# B.E. AERO
# R-2023
## CURRICULUM & SYLLABUS
### (CHOICE BASED CREDIT SYSTEM)

**RAJALAKSHMI ENGINEERING COLLEGE**
**(An Autonomous Institution Affiliated to Anna University Chennai)**

**DEPARTMENT OF AERONAUTICAL ENGINEERING**
**CBCS CURRICULUM AND SYLLABUS R – 2023**
**B.E., AERONAUTICAL ENGINEERING**

## VISION

To provide excellent graduate education in Aeronautical Engineering and continuously support the community of aerospace professionals that will spearhead and strengthen the design and development of Aerospace related industries and institutions in India.

## MISSION

- To impart quality exposure in theory and practical with proficiency, skill and humane values with the best of teaching and industrial expertise.
- To continuously strengthen the laboratory learning of students in tune with the best industry processes and practices.
- To ensure the updated knowledge and skill sets of students in emerging technologies.
- To provide the students the right ambience and opportunities to develop into creative, talented and globally competent Aero professionals.
- To promote research and development activities in the sphere of aeronautics for the benefit of the society.

## Program Educational Objectives (PEOs)

1. Our graduates have the ability to apply knowledge across the disciplines and in emerging areas of Aerospace Engineering for higher studies, research, employability and product development.
2. Our graduates have the communication skills, sense of responsibility to protect the environment and ethical conduct towards their profession and commitment to serve the society.
3. Our graduates possess academic excellence, managerial skills, leadership qualities and understand the need for lifelong learning for a successful professional career.

## Programme Outcomes (POs)

Engineering Graduates will be able to,

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

## Programme Specific Outcome (PSOs)

A graduate of the Aeronautical Engineering program will

1. Develop deep working knowledge to solve complex problems in aerodynamics, propulsion, structures and flight mechanics
2. Demonstrate the problem-solving ability and hands-on skills to enter careers in the design, manufacturing, testing, or maintenance of aeronautical systems.
3. Be equipped to use CAE packages and simulation language skills to solve practical, design and analysis problems.

# CBCS CURRICULUM AND SYLLABUS
# B.E. AERONAUTICAL ENGINEERING
# REGULATION 2023
# CURRICULUM

## SEMESTER I

| Sl. No | COURSE CODE | COURSE TITLE | CATEGORY | CONTACT PERIODS | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| 1 | HS23111 | Technical Communication I | HS | 2 | 2 | 0 | 0 | 2 |
| 2 | MA23112 | Algebra and Calculus | BS | 4 | 3 | 1 | 0 | 4 |
| 3 | PH23131 | Physics of Materials | BS | 5 | 3 | 0 | 2 | 4 |
| 4 | GE23111 | Engineering Graphics | ES | 6 | 2 | 0 | 4 | 4 |
| 5 | GE23117 | தமிழர் மரபு /Heritage of Tamils | HS | 1 | 1 | 0 | 0 | 1 |
| 6 | EE23133 | Basic Electrical and Electronics Engineering | ES | 5 | 3 | 0 | 2 | 4 |
| 7 | MC23112 | Environmental Science and Engineering | MC | 3 | 3 | 0 | 0 | 0 |
| 8 | GE23121 | Engineering Practices - Civil and Mechanical | ES | 2 | 0 | 0 | 2 | 1 |
| **TOTAL** | | | | **28** | **17** | **1** | **10** | **20** |

## SEMESTER II

| Sl. No | COURSE CODE | COURSE TITLE | CATEGORY | CONTACT PERIODS | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| 1 | HS23221/ HS23222 | Technical Communication II / English for Professional Competence | HS | 2 | 0 | 0 | 2 | 1 |
| 2 | MA23212 | Differential Equation and Complex variables | BS | 4 | 3 | 1 | 0 | 4 |
| 3 | CY23233 | Engineering Chemistry | BS | 5 | 3 | 0 | 2 | 4 |
| 4 | GE23211 | Engineering Mechanics | ES | 3 | 2 | 1 | 0 | 3 |
| 5 | AE23211 | Fundamentals of Aerospace Engineering | PC | 3 | 3 | 0 | 0 | 3 |
| 6 | GE23233 | Problem Solving and Python Programming | ES | 6 | 2 | 0 | 4 | 4 |
| 7 | GE23217 | தமிழரும் தொழில்நுட்பமும் / Tamils and Technology | HS | 1 | 1 | 0 | 0 | 1 |
| 8 | MC23111 | Indian Constitution and Freedom Movement | MC | 3 | 3 | 0 | 0 | 0 |
| 9 | GE23122 | Engineering Practices - Electrical and Electronics | ES | 2 | 0 | 0 | 2 | 1 |
| **TOTAL** | | | | **29** | **17** | **2** | **10** | **21** |

