integration, Various phases in product life cycle, Systems verification & Integration

**UNIT III DESIGN FOR OPERATIONAL FEASIBILITY 9**

Design for Reliability, Maintainability, Usability, Sustainability and Affordability - Definition and Explanation, Measures, System Life Cycle cost, Analysis Methods, Practical considerations.

**UNIT IV SYSTEMS ENGINEERING MANAGEMENT 9**

Systems Engineering Planning and Organization, Systems Engineering Management Plan (SEMP), Program Leadership and Direction, Risk Management, Evaluation and Feedback.

**UNIT V CASE STUDIES 9**

Systems Integration -Aircraft Systems, Missile Systems, Satellite Systems-Launch Vehicle Systems and Radar, Design Drivers in the Project, Product, Operating Environment-Interfaces with the Subsystems.

**TOTAL: 45 PERIODS**

**OUTCOME:**

Upon completion of this course, students will understand to impart the advanced concepts of systems engineering to the engineers and to provide the necessary mathematical knowledge that are needed in understanding their significance and operation. The students will have an exposure on various topics such as conceptual system design, system design and development, design for operational feasibility, systems engineering management and will be able to deploy these skills effectively in the understanding of systems engineering.

**REFERENCES:**


1. Design and Development of an Aircraft Systems by Ian Moir and Allan Seabridge.
2. Gandoff, M.,(1990). Systems Analysis and Design.
3. Introduction to Systems Engineering by Andrew P.Sage and James .Armstrong.
4. Systems Engineering and Analysis by Benjamin S. Blanchard / Wolter J.Fabrycky, Prentice Hall, International Version 2010
5. Systems Engineering by Erik Aslaksen and Rod Belcher.


**AS5002 CRYOGENIC TECHNOLOGY**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**OBJECTIVES:**

- To make the students learn various thermodynamic cycles for cryogenic plants and the problems associated with a cryopropellants and calculation of efficiencies of cryogenic systems. Students will also learn the preliminary aspects on the design of cryogenic rocket engines.

**UNIT I FUNDAMENTALS OF CRYOGENICS 10**

Theory behind the production of low temperature - expansion engine - heat exchangers - Cascade process - Joule Thomson and magnetic effects - cryogenic liquids as cryogenic propellants for cryogenic rocket engines - properties of various cryogenic propellants - handling problems associated with cryogenic propellants.

**UNIT II CRYOGENIC SYSTEMS EFFICIENCY 8**

Types of losses and efficiency of cycles - amount of cooling - the features liquefied - cooling coefficient of performance - Thermodynamic efficiency - The energy balancing method.

**UNIT III THERMODYNAMIC CYCLES FOR CRYOGENIC PLANTS 8**

Classification of cryogenic cycles - The structure of cycles Throttle expansion cycles - Expander cycles - Mixed throttle expansion and expander cycles - Thermodynamic analysis - Numerical problems.

**UNIT IV PECULIAR PROBLEMS ASSOCIATED WITH CRYOPROPELLANTS 10**

Storage problems of cryogenic propellants - zero gravity problems associated with cryopropellants - phenomenon of tank collapse - geysering effect - material strength consideration.

**UNIT V CRYOGENIC ROCKET ENGINES 9**

Peculiar design difficulties associated with the design of feed system, injector and thrust chamber of cryogenic rocket engines - Relative performance of cryogenic engines when compared to non-cryo engines.

**TOTAL: 45 PERIODS**

**OUTCOMES:**

Upon completion of the course, students will understand the concepts of cryogenic propulsion systems and the design aspects of cryogenic rocket engines and also the problems associated with a cryopropellants and calculation of efficiencies of cryogenic systems.

**REFERENCES**

1. Barron.R.F. Cryogenic systems, Oxford University, 1985
2. Haseldom.G., Cryogenic Fundamentals, Academic press, 2001.
3. Hazel.K & Hungdh, "Design of Liquid Propellant Rocket Engines", NASA special publications, 125, 1971
4. Parner.S.F., Propellant Chemistry Reinfold Publishing Corproation New York, 1985.
5. Sutton.G.P., "Rocket Propulsion Elements", John Wiley, 8th Edition,2010

**AS5003 SPACE WEAPONS AND WARFARE**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**UNIT I INTRODUCTION 9**

Fundamentals concepts in missile trajectories and satellite orbits – Bombardment satellites – directed energy weapons – general characteristics – use of laser for missile targets – kinetic energy weapons above the atmosphere – weapons against terrestrial targets – conventional weapons against terrestrial targets.

**UNIT II EMPLOYMENT & COMMAND 9**

Functions and tasks – component and sequence about commanding space weapon systems – Advantages with respect to access and reach, responsiveness, distance and difficulty in defending against the weapons – Limitations and uses and implications.

**UNIT III BALLISTIC MISSILE DEFENCE 9**

Introduction to ballistic missile defence – Theatre Ballistic Missiles (TBM) – Classification – threat assessment – limitations and uncertainties - Threat analysis for Boost phase interception – Typical assessment errors.