## SEMESTER III

| Sl. No | COURSE CODE | COURSE TITLE | CATEGORY | CONTACT PERIODS | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| 1 | MA23311 | Transforms and Applied Partial Differential Equations | BS | 4 | 3 | 1 | 0 | 4 |
| 2 | AE23331 | Solid Mechanics | PC | 5 | 2 | 1 | 2 | 4 |
| 3 | AE23332 | Fluid Mechanics and Fluid Machinery | PC | 5 | 2 | 1 | 2 | 4 |
| 4 | AE23333 | Aero Engineering Thermodynamics | PC | 5 | 2 | 1 | 2 | 4 |
| 5 | CS23422 | Python Programming for Machine Learning | ES | 4 | 0 | 0 | 4 | 2 |
| 6 | | Open elective - I | OE | 3 | 3 | 0 | 0 | 3 |
| 7 | AE23321 | Computer Aided Modelling Laboratory | PC | 4 | 0 | 0 | 4 | 2 |
| **TOTAL** | | | | **30** | **12** | **4** | **14** | **23** |

## SEMESTER IV

| Sl. No | COURSE CODE | COURSE TITLE | CATEGORY | CONTACT PERIODS | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| 1 | MA23432 | Statistics and Numerical Methods | BS | 4 | 3 | 0 | 2 | 4 |
| 2 | AE23411 | Aircraft Structures - I | PC | 3 | 2 | 1 | 0 | 3 |
| 3 | AE23412 | Control Engineering | PC | 3 | 3 | 0 | 0 | 3 |
| 4 | AE23431 | Incompressible Aerodynamics | PC | 5 | 2 | 1 | 2 | 4 |
| 5 | AE23432 | Aircraft Materials and Processes | PC | 5 | 3 | 0 | 2 | 4 |
| 6 | AE23433 | Aircraft Systems and Instruments | PC | 5 | 3 | 0 | 2 | 4 |
| 7 | GE23421 | Soft Skills – 1 | EEC | 2 | 0 | 0 | 2 | 1 |
| | | Value Added Program – I[#] | EEC | 2 | 0 | 0 | 2 | 1[#] |
| **TOTAL** | | | | **27** | **16** | **2** | **10** | **23** |

[#]credit not to consider for CGPA

## SEMESTER V

| Sl. No | COURSE CODE | COURSE TITLE | CATEGORY | CONTACT PERIODS | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| 1 | AE23511 | Aircraft Propulsion | PC | 3 | 2 | 1 | 0 | 3 |
| 2 | AE23512 | Compressible Aerodynamics | PC | 3 | 2 | 1 | 0 | 3 |
| 3 | AE23513 | Flight Dynamics | PC | 4 | 3 | 1 | 0 | 4 |
| 4 | AE23531 | Aircraft Structures - II | PC | 5 | 2 | 1 | 2 | 4 |
| 5 | | Professional Elective – I | PE | 3 | 3 | 0 | 0 | 3 |
| 6 | | Open Elective – II | OE | 3 | 3 | 0 | 0 | 3 |
| 7 | GE23521 | Soft Skills – II | EEC | 2 | 0 | 0 | 2 | 1 |
| 8 | AE23521 | Computational Simulation Laboratory | PC | 4 | 0 | 0 | 4 | 2 |
| 9 | AE23522 | Internship | EEC | 0 | 0 | 0 | 2 | 1 |
| **TOTAL** | | | | **27** | **15** | **4** | **10** | **24** |

## SEMESTER VI

| Sl. No | COURSE CODE | COURSE TITLE | CATEGORY | CONTACT PERIODS | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| 1 | AE23611 | Rocket and Missile Propulsion | PC | 3 | 2 | 1 | 0 | 3 |
| 2 | AE23631 | Flight Vehicle Design | PC | 5 | 3 | 0 | 2 | 4 |
| 3 | | Professional Elective – II | PE | 3 | 3 | 0 | 0 | 3 |
| 4 | | Professional Elective – III | PE | 3 | 3 | 0 | 0 | 3 |
| 5 | GE23627 | Design Thinking and Innovation | EEC | 4 | 0 | 0 | 4 | 2 |
| 6 | AE23622 | Jet propulsion Laboratory | PC | 4 | 0 | 0 | 4 | 2 |
| 7 | AE23623 | Airframe Repair and Aero Engine Laboratory | PC | 4 | 0 | 0 | 4 | 2 |
| 8 | GE23621 | Problem Solving Techniques | EEC | 2 | 0 | 0 | 2 | 1 |
| **TOTAL** | | | | **28** | **11** | **1** | **16** | **20** |

## SEMESTER VII

| Sl. No | COURSE CODE | COURSE TITLE | CATEGORY | CONTACT PERIODS | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| 1 | AE23731 | Avionics | PC | 5 | 3 | 0 | 2 | 4 |
| 2 | AE23711 | Composite Materials and Structures | PC | 3 | 3 | 0 | 0 | 3 |
| 3 | GE23311 | Fundamentals of Management for Engineers | HS | 3 | 3 | 0 | 0 | 3 |
| 4 | | Professional Elective – IV | PE | 3 | 3 | 0 | 0 | 3 |
| 5 | | Professional Elective – V | PE | 3 | 3 | 0 | 0 | 3 |
| 6 | AE23721 | Project Work Phase I | EEC | 4 | 0 | 0 | 4 | 2 |
| 7 | AE23722 | Artificial Intelligence and Machine Learning for Aeronautical Engineering | PC | 4 | 0 | 0 | 4 | 2 |
| | | Value Added Program – II[#] | EEC | 2 | 0 | 0 | 2 | 1 |
| **TOTAL** | | | | **25** | **15** | **0** | **10** | **20** |