**UNIT IV ARCHITECTURE AND EXTERNAL CUEING 9**

Selection of defended assets and threat scenario – defence system qualities and constraints – defence architecture process and development – External cueing process and uses – calculation of launch point – cued acquisition – Defence planning using external cueing – Radar degraded performance multiple radars and cue sources – system characteristics and use of cues.

**UNIT V INTERCEPTION GUIDANCE AND INTERCEPTION OF MANEUVERING TARGETS 9**

Proportional navigation geometry – proportional navigation linearized system and zero miss distance proportional navigation – optimal guidance law – mathematical modeling of pursuit – evasion – solution with constrained evader – stochastic analysis.

**TOTAL: 45 PERIODS**

**OUTCOME:**

Upon completion of this course, students will understand the advanced notions of missile trajectories and satellite orbits, defence architecture process and development, system characteristics and use of cues and to make use of the mathematical knowledge in modeling the physical processes.

**REFERENCES**


1. Space weapons and Earth wars by Sean Edwards, Bob Preston, Dand J Johnson and Jennifer Gross, 2002, RAND Publications, USA
2. Theatre Ballistic Missile Defense, Edited by Ben-Zion Naveh and Azrial Lorber, Progress in Astronautics and Aeronautics, Volume 192, published by AIAA, USA 2001


**AO5253 COMPUTATIONAL FLUID DYNAMICS FOR AEROSPACE APPLICATIONS**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**OBJECTIVES:**

- To introduce to the students various numerical solution methods pertaining to grid generation, time dependant and panel methods and also techniques pertaining to transonic small perturbation force.

**UNIT I NUMERICAL SOLUTIONS OF SOME FLUID DYNAMICAL PROBLEMS 9**

Basic fluid dynamics equations, Equations in general orthogonal coordinate system, Body fitted coordinate systems, Stability analysis of linear system. Finding solution of a simple gas dynamic problem, Local similar solutions of boundary layer equations, Numerical integration and shooting technique. Numerical solution for CD nozzle isentropic flows and local similar solutions of boundary layer equations.

**UNIT II GRID GENERATION 9**

Need for grid generation – Various grid generation techniques – Algebraic, conformal and numerical grid generation – importance of grid control functions – boundary point control – orthogonality of grid lines at boundaries. Elliptic grid generation using Laplace's equations for geometries like airfoil and CD nozzle.

**UNIT III TRANSONIC RELAXATION TECHNIQUES 9**

Small perturbation flows, Transonic small perturbation (TSP) equations, Central and backward difference schemes, conservation equations and shock point operator, Line relaxation techniques, Acceleration of convergence rate, Jameson's rotated difference scheme -stretching of coordinates, shock fitting techniques Flow in body fitted coordinate system. Numerical solution of 1-D conduction-convection energy equation using time dependent methods using both implicit and explicit schemes – application of time split method for the above equation and comparison of the results.

**UNIT IV TIME DEPENDENT METHODS 9**

Stability of solution, Explicit methods, Time split methods, Approximate factorization scheme, Unsteady transonic flow around airfoils. Some time-dependent solutions of gas dynamic problems. Numerical solution of unsteady 2-D heat conduction problems using SLOR methods

**UNIT V PANEL METHODS 9**

Elements of two and three dimensional panels, panel singularities. Application of panel methods to incompressible, compressible, subsonic and supersonic flows. Numerical solution of flow over a cylinder using 2-D panel methods using both vertex and source panel methods for lifting and non-lifting cases respectively.

**TOTAL: 45 PERIODS**

**OUTCOME:**
Upon completion of the course, Students will learn the flow of dynamic fluids by computational methods.

**REFERENCES**

1. A.A. Hirsch, 'Introduction to Computational Fluid Dynamics", McGraw-Hill, 1989.
2. C.Y.Chow, "Introduction to Computational Fluid Dynamics", John Wiley, 1979.
3. H.J. Wirz and J.J. Smeldern "Numerical Methods in Fluid Dynamics", McGraw-Hill & Co., 1978.
4. John D. Anderson, JR" Computational Fluid Dynamics", McGraw-Hill Book Co., Inc., New York, 1995.
5. T.J. Chung, Computational Fluid Dynamics, Cambridge University Press, 2002
6. T.K.Bose, "Computation Fluid Dynamics" Wiley Eastern Ltd., 1988.

**AO5254 COMPOSITE MATERIALS AND STRUCTURES** **L T P C**
**3 0 0 3**

**OBJECTIVE:**

- To impart knowledge to the students on the macro mechanics of composite materials, analysis and manufacturing methods of composite materials and introduce failure theories of composites.

**UNIT I INTRODUCTION 10**
Classification and characteristics of composite materials - Types of fiber and resin materials, functions and their properties – Application of composite to aircraft structures-Micromechanics-Mechanics of materials, Elasticity approaches-Mass and volume fraction of fibers and resins-Effect of voids, Effect of temperature and moisture.

**UNIT II MACROMECHANICS 10**
Hooke's law for orthotropic and anisotropic materials-Lamina stress-strain relations referred to natural axes and arbitrary axes.

**UNIT III ANALYSIS OF LAMINATED COMPOSITES 10**
Governing equations for anisotropic and orthotropic plates- Angle-ply and cross ply laminates-Analysis for simpler cases of composite plates and beams - Interlaminar stresses- Netting analysis.

**UNIT IV MANUFACTURING & FABRICATION PROCESSES 8**
Manufacture of glass, boron and carbon fibers-Manufacture of FRP components- Open mould and closed mould processes. Properties and functions of resins.

**UNIT V FAILURE THEORY AND NDE 7**
Failure criteria-Flexural rigidity of Sandwich beams and plates – composite repair- Ultra Sonic Technique - AE technique.

**TOTAL: 45 PERIODS**

**OUTCOME:**
Upon completion of the course, students will understand the fabrication, analysis and design of composite materials & structures.

**REFERENCES**

1. Autar K. Kaw, Mechanics of Composite Materials, CRC Press LLC, 1997
2. B.D. Agarwal and L.J. Broutman, “Analysis and Performance of fiber composites”, John-Wiley and Sons, 1990.
3. G.Lubin, “Hand Book on Fibre glass and advanced plastic composites”, Van Nostrand Co., New York, 1989.
4. J Prasad & CGK Nair Non-Destructive Testing and Evaluation of Material, Second Edition Paperback –ISBN-13: 978-0070707030,Amazon,2011
5. L.R. Calcote, “Analysis of laminated structures”, Van Nostrand Reinhold Co.,1989.
6. Michael Chun-Yung Niu Composite Airframe Structures Third Edition Conmilit Publishers 1997
7. P. Fordham, “Non-Destructive Testing Techniques” Business Publications, London, 1988.
8. R.M. Jones, “Mechanics of Composite Materials”, 2nd Edition, Taylor & Francis, 1999

**AO5073 ADVANCED PROPULSION SYSTEMS**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**OBJECTIVES**

- To familiarize the students on advanced air breathing propulsion systems like air augmented rockets, scramjets and also to introduce the students various technical details and operating principles of nuclear and electric propulsion.

**UNIT I THERMODYNAMIC CYCLE ANALYSIS OF AIR-BREATHING PROPULSION SYSTEMS 8**

Air breathing propulsion systems like Turbojet, turboprop, ducted fan, Ramjet and Air augmented rockets – Thermodynamic cycles – Pulse propulsion – Combustion process in pulse jet engines – inlet charging process – Subcritical, Critical and Supercritical charging.

**UNIT II RAMJETS AND AIR AUGMENTED ROCKETS 8**

Preliminary performance calculations – Diffuser design with and without spike, Supersonic inlets – combustor and nozzle design – integral Ram rocket.

**UNIT III SCRAMJET PROPULSION SYSTEM 12**

Fundamental considerations of hypersonic air breathing vehicles – Preliminary concepts in engine airframe integration – calculation of propulsion flow path – flow path integration – Various types of supersonic combustors – fundamental requirements of supersonic combustors – Mixing of fuel jets in supersonic cross flow – performance estimation of supersonic combustors.

**UNIT IV NUCLEAR PROPULSION 9**

Nuclear rocket engine design and performance – nuclear rocket reactors – nuclear rocket nozzles – nuclear rocket engine control – radioisotope propulsion – basic thruster configurations – thruster technology – heat source development – nozzle development – nozzle performance of radioisotope propulsion systems.

**UNIT V ELECTRIC AND ION PROPULSION 8**

Basic concepts in electric propulsion – power requirements and rocket efficiency – classification of thrusters – electrostatic thrusters – plasma thruster of the art and future trends – Fundamentals of ion propulsion – performance analysis – ion rocket engine.

**TOTAL: 45 PERIODS**

**OUTCOME:**
Upon completion of the course, students will learn in detail about gas turbines, ramjet, fundamentals of rocket propulsion and chemical rockets.

**REFERENCES**

1. Cumpsty, Jet propulsion, Cambridge University Press, 2003.
2. Fortescue and Stark, Spacecraft Systems Engineering, 1999.
3. G.P. Sutton, “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York,1998.
4. William H. Heiser and David T. Pratt, Hypersonic Air-breathing propulsion, AIAA Education Series, 2001.

**AO5072 COMPUTATIONAL HEAT TRANSFER** **L T P C**
**3 0 0 3**

**OBJECTIVES:**

- To make the students learn to solve conductive, transient conductive, convective, radiative heat transfer problems using computational methods.

**UNIT I INTRODUCTION 9**
Finite Difference Method-Introduction-Taylor’s series expansion - Discretization Methods Forward, backward and central differencing scheme for $I^{st}$ order and second order Derivatives – Types of partial differential equations-Types of errors. Solution to algebraic equation-Direct Method and Indirect Method-Types of boundary condition.
FDM - FEM - FVM.

**UNIT II CONDUCTIVE HEAT TRANSFER 9**
General 3D-heat conduction equation in Cartesian, cylindrical and spherical coordinates. Computation (FDM) of One –dimensional steady state heat conduction –with Heat generation- without Heat generation- 2D-heat conduction problem with different boundary conditions- Numerical treatment for extended surfaces. Numerical treatment for 3D- Heat conduction. Numerical treatment to 1D-steady heat conduction using FEM.