#credit not to consider for CGPA

## SEMESTER VIII

| Sl. No | COURSE CODE | COURSE TITLE | CATEGORY | CONTACT PERIODS | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| 1 | | Professional Elective VI | PE | 3 | 3 | 0 | 0 | 3 |
| 2 | AE23821 | Project Work Phase II | EEC | 16 | 0 | 0 | 16 | 8 |
| **TOTAL** | | | | **19** | **3** | **0** | **16** | **11** |

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### CREDIT DISTRIBUTION – SEMESTER WISE

| SEMESTER | NO. OF CREDITS |
|---|---|
| I | 20 |
| II | 21 |
| III | 23 |
| IV | 23 |
| V | 24 |
| VI | 20 |
| VII | 20 |
| VIII | 11 |
| **TOTAL** | **162** |

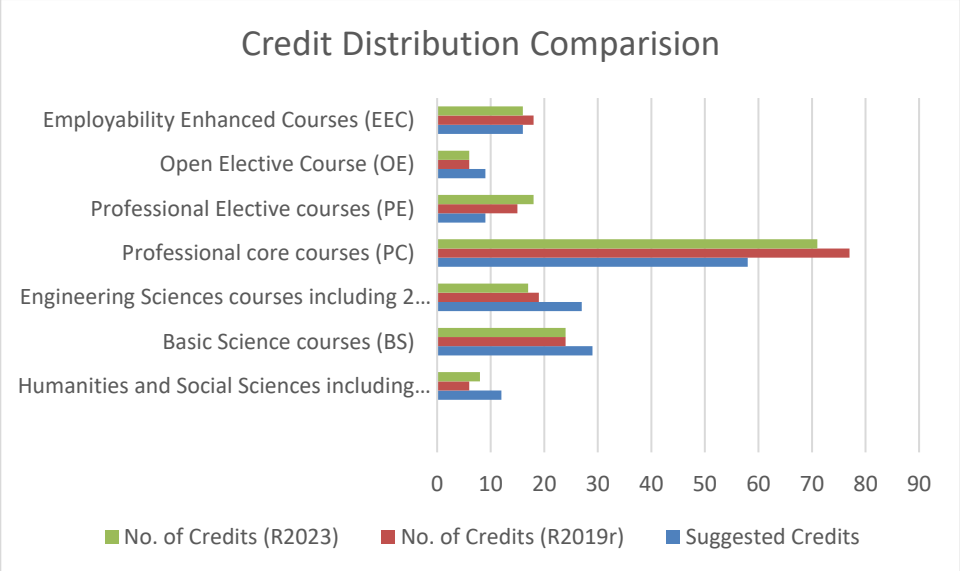
# VERTICALS for PROFESSIONAL ELECTIVES and HONOURS

| Semester | VERTICAL 1 | VERTICAL 2 | VERTICAL 3 | VERTICAL 4 | DIVERSIFIED COURSES |
|---|---|---|---|---|---|
| | **Aerodynamics** | **Propulsion** | **Structures And Materials** | **Drone Technology** | |
| V | AE23A11 - Computational Aerodynamics | AE23B11 - Heat Transfer for Aerospace | AE23C11 - Theory of Elasticity | **AE23D11 - Fundamentals of UAV Systems and Design** | AE23E11 - Mechanics of Machines |
| | AE23A12 - Applied Aerodynamics | AE23B12– Fundamentals of Refrigeration and Cryogenics | AE23C12 - Finite Element Method | **AE23D12 - Drone Computing Systems** | AE23E12 - Aircraft General Engineering and Maintenance Practices |
| VI | AE23A13 - Experimental Aerodynamics | AE23B13 - Computational Heat transfer | AE23C13 - Introduction to Vibrations | **AE23D13 - Electronic Warfare** | AE23E13 - Modern Manufacturing Processes |
| | AE23A14 - Missile Aerodynamics | AE23B14 - Turbo Machines | AE23C14 - Fatigue and Fracture | **AE23D14 - Embedded Systems in UAV** | AE23E14 - Airframe Repair and Maintenance |
| VII | AE23A15 - Hypersonic Aerodynamics | AE23B15 - Design of Gas Turbine Engine components | AE23C15 - Theory of Plates and Shells | **AE23D15 - Image Processing Techniques for UAV** | AE23E15 - Civil Aviation Requirements |
| | AE23A16 - Helicopter Theory | AE23B16 - Advanced Propulsion Systems | AE23C16 - Aeroelasticity | **AE23D16 - Drone Safety rules and Regulations** | ME23712 - Total Quality Management |
| | AE23A17 - Introduction to Aeroacoustics | AE23B17- Combustion and Flames | AE23C17 - Non-Destructive Evaluation | AE23D17 - Fault Tolerant Control | AE23E17 - Aero Engine Maintenance and Repair |
| VIII | AE23A18 - Turbulence modeling in Fluid Flows | AE23B18 - High-temperature Gas Dynamics | AE23C18 - Experimental stress Analysis | AE23D18 - Air Traffic Control and Planning | AE23E18 - Entrepreneurship for Engineers |
| | AE23A19 - Boundary Layer Theory | AE23B19 - Spray Theory | AE23C19 - Material Testing and Characterization | AE23D19 - Missile Systems | AE23E19 - Spaceflight Mechanics |