**UNIT III TRANSIENT HEAT CONDUCTION 9**
Introduction to Implicit, explicit Schemes and crank-Nicolson Schemes Computation(FDM) of One – dimensional un-steady heat conduction –with heat Generation-without Heat generation - 2D- transient heat conduction problem with different boundary conditions using Implicit, explicit Schemes. Importance of Courant number. Analysis for I-D,2-D transient heat Conduction problems.

**UNIT IV CONVECTIVE HEAT TRANSFER 9**
Convection- Numerical treatment (FDM) of steady and unsteady 1-D and 2-d heat convection-diffusion steady-unsteady problems- Computation of thermal and Velocity boundary layer flows. Upwind scheme. Stream function-vorticity approach-Creeping flow.

**UNIT V RADIATIVE HEAT TRANSFER 9**
Radiation fundamentals-Shape factor calculation-Radiosity method- Absorption Method-Monta-calro method-Introduction to Finite Volume Method- Numerical treatment of radiation enclosures using finite Volume method. Developing a numerical code for 1D, 2D heat transfer problems.

**TOTAL: 45 PERIODS**

**OUTCOME:**
Upon completion of the course, students will learn the concepts of computation applicable to heat transfer for practical applications.

**REFERENCES**
1. C.Y.Chow, "Introduction to Computational Fluid Dynamics", John Wiley, 1979.
2. J.P. Holman, "Heat Transfer", McGraw-Hill Book Co., Inc., New York, 6th Edition, 1991.
3. John D. Anderson, JR" Computational Fluid Dynamics", McGraw-Hill Book Co., Inc., New York, 1995.
4. John H. Lienhard, "A Heat Transfer Text Book", Prentice Hall Inc., 1981.
5. Pletcher and Tennahils " Computational Heat Trasnfer"…..
6. S.C. Sachdeva, "Fundamentals of Engineering Heat & Mass Transfer", Wiley Eastern Ltd., New Delhi, 1981.
7. T.J. Chung, Computational Fluid Dynamics, Cambridge University Press, 2002
8. Yunus A. Cengel, Heat Transfer – A Practical Approach Tata McGraw Hill Edition, 2003.

**AO5074 FATIGUE AND FRACTURE MECHANICS L T P C**
**3 0 0 3**

**OBJECTIVES**
- To make the students learn about fundamentals of fatigue & fracture mechanics, statistical aspects of fatigue behaviour & fatigue design and testing of aerospace structures.

**UNIT I FATIGUE OF STRUCTURES 10**
S.N. curves – Endurance limit – Effect of mean stress – Goodman, Gerber and Soderberg relations and diagrams – Notches and stress concentrations – Neuber's stress concentration factors – plastic stress concentration factors – Notched S-N curves.

**UNIT II STATISTICAL ASPECTS OF FATIGUE BEHAVIOUR 8**
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.

**UNIT III PHYSICAL ASPECTS OF FATIGUE 5**
Phase in fatigue life – Crack initiation – Crack growth – Final fracture – Dislocations – Fatigue fracture surfaces.

**UNIT IV FRACTURE MECHANICS 15**
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.

**UNIT V FATIGUE DESIGN AND TESTING 7**
Safe life and fail safe design philosophies – Importance of Fracture Mechanics in aerospace structure – Application to composite materials and structures.

**TOTAL: 45 PERIODS**

**OUTCOME:**
Upon completion of the course, students will learn about fracture behaviour, fatigue design and testing of structures.

**REFERENCES**
1. C.G.Sih, "Mechanics of Fracture", Vol.1 Sijthoff and Noordhoff International Publishing Co., Netherland, 1989.

2. D.Brock, “Elementary Engineering Fracture Mechanics”, Noordhoff International Publishing Co., London, 1994.
3. J.F.Knott, “Fundamentals of Fracture Mechanics”, Butterworth & Co., (Publishers) Ltd., London, 1983.
4. W.Barrois and L.Ripley, “Fatigue of Aircraft Structures”, Pergamon Press, Oxford, 1983.

**AS5004 STRUCTURAL DYNAMICS L T P C**
**3 0 0 3**

**OBJECTIVE:**

- To introduce the students the force deflection properties of structures, natural modes of vibration, principles of dynamics and energy and approximate methods for aerospace structures.

**UNIT I FORCE-DEFLECTION PROPERTIES OF STRUCTURES 10**

Constraints and Generalized coordinates – Virtual work and generalized forces – Force – Deflection influence functions – stiffness and flexibility methods.

**UNIT II PRINCIPLES OF DYNAMICS 10**

Free, Damped and forced vibrations of systems with finite degrees of freedom. D”Alembert’s principle – Hamilton’s principle – Lagrange’s equations of motion and its applications.

**UNIT III NATURAL MODES OF VIBRATION 10**

Equations of motion for free vibrations. Solution of Eigen value problems – Normal coordinates and orthogonality conditions of eigen vectors.

**UNIT IV ENERGY METHODS 8**

Rayleigh’s principle and Rayleigh – Ritz method. Coupled natural modes. Effect of rotary inertia and shear on lateral vibrations of beams.

**UNIT V APPROXIMATE METHODS 7**

Approximate methods of evaluating the eigen values and the dynamic response of continuous systems. Application of Matrix methods for dynamic analysis.

**TOTAL: 45 PERIODS**

**OUTCOME:**

Upon completion of the course, students will learn how to use the approximate methods for dynamic response of continuous systems.

**REFERENCES**

1. F.S.Tse, I.E. Morse and H.T. Hinkle, “Mechanical Vibration”, Prentice Hall of India Pvt., Ltd., New Delhi, 1988.
2. R.K. Vierck, “Vibration Analysis”, 2nd Edition, Thomas Y. Crowell & Co., Harper & Row Publishers, New York, U.S.A., 1989.
3. S.P. Timoshenko and D.H. Young, “Vibration Problems in Engineering”, John Willey & Sons Inc., 1984.
4. Von. Karman and A.Biot, “Mathematical Methods in Engineering”, McGraw-Hill Book Co., New York, 1985.
5. W.C. Hurty and M.F. Rubinstein, “Dynamics of Structures”, Prentice Hall of India Pvt., Ltd., New Delhi, 1987.

**AS5005 RELIABILITY AND QUALITY ASSURANCE**

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**OBJECTIVES:**

- To impart knowledge to students in statistical quality control, total quality management, failure data analysis and in quality systems.

**UNIT I STATISTICAL QUALITY CONTROL 9**

Methods and Philosophy of statistical process control – Control charts for variables Attributes – Cumulative sum and Exponentially weighted moving average control charts – Other SPC Techniques – Process – Capability analysis.

**UNIT II ACCEPTANCE SAMPLING 9**

Acceptance sampling problem – Single sampling plans for attributes – double multiple and sequential sampling – Military standards – The Dodge Roaming sampling plans.

**UNIT III INTRODUCTION TO TQM 9**

Need for quality – Definition of quality – Continuous process improvement – Contributions of Deming, Juran and Crosby - Basic concepts of TQM – Six Sigma: concepts, methodology, and application to manufacturing.

**UNIT IV FAILURE DATA ANALYSIS RELIABILITY PREDICTION 9**

Repair time distributions – Exponential, normal, log normal, gamma and Weibull – reliability data requirements – Graphical evaluation - Failure rate estimates – Effect of environment and stress – Series and Parallel systems – RDB analysis – Standby systems – Complex systems – Reliability demonstration testing – Reliability growth testing – Duane curve – Risk assessment – FMEA, Fault tree.

**UNIT V QUALITY SYSTEMS 9**

Need for ISO 9000, ISO 9000-2000 Quality system – Elements, Documentation, Quality auditing – QS 9000 – ISO 14000 – Concepts, Requirements and Benefits – Case studies of TQM implementation in manufacturing and service sectors including IT.

**TOTAL: 45 PERIODS**

**OUTCOME:**

Upon completion of this course, students will understand the advanced concepts of reliability and quality assurance manned space missions to the engineers and to provide the necessary mathematical knowledge that are needed in understanding their significance and operation. The students will have an exposure on various topics such as missile space stations, space vs earth environment, life support systems, mission logistics and planning and will be able to deploy these skills effectively in the understanding of reliability and quality assurance.

**REFERENCES**


1. Harvid Noori and Russel, Production and Operations Management – Total Quality and Responsiveness, McGraw Hill Inc., 1995
2. John Bank, The Essence of Total Quality Management, Prentice Hall of India Pvt ltd., 1995
3. Mohamed Zairi, Total Quality Management for Engineers, Woodhead Publishing Ltd., 1991
4. Suresh Dalela and Saurabh, ISO 900, A manual for Total Quality Management, S.Chand and Company Ltd., 1997.

**AO5091 HYPERSONIC AERODYNAMICS** **L T P C**
**3 0 0 3**

**OBJECTIVES:**

- To make students learn the peculiar hypersonic speed flow characteristics pertaining to flight vehicles and the approximate solution methods for hypersonic flows. The objective is also to impart knowledge on hypersonic viscous interactions and their effect on aerodynamic heating.

**UNIT I BASICS OF HYPERSONIC AERODYNAMICS 8**

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.

**UNIT II SURFACE INCLINATION METHODS FOR HYPERSONIC INVISCID FLOWS 9**

Local surface inclination methods – modified Newtonian Law – Newtonian theory – tangent wedge or tangent cone and shock expansion methods – Calculation of surface flow properties

**UNIT III APPROXIMATE METHODS FOR INVISCID HYPERSONIC FLOWS 9**

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.

**UNIT IV VISCOUS HYPERSONIC FLOW THEORY 10**

Navier–Stokes equations – boundary layer equations for hypersonic flow – hypersonic boundary layer – hypersonic boundary layer theory and non similar hypersonic boundary layers – hypersonic aerodynamic heating and entropy layers effects on aerodynamic heating – heat flux estimation.

**UNIT V VISCOUS INTERACTIONS IN HYPERSONIC FLOWS 9**

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.

**TOTAL: 45 PERIODS**

**OUTCOME:**

Upon completion of the course, students will learn basics of hypersonic flow, shock wave - boundary layer interaction and hypersonic aerodynamic heating.

**REFERENCES**


1. John D. Anderson, Jr, Hypersonic and High Temperature Gas Dynamics, McGraw-Hill Series, New York, 1996.
2. John T. Bertin, Hypersonic Aerothermodynamics, 1994 AIAA Inc., Washington D.
3. John.D.Anderson, Jr., Modern Compressible Flow with Historical perspective Hypersonic Series.
4. William H. Heiser and David T. Pratt, Hypersonic Air Breathing propulsion, AIAA Education Series.