## STRUCTURE OF UNDERGRADUATE ENGINEERING PROGRAM

| Sl. No | Category | Suggested Credits (AICTE)* | No. of Credits (R2019r) | No. of Credits (R2023) | % Distribution (R2023) |
|---|---|---|---|---|---|
| 1 | Humanities and Social Sciences including Management courses (HS) | 12 | 6 | 8 | 4.9 |
| 2 | Basic Science courses (BS) | 29 | 24 | 24 | 14.8 |
| 3 | Engineering Sciences courses including 2 programming subjects (ES) | 27 | 19 | 19 | 11.7 |
| 4 | Professional core courses (PC) | 58 | 77 | 71 | 43.8 |
| 5 | Professional Elective courses (PE) | 9 | 15 | 18 | 11.1 |
| 6 | Open Elective Course (OE) | 9 | 6 | 6 | 3.7 |
| 7 | Employability Enhanced Courses (EEC) | 16 | 18 | 16 | 9.9 |
| 8 | Mandatory Courses (MC) [Environmental Sciences, Induction training, Indian Constitution, Essence of Indian Traditional Knowledge] | 0 | 0 | 0 | 0 |

*AICTE model curriculum (aicte-india.org)

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## TENTATIVE LIST OF VAP COURSES

| S. No | Semester | Title of VAP (tentative) |
|---|---|---|
| 1 | IV | Aircraft Component Drawing |
| 2 | VII | RC Plane Modeling |

# OPEN ELECTIVES OFFERED BY AERO

| S.NO. | COURSE CODE | COURSE TITLE | CATEGORY | L | T | P | C |
|---|---|---|---|---|---|---|---|
| 1 | OAE2301 | Fundamentals of Jet Propulsion | OE | 3 | 0 | 0 | 3 |
| 2 | OAE2302 | Introduction to Space Flight | OE | 3 | 0 | 0 | 3 |

# SEMESTER I

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **HS 23111** | **TECHNICAL COMMUNICATION I** | Theory | 2 | 0 | 0 | 2 |

(Common to all branches of B.E/B. Tech programmes – First Semester)

**Objectives:**

To facilitate students develop their comprehension skills
To enable students to improve their receptive skills
To equip learners with better vocabulary and enhance their writing skills
To aid students speak effectively in all kinds of communicative contexts.
To improve the learners' basic proficiency in workplace communication

**UNIT-I DEVELOPING COMPREHENSION SKILLS** 6

**Listening**: Introduction to Informational listening – Listening to Podcasts, News
**Reading**: Short Narratives and Skimming Passages.
**Speaking:** Introducing Oneself, Narrating a Story / Incident.
**Writing:** Sequential Writing (Jumbled Sentences), Process Description
**Grammar:** Verbs – Main & Auxiliary: Simple Tenses – Form, Function and Meaning.
**Vocabulary**: Word formation – Prefix, Suffix, Compound Words.

**UNIT-II LISTENING AND EXTENDED READING** 6

**Listening**: Deep Listening – Listening to Talk Shows and Debates
**Reading**: In-depth Reading - Scanning Passages
**Speaking**: Describing Current Issues, Happenings, etc..,
**Writing**: Note Making, Note Taking – Paragraph Writing
**Grammar**: Continuous Tenses, Prepositions, Articles
**Vocabulary**: One Word Substitutes, Phrasal Verbs.

**UNIT-III FORMAL WRITING AND VERBAL ABILITY** 6

**Listening:** Listening to Lectures and Taking Notes
**Reading:** Interpretation of Tables, Charts and Graphs
**Speaking:** SWOT Analysis on Oneself
**Writing:** Formal Letter Writing and Email Writing
**Grammar:** Perfect Tenses, Phrases and Clauses, Discourse Markers
**Vocabulary :** Verbal Analogy / Cloze Exercise

**UNIT-IV ENHANCING SPEAKING ABILITY** 6

**Listening:** Listening to eminent voices of one's interest (Martin Luther King, APJ Abdul Kalam, etc..)
**Reading:** Timed Reading, Filling KWL Chart.
**Speaking:** Just a Minute, Impromptu
**Writing:** Check-list, Instructions.
**Grammar:** 'Wh' Questions / 'Yes' or 'No' Questions, Imperatives
**Vocabulary:** Synonyms, Antonyms, Different forms of the same words.

**UNIT-V LANGUAGE FOR WORKPLACE** 6

**Listening**: Extensive Listening (Audio books, rendering of poems, etc.)
**Reading**: Extensive reading (Jigsaw Reading, Short Stories, Novels)
**Speaking**: Short Presentations on Technical Topics
**Writing:** Recommendations, Essay Writing
**Grammar:** Impersonal Passive, Reported Speech, Concord
**Vocabulary :** Informal Vocabulary and Formal Substitutes

**Total Contact Hours: 30**

**Course Outcomes:**

**On completion of the course students will be able to**

apply their comprehension skills and interpret different contents effortlessly
read and comprehend various texts and audio visual contents
infer data from graphs and charts and communicate it efficiently in varied contexts
participate effectively in diverse speaking situations
to present, discuss and coordinate with their peers in workplace using their language skills