**AS5006 MISSILE GUIDANCE AND CONTROL** **L T P C**
**3 0 0 3**

**OBJECTIVE:**

- To impart knowledge to students on basic missile configurations and preliminary drag estimation. The objective is also to introduce slender body aerodynamics, aerodynamic aspects during launching phase and stability and control aspects of missile.

**UNIT I MISSILE SYSTEMS INTRODUCTION 8**

History of guided missile for defence applications- Classification of missiles– The Generalized Missile Equations of Motion- Coordinate Systems- Lagrange's Equations for Rotating Coordinate Systems- Rigid-Body Equations of Motion-missile system elements, missile ground systems.

**UNIT II MISSILE AIRFRAMES, AUTOPILOTS AND CONTROL 9**

Missile aerodynamics- Force Equations, Moment Equations, Phases of missile flight. Missile control configurations. Missile Mathematical Model. Autopilots — Definitions, Types of Autopilots, Example Applications. Open-loop autopilots. Inertial instruments and feedback. Autopilot response, stability, and agility- Pitch Autopilot Design, Pitch-Yaw-Roll Autopilot Design.

**UNIT III MISSILE GUIDANCE LAWS 10**

Tactical Guidance Intercept Techniques, Derivation of the Fundamental Guidance Equations, explicit, Proportional Navigation, Augmented Proportional Navigation, beam riding, bank to turn missile guidance, Three-Dimensional Proportional Navigation, comparison of guidance system performance, Application of Optimal Control of Linear Feedback Systems.

**UNIT IV STRATEGIC MISSILES 10**

Introduction, The Two-Body Problem, Lambert's Theorem, First-Order Motion of a Ballistic Missile , Correlated Velocity and Velocity-to-Be-Gained Concepts, Derivation of the Force Equation for Ballistic Missiles, Atmospheric Reentry, Ballistic Missile Intercept, Missile Tracking Equations of Motion, Introduction to Cruise Missiles , The Terrain-Contour Matching (TERCOM) Concept.

**UNIT V WEAPON DELIVERY SYSTEMS 8**

Weapon Delivery Requirements, Factors Influencing Weapon Delivery Accuracy, Unguided Weapons, The Bombing Problem, Guided Weapons, Integrated Flight Control in Weapon Delivery, Missile Launch Envelope, and Mathematical Considerations Pertaining to the Accuracy of Weapon Delivery Computations.

**TOTAL: 45 PERIODS**

**OUTCOME:**

Upon completion of this course, students will understand the advanced concepts of missile guidance and control to the engineers and to provide the necessary mathematical knowledge that are needed in understanding the physical processes. The students will have an exposure on various topics such as missile systems, missile airframes, autopilots, guidance laws and will be able to deploy these skills effectively in the understanding of missile guidance and control.

**REFERENCES:**

1. Blakelock, J. H.; Automatic Control of Aircraft and Missiles, 2nd Edition, John Wiley & Sons, 1990.
2. Fleeman, Eugene L.; Tactical Missile Design, First Edition, AIAA Education series, 2001.
3. Garnell, P., "Guided Weapon Control Systems", 2nd Edition, Pergamon Press, 1980.
4. Joseph Ben Asher and Isaac Yaesh "Advances in Missile Guidance Theory" AIAA Education series, 1998
5. Paul Zarchan "Tactical and Strategic Missile Guidance" AIAA Education series,2007
6. Siouris, G.M. "Missile Guidance and control systems", Springer, 2003.

**AS5007** **TRANSONIC AERODYNAMICS** **L T P C**
**3 0 0 3**

**OBJECTIVES:**

- Students will be exposed to linearized theory and unsteady flow characteristics of transonic flow.
- Students will also learn transonic expansion procedures and design and operation of transonic wind tunnels

**UNIT I INTRODUCTION** **6**

Concepts and Properties of Transonic flow-Fundamental Equations-Similarity rule.

**UNIT II LINEARIZED THEORY** **9**

Equations of Acoustics. Galilean Transformation - Uniform Translation. Slender Body Theory - Acoustics. Exact Equations of Planar Flow; Shock Waves and Entropy Jump. Linearized Theory for Thin Airfoils.

**UNIT III TRANSONIC EXPANSION PROCEDURES** **12**

**Simple Solutions, Integral Relations -** Expansion Procedure for Steady Flow Past Airfoils. Expansion Procedure Applied to the Basic System of Equations. Expansion Procedures for Jet Flows. Transonic Similarity Rules. Hodograph Equations for Planar Flow. Simple Waves, Shock Waves, Detachment. Nozzle Flow, Branch Lines, Limit Lines. Subsonic and Sonic Jets. Transonic Slender Bodies; Expansion Procedure, Area Rule. Lift and Drag Integrals. Unsteady Transonic Flow.

**UNIT IV TRANSONIC AIRFOIL THEORY** **9**

Problem Formulation. Nose Singularity. Shock Waves at a Curved Surface. Numerical Methods-TSP equations - Solution Methods - Physical Plane, Steady Flow. Airfoils at Sonic Velocity. The Stabilization Law.

**UNIT V TRANSONIC WIND TUNNELS** **9**

Wind tunnels- Wide slots, Narrow slots- slotted walls - Slotted walls with perforated Cover Plates-Transonic testing with wing flow Technique-Movable walls, Slotted walls, Perforated walls.

**TOTAL : 45 PERIODS**

**OUTCOME:**

Upon completion of the course the students will be able to understand the linearized theory and unsteady flow characteristics of transonic flow. Students will also learn transonic expansion procedures and design and operation of transonic wind tunnels

**REFERENCES:**


1. Bernhard H.Goethert "Transonic Wind tunnel Testing" Pergamon Press,1961.
2. Cole and Cook, "Transonic Aerodynamics", 1st Edition,1975.
3. K. Gottfried Guderley," The theory of transonic flow", Pergamon Press, 1962


**AS5008** **ORBITAL MECHANICS AND SPACE FLIGHT** **L T P C**
**3 0 0 3**

**OBJECTIVE:**

- To introduce concepts of satellite injection and satellite perturbations, trajectory computation for interplanetary travel and flight of ballistic missiles based on the fundamental concepts of orbital mechanics.

**UNIT I SPACE ENVIRONMENT 8**

Peculiarities of space environment and its description– effect of space environment on materials of spacecraft structure and astronauts- manned space missions – effect on satellite life time

**UNIT II BASIC CONCEPTS AND THE GENERAL N- BODY PROBLEM 10**

The solar system – reference frames and coordinate systems – terminology related to the celestial sphere and its associated concepts – 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.

**UNIT III SATELLITE INJECTION AND SATELLITE PERTURBATIONS 10**

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.

**UNIT IV INTERPLANETARY TRAJECTORIES 8**

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

**UNIT V BALLISTIC MISSILE TRAJECTORIES 9**

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 – influence coefficients.

**TOTAL: 45 PERIODS**

**OUTCOME:**

Upon completion of this course, students will understand the advanced concepts of satellite injection and satellite perturbations, trajectory computation for interplanetary travel and flight of ballistic missiles based on the fundamental concepts of orbital mechanics.

**REFERENCES:**


1. Cornelisse, J.W., "Rocket Propulsion and Space Dynamics", J.W. Freeman &Co.,Ltd, London, 1982
2. Parker, E.R., "Materials for Missiles and Spacecraft", Mc.Graw Hill Book Co. Inc., 1982.
3. Sutton, G.P., "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 5$^{th}$ Edition, 1993.


**AS5009 DIGITAL IMAGE PROCESSING FOR AEROSPACE APPLICATIONS L T P C**
**3 0 0 3**

**UNIT I FUNDAMENTALS OF IMAGE PROCESSING 9**

Introduction – Elements of visual perception, Steps in Image Processing Systems – Image Acquisition – Sampling and Quantization – Pixel Relationships – Colour Fundamentals and Models, File Formats Introduction to the Mathematical tools

**UNIT II IMAGE ENHANCEMENT 9**

Spatial Domain Gray level Transformations Histogram Processing Spatial Filtering – Smoothing and Sharpening. Frequency Domain: Filtering in Frequency Domain – DFT, FFT, DCT, Smoothing and Sharpening filters – Homomorphic Filtering.

**UNIT III IMAGE SEGMENTATION AND FEATURE ANALYSIS 9**

Detection of Discontinuities – Edge Operators – Edge Linking and Boundary Detection – Thresholding – Region Based Segmentation – Motion Segmentation, Feature Analysis and Extraction.

**UNIT IV MULTI RESOLUTION ANALYSIS 9**

Multi Resolution Analysis: Image Pyramids – Multi resolution expansion – Wavelet Transforms, Fast Wavelet transforms, Wavelet Packets.

**UNIT V AEROSPACE APPLICATIONS 9**

Principles of digital aerial photography- Sensors for aerial photography - Aerial Image Exploration - Photo-interpretation, objective analysis and image quality - Image Recognition - Image Classification – Image Fusion – Colour Image Processing - Video Motion Analysis – Case studies – vision based navigation and control.

**TOTAL: 45 PERIODS**

**OUTCOME:**

Upon completion of this course, students will understand the advanced concepts of Image processing for aerospace applications to the engineers and to provide the necessary mathematical knowledge that are needed in modeling physical processes. The students will have an exposure on various topics such as Image enhancement, Wavelet transforms, multi-resolution analysis and vision based navigation and control and will be able to deploy these skills effectively in the solution of problems in avionics engineering.