**SUGGESTED ACTIVITIES**

- Ice breaker
- Just A Minute
- Shipwreck
- Hot seat
- Vocabulary building
- Chinese whispers
- Case study

**SUGGESTED EVALUATION METHODS**

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous Assessment Tests

**Text Book(s):**

1. Effective Technical Communication by M. Ashraf Rizvi (Author) 2nd Edition Paperback 2017
2. Sylvan Barnet and Hugo Bedau, 'Critical Thinking Reading and Writing', Bedford/st. Martin's: Fifth Edition (June 28, 2004)
3. Meenakshi Upadhyay, Arun Sharma – Verbal Ability and Reading Comprehension.
4. Teaching Speaking: A Holistic Approach, Book by Anne Burns and Christine ChuenMeng Goh, Cambridge University Press

**Reference Books(s) / Web links:**

1. Basic Vocabulary in Use: 60 Units of Vocabulary Practice in North American English With Answers 2nd Edition by Michael McCarthy (Author), Felicity O'Dell (Author), John D. Bunting (Contributor)
2. Reading Development and Difficulties By Kate Cain
3. The 7 Habits of Highly Effective People by Stephen Covey, Simon and Schuster, UK
4. Everybody Writes: Your Go-To Guide to Creating Ridiculously Good Content Hardcover by Ann Handley (Author)

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **HS23111.1** | 1 | 3 | - | 2 | - | 2 | 1 | - | 3 | 3 | - | 1 | 1 | 1 | 1 |
| **HS23111.2** | - | - | 2 | 2 | 1 | 2 | 3 | 3 | 3 | 1 | - | 3 | 2 | - | 2 |
| **HS23111.3** | - | - | - | 1 | - | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 1 | - | 1 |
| **HS23111.4** | - | - | 1 | - | - | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | - | 1 |
| **HS23111.5** | - | - | - | 1 | - | 2 | 2 | - | 1 | 2 | 3 | 3 | 1 | 1 | - |
| **Average** | 1 | 3 | 1.5 | 1.5 | 1 | 1.8 | 1.8 | 2 | 2.4 | 2.2 | 3 | 2.4 | 1.4 | 1 | 1.25 |

| Course Code | Course Title | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **MA23112** | **ALGEBRA AND CALCULUS** | BS | 3 | 1 | 0 | 4 |

Common to AERO, AUTO, MECH, MCT, R&A, CIVIL, BIOTECH, FOODTECH, CHEM

**Objectives:**

- To gain knowledge in using matrix algebra techniques and the concepts of rank and nature of the matrix.
- To understand the techniques by numerical way of solving matrix Problems.
- To understand the techniques of analysing the data and apply the concept of correlation and regression in real life problems.
- To understand the techniques of calculus those are applied in the Engineering problems.
- To understand the techniques of Integration those are applied in finding area and volumes.

**UNIT-I MATRICES** 12

Matrices - Eigenvalues and eigenvectors - Diagonalization of matrices using orthogonal transformation - Cayley-Hamilton Theorem(without proof) -Quadratic forms- Reduction to canonical form using orthogonal transformation- Numerical computation of Eigen value using Power method

**UNIT-II STATISTICS** 12

Scatter diagram - Karl Pearson coefficient of correlation for raw data –Spearman rank correlation coefficient - Lines of regression - Regression equation X on Y and Y on X- Curve fitting by Principle of least squares - Fitting a straight line y = ax+b and a parabola $y = ax^2 + bx + c$.

**UNIT-III FUNCTIONSOFSEVERALVARIABLES** 12

Partialdifferentiation–Totalderivative–Changeofvariables–Jacobians–Partialdifferentiationofimplicitfunctions–Taylor'sseriesforfunctionsoftwovariables–Maximaandminimaoffunctionsoftwovariables–Lagrange's method of undetermined multipliers.

**UNIT-IV INTEGRAL CALCULUS** 12

Integral Calculus: Definite Integrals as a limit of sums - Applications of integration to area, volume - Improper integrals: Beta and Gamma integrals- Numerical computation of integrals -Trapezoidal rule- Gaussian Two point quadrature

**UNIT-V MULTIPLEINTEGRAL** 12

Double integrals–Change of order of integration–Area enclosed by plane curves–Triple integrals–Volume of solids–Numerical computation of double integrals- Trapezoidal rule.

**Total Contact Hours:60**

**Course Outcomes:**

On completion of the course students will be able to:

- Apply the concept of Eigenvalues and eigenvectors, diagonalization of a matrix for solving problems and numerical way of solving matrix problems
- Apply the concept of analysis of data, correlation and regression in real life situation.
- Analyse, sketch and study the properties of different curves and to handle functions of several variables and problems of maxima and minima.
- Evaluate area and volume using single integration and numerical integration
- Evaluate surface area and volume using multiple integrals.

**SUGGESTED ACTIVITIES**

- Problem solving sessions
- Activity Based Learning (Correlation and Regression using online calculator.)
- Implementation of small module (https://www.wolframalpha.com/calculators/eigenvalue-calculator)

**SUGGESTED EVALUATION METHODS**

Tutorial problems
Assignment problems
Quizzes

Class Presentation/Discussion

**Text Book(s):**

1. Grewal B.S., " Higher Engineering Mathematics ", Khanna Publishers, New Delhi, 43rd Edition, 2014. http://library.lol/main/753072EA7A0A4404C0C70587330B28AB
2. T Veerarajan ,Fundamentals of Mathematical Statistics , yesdee publications, 2017. http://library.lol/main/7400A01CB4E5D8CD7DA0631EE34A25D6
3. T Veerarajan, Engineering Mathematics –I , Mc Graw Hill Education, 2018. http://library.lol/main/7B66D2FA0CB50B3C37369267355677B8

**Reference Books(s) / Web links:**

1. Ramana. B.V., " Higher Engineering Mathematics ", McGraw Hill Education Pvt.Ltd, New Delhi, 2016.
2. Gupta S.C. and Kapoor V.K."Fundamentals of Mathematical Statistics", Sultan and Sons.
3. Erwin Kreyszig ," Advanced Engineering Mathematics ", John Wiley and Sons, 10th Edition, New Delhi, 2016.

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MA23112.1** | 3 | 3 | 3 | 3 | 3 | 2 | - | - | - | - | 2 | 2 | 3 | 2 | 1 |
| **MA23112.2** | 3 | 3 | 3 | 3 | 3 | 2 | - | - | - | - | 2 | 2 | 3 | 2 | 1 |
| **MA23112.3** | 3 | 3 | 3 | 3 | 2 | 1 | - | - | - | - | 2 | 2 | 3 | 2 | 1 |
| **MA23112.4** | 3 | 3 | 2 | 2 | 2 | 1 | - | - | - | - | 1 | 1 | 3 | 1 | 1 |
| **MA23112.5** | 3 | 3 | 2 | 2 | 2 | 1 | - | - | - | - | 1 | 1 | 3 | 1 | 1 |
| **Average** | 3 | 3 | 2.6 | 2.6 | 2.4 | 1.4 | - | - | - | - | 1.6 | 1.6 | 3 | 1.6 | 1 |

| Subject Code | Subject Name | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| PH23141 | **PHYSICS OF MATERIALS**<br>**Common to I sem. B.E. - Aero, Auto, Civil, Mech, MCT and R&A** | BS | 3 | 0 | 2 | 4 |

**Objectives:**

- To enhance the fundamental knowledge of elasticity and its applications relevant to engineering streams.
- To become proficient in crystal growth and crystal systems.
- To introduce the essential of phase transformation in materials.
- To impart knowledge on the structure, properties, treatment, testing and applications of metals and alloys.
- To familiarize students with thermal properties and applications.

**UNIT-I PROPERTIES OF MATTER** 9

Elasticity–Hooke's law-stress–strain-modulus of elasticity-stress-strain diagram-Poisson's ratio-rigidity modulus-twisting couple on a cylinder-moment of inertia - torsional pendulum method. Bending of beams -bending moment-cantilever depression-theory and experiment - Young's modulus determination–uniform and non-uniform bending-I-shape girders. Viscosity-flow of motion-Reynolds number.

**UNIT-II CRYSTAL PHYSICS** 9

Basis – lattices – unit cell-crystal systems – Bravais lattices –number of atoms, atomic radius, co-ordination number and packing fraction - SC, BCC, FCC, HCP lattices –diamond structure - polymorphism and allotropy-graphite structure - Miller indices – determination of d-space-crystal growth techniques-solution growth –melt growth- Czochralski and Bridgmann- crystal defects.

**UNIT-III PHASE DIAGRAMS** 9

Solid solutions - Hume-Rothery's rules –Gibb's phase rule – unary phase diagram- binary phase diagrams - isomorphous systems - tie-line and lever rule - eutectic, eutectoid, peritectic, peritectoid, monotectic and syntectic systems - formation of microstructures-homogeneous and non-homogenous cooling – nucleation (Qualitative)– iron-carbon phase diagram - eutectoid steel – hypo-eutectoid and hyper-eutectoid steel – diffusion - Fick's laws – T-T-T diagrams.

**UNIT-IV ADVANCED MATERIALS & TESTING** 9

Metallic glasses – preparation, properties and applications - Ceramics – types, manufacturing methods and properties – applications - Composites – types and properties - Shape memory alloys – properties and applications - Nano-materials – top down and bottom up approaches –sol-gel method-pulsed laser deposition-ball milling-hydrothermal method-properties-applications - Tensile strength – Hardness – Fatigue - Impact strength – Creep - Fracture – types of fracture.

**UNIT-V THERMAL PHYSICS** 9

Transfer of heat energy – thermal expansion of solids and liquids – expansion joints - bimetallic strips - thermal conduction, convection and radiation –rectilinear heat flow – thermal conductivity - Forbe's and Lee's disc method: theory and experiment - conduction through compound media (series and parallel) – thermal insulation – applications: heat exchangers, refrigerators, ovens and solar water heaters.

**Contact Hours : 45**

**List of Experiments**

1. Determination of Young's modulus of given material by non-uniform bending method
2. Determination of moment of inertia and rigidity modulus of a wire by Torsional pendulum.
3. Determination of Young's modulus of given beam by cantilever method
4. Determination of Velocity of ultrasound and compressibility of given liquid – Ultrasonic interferometer
5. Find the wavelength of Laser and particle size of given powder.
6. Study the Hysteresis loss of ferromagnetic material by B-H curve experiment
7. Determination of Thermal conductivity of a bad conductor – Lee's Disc method.
8. Study the solar cell parameters.
9. Find the thickness of a given thin wire – Air wedge method
10. Determination of viscosity of the given liquid using Poiseuille's method.

**Contact Hours : 30**
**Total Contact Hours : 75**

**Course Outcomes:**

On completion of the course, the students will be able to

- apply the elastic nature of materials and determine the elastic moduli of different materials.
- apply the basic knowledge of crystal structure in solids.
- analyze and measure the properties of alloys.
- analyze various material testing methods and use them in suitable applications.
- understand the concepts of heat transfer in various applications.

**Suggested Activities**

- Problem solving sessions

**Suggested Evaluation Methods**

- Quizzes
- Class Presentation / Discussion

**Text Book(s):**


1 Bhattacharya, D.K. &Poonam, T. *"Engineering Physics".*Oxford University Press, 2018.
2 Gaur, R.K. & Gupta, S.L. *"Engineering Physics".*DhanpatRai Publishers, 2018.
3 Raghavan, V. *"Physical Metallurgy: Principles and Practice"*. PHI Learning, 2019.


**Reference Books(s) / Web links:**


1 Balasubramaniam, R. *"Callister's Materials Science and Engineering".*Wiley India Pvt. Ltd., 2017
2 Resnick, R., Halliday, D., & Walker, J. *"Principles of Physics*", Wiley India Pvt., 2018.
3 Raghavan, V. *"Materials Science and Engineering : A First course"*. PHI Learning, 2019.
4 https://nptel.ac.in/courses/113104068
5 https://archive.nptel.ac.in/courses/115/105/115105099/


**List of Equipment Available**
**(Common to B.E. Aero, Auto, Civil, Mechanical, Mechatronics Engineering and R&A)**

| S. No | Name of the equipment | Quantity Required | Quantity Available | Deficiency |
|---|---|---|---|---|
| 1 | Young's modulus by Non - Uniform bending method Travelling Microscopes, Meter scale etc., | 6 | 13 | - |
| 2 | Rigidity Modulus - Torsional Pendulum Setup | 6 | 19 | - |
| 3 | Velocity of sound and compressibility of liquid – Ultrasonic Interferometer | 6 | 14 | - |
| 4 | Wavelength of Laser and Characteristics -Laser source And grating plate | 6 | 15 | - |
| 5 | B-H curve Setup and CRO | 6 | 7 | - |
| 6 | Thermal conductivity of bad conductor- Lee's Disc setup | 6 | 16 | - |
| 7 | LCR circuit kit | 6 | 7 | - |
| 8 | Thickness of a thin wire-Air wedge method – Travelling microscope | 6 | 13 | - |
| 9 | Solar cell parameters setup | 6 | 8 | - |
| 10 | Poiseuille's method set up | 6 | 10 | - |

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PH23141.1 | 3 | 2 | 1 | 1 | 2 | 1 | - | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 |
| PH23141.2 | 3 | 2 | 1 | 1 | 2 | 2 | 1 | - | 1 | 1 | 1 | 2 | 2 | 1 | 1 |
| PH23141.3 | 3 | 2 | 1 | 1 | 2 | 1 | 2 | - | 1 | 1 | 1 | 2 | 2 | 1 | 1 |
| PH23141.4 | 3 | 2 | 1 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 |
| PH23141.5 | 3 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 1 | 1 |
| Average | 3 | 2 | 1 | 1 | 2 | 1.6 | 1.4 | 1.33 | 1 | 1 | 1 | 2 | 2 | 1 | 1 |

| GE23111 | ENGINEERING GRAPHICS | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| | | ES | 2 | 0 | 4 | 4 |

**OBJECTIVES:**

- To understand the importance of the drawing in engineering applications
- To develop graphic skills for communication of concepts, ideas and design of engineering products
- To expose them to existing national standards related to technical drawings.
- To improve their visualization skills so that they can apply this skill in developing new products.
- To improve their technical communication skill in the form of communicative drawings

**CONCEPTS AND CONVENTIONS (Not for Examination)** **1**

Importance of graphics in engineering applications–Use of drafting instruments– BIS conventions and specifications–Size, layout and folding of drawing sheets– Lettering and dimensioning. Basic Geometrical constructions.

**UNIT-I PLANE CURVES AND PROJECTION OF POINTS** **5+12**

Curves used in engineering practices: Conics–Construction of ellipse, parabola and hyperbola by eccentricity method – Cycloidal Curves–Construction of cycloid, epicycloid and hypocycloid – Construction of involutes of square and circle–Drawing of tangents and normal to the above curves.

Principles of Projection and Projection of points.

**UNIT-II PROJECTION OF LINES AND PLANE SURFACES** **6+12**

Projection of straight lines (First angle projection) inclined to both the principal planes – Determination of true lengths and true inclinations by rotating line method

Projection of planes (polygonal and circular surfaces) inclined to both the principal planes by rotating object method.

**UNIT-III PROJECTION OF SOLIDS AND PROJECTION OF SECTIONED SOLIDS** **6+12**

Projection of simple solids like prisms, pyramids, cylinder and cone when the axis is inclined to one of the principal planes by rotating object method.

Sectioning of solids in simple vertical position when the cutting plane is inclined to HP and perpendicular to VP – obtaining true shape of the section.

Practicing three-dimensional modeling of simple objects by CAD software (Not for examination)

**UNIT-IV DEVELOPMENT OF SURFACE AND ISOMETRIC PROJECTIONS** **6+12**

Development of lateral surfaces of simple and sectioned solids – Prisms, pyramids cylinders and cones.

Principles of isometric projection–isometric scale–Isometric projections of simple solids and truncated solids - Prisms, pyramids, cylinders and cones

Model making of isometric projection of combination of solids as assignment (Not for End semester)

**UNIT-V FREE HAND SKETCHING AND PERSPECTIVE PROJECTIONS** **6+12**

Free Hand sketching: Freehand sketching of multiple views from pictorial views of objects - Freehand sketching of pictorial views of object from multiple views

Perspective projection of simple solids-Prisms, pyramids, cylinder and cone by visual ray method.

**Total Contact Hours: (L=30; P=60) 90 Periods**

**COURSE OUTCOMES:**

After learning the course, the students should be able

- To construct different plane curves and to comprehend the theory of projection

- To draw the basic views related to projection of lines and planes
- To draw the projection of simple solids and to draw the projection of Sectioned solids in simple vertical position

- To draw the development of surfaces of solids and Isometric projections of simple solids
- To draw the free hand sketching of multiple views from pictorial objects and to visualize Perspective view of simple solids.

**TEXTBOOK (S):**

1. Bhatt N.D. and Panchal V.M., "Engineering Drawing", Charotar Publishing House, 50th Edition, 2010.
2. Natarajan K.V., "A textbook of Engineering Graphics", Dhanalakshmi Publishers, Chennai,2017.

**REFERENCE BOOKS(S) / WEB LINKS:**

1. Varghese P I., "Engineering Graphics", McGraw Hill Education (I) Pvt.Ltd., 2013.
2. V.B Sikka "Civil Engineering Drawing", S.K Kataria & Sons, New Delhi.
3. Venugopal K. and Prabhu Raja V., "Engineering Graphics", New Age International(P)Limited, 2008.
4. Gopalakrishna K.R., "Engineering Drawing" (Vol. I&II combined), Subhas Stores,Bangalore, 2017.
5. Basant Agarwal and Agarwal C.M., "Engineering Drawing", McGraw Hill PublishingCompany Limited, New Delhi, 2018.

**CO PO PSO MAPPING**

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GE23211.1** | 3 | 2 | 2 | 1 | - | 1 | - | 2 | 2 | 2 | - | 2 | 2 | 2 | 3 |
| **GE23211.2** | 3 | 2 | 2 | 1 | - | 1 | - | 2 | 2 | 2 | - | 2 | 2 | 2 | 3 |
| **GE23211.3** | 3 | 2 | 2 | 1 | - | 1 | - | 2 | 2 | 2 | - | 2 | 2 | 2 | 3 |
| **GE23211.4** | 3 | 2 | 2 | 1 | - | 1 | - | 2 | 2 | 2 | - | 2 | 2 | 2 | 3 |
| **GE23211.5** | 3 | 2 | 2 | 1 | - | 1 | - | 2 | 2 | 2 | - | 2 | 2 | 2 | 3 |
| **Average** | 3 | 2 | 2 | 1 | - | 1 | - | 2 | 2 | 2 | - | 2 | 2 | 2 | 3 |

| Subject Code | தமிழர மரபு / Heritage of Tamils | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| GE23117 | Common to all branches of B.E / B.Tech programmes | HS | 1 | 0 | 0 | 1 |

**அலகு I மொழி மற்றும் இலக்கியம்: 3**

இந்திய மொழிக் குடும்பங்கள் - திராவிட மொழிகள் - தமிழ் ஒரு செம்மொழி - தமிழ் செவ்விலக்கியங்கள் - சங்க இலக்கியத்தின் சமய சார்பற்ற தன்மை - சங்க இலக்கியத்தில் பகிர்தல் அறம் - திருக்குறளில் மேலாண்மைக் கருத்துக்கள் - தமிழிக் காப்பியங்கள், தமிழகத்தில் சமண பௌத்த சமயங்களின் தாக்கம் - பக்தி இலக்கியம், ஆழ்வார்கள் மற்றும் நாயன்மார்கள் - சிற்றிலக்கியங்கள் - தமிழில் நவீன இலக்கியத்தின் வளர்ச்சி - தமிழ் இலக்கிய வளர்ச்சியில் பாரதியார் மற்றும் பாரதிதாசன் ஆகியோரின் பங்களிப்பு.

**அலகு II மரபு - பாறை ஓவியங்கள் முதல் நவீன ஓவியங்கள் வரை - சிற்பக் கலை: 3**

நடுகல் முதல் நவீன சிற்பங்கள் வரை - ஐம்பொன் சிலைகள் - பழங்குடியினர் மற்றும் அவர்கள் தயாரிக்கும் கைவினைப் பொருட்கள், பொம்மைகள் - தேர் செய்யும் கலை - சுடுமண