**REFERENCES:**


1. Anil K.Jain, “Fundamentals of Digital Image Processing”, Prentice-Hall India, 2007.
2. Madhuri A. Joshi, ‘Digital Image Processing: An Algorithmic Approach”, Prentice-Hall India, 2006.
3. Milan Sonka, Vaclav Hlavac and Roger Boyle, “Image Processing, Analysis and Machine Vision”, Third Edition, Third Edition, Brooks Cole, 2008.
4. Rafael C.Gonzalez, Richard E.Woods and Steven L. Eddins, “Digital Image Processing Using MATLAB”, First Edition, Pearson Education, 2004.
5. Rafael C.Gonzalez and Richard E.Woods, “Digital Image Processing”, Third Edition, Pearson Education, 2008
6. Ron Graham, Alexander Koh, ”Digital Aerial Survey: Theory and Practice”, Whittles Publishing; First edition,2002


**AS5010 MATHEMATICAL MODELING AND SIMULATION**

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**UNIT I SYSTEM MODELS AND SIMULATION 7**

Continuous and discrete systems, System modeling, Static models, Dynamic models, Principles used in modeling the techniques of simulation, Numerical computation techniques for models, Distributed lag models, Cobweb models.

**UNIT II PROBABILITY, CONCEPTS IN SIMULATION 8**

Stochastic Variables, Discrete probability functions, continuous probability function, Measure of probability functions, Continuous uniformly distributed random number, Congestion in systems, Arrival patterns, Various types of distribution.

**UNIT III SYSTEM SIMULATION 10**

Discrete events, Representation of time, Generation of arrival patterns, Simulation programming tasks, Gathering statistics, Counters and summary statistics, Simulation language. Continuous System models, Differential equation, Analog methods, digital analog simulators, Continuous system simulation language (CSSLs), Hybrid simulation, Simulation of an autopilot, Interactive systems.

**UNIT IV SYSTEM DYNAMICS AND MATHEMATICAL MODELS FOR FLIGHT SIMULATION 12**

Historical background growth and decay models, System dynamics diagrams, Multi – segment models, Representation of time delays, The Dynamo Language Elements of Mathematical models, Equation of motion, Representation of aerodynamics data, Aircraft systems, Structure and cockpit systems, Motion system, Visual system, Instructor's facilities.

**UNIT V FLIGHT SIMULATOR AS A TRAINING DEVICE AND RESEARCH TOOL 8**

Introduction, advantage of simulator, the effectiveness of Simulator, The user's role, Simulator Certification, Data sources, Validation, in- flight simulators

**TOTAL: 45 PERIODS**

**OUTCOME:**

Upon completion of this course, students will understand the advanced concepts of Mathematical Modeling and Simulation to the engineers and to provide the necessary mathematical knowledge that are needed in modeling physical processes. The students will have an exposure on various topics such as System Models, probability concepts in simulation and flight simulators and will be able to deploy these skills effectively in the understanding the concepts and working of a flight simulator.

**REFERENCES:**


1. Gordon. G., "System Simulation" , Prentice – Hall Inc., 1992.
2. Stables, K.J. and Rolfe, J.M. "Flight Simulation", Cambridge University Press, 1986.


**AO5075 HIGH SPEED JET FLOWS**

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**OBJECTIVES:**

To make the students learn about various jet control methods, jet acoustics aspects and free shear layer flow theory pertaining to turbulent jets with high speed.

**UNIT I INTRODUCTION 9**

Types of nozzles – over expanded and under expanded flows - Isentropic flow through nozzles– Interaction of nozzle flows over adjacent surfaces – Mach disk - Jet flow – types - Numerical problems.

**UNIT II COMPRESSIBLE FLOW THEORY 9**

One-dimensional compressible fluid flow – flow through variable area passage – nozzles and diffusers – normal and oblique shock waves and calculation of flow and fluid properties across the shocks and expansion fans. Interaction of shocks with solid and fluid surface.

**UNIT III JET CONTROL 9**

Types of jet control - single jet, multi jet, co-flow jet, parallel flow jet. Subsonic jets- Mathematical treatment of jet profiles- Theory of Turbulent jets- Mean velocity and mean temperature- Turbulence characteristics of free jets- Mixing length- Experimental methods for studying jets and the Techniques used for analysis- Expansion levels of jets- Over-expanded, Correctly expanded, Under-expanded jets - Control of jets. Centre line decay, Mach number Profile, Iso-Mach (or iso-baric) contours, Shock cell structure in under-expanded and over-expanded jets, Mach discs.

**UNIT IV BOUNDARY LAYER CONCEPT 9**

Boundary Layer – displacement and momentum thickness- laminar and turbulent boundary layers over flat plates – velocity distribution in turbulent flows over smooth and rough boundaries- laminar sublayer. Shock-boundary layer interactions.

**UNIT V JET ACOUSTICS 9**

Introduction to Acoustic – Types of noise – Source of generation- Traveling wave solution- standing wave solution – multi-dimensional acoustics -Noise suppression techniques– applications to problems.

**TOTAL: 45 PERIODS**

**OUTCOME:**

Upon completion of this course, students will be able to understand various jet control methods, jet acoustics aspects and free shear layer flow theory pertaining to turbulent jets with high speed.

**REFERENCES**


1. Ethirajan Rathakrishnan, “Applied Gas Dynamics”, John Wiley, NY, 2010.
2. Liepmann and Roshko, “Elements of Gas Dynamics”, John Wiley, NY, 1963.
3. Rathakrishnan E., “Gas Dynamics***”***, Prentice Hall of India, New Delhi, 2008.
4. Shapiro*,* AH, “Dynamics and Thermodynamics of Compressible Fluid Flow”, Vols. I & II, Ronald Press, New York, 1953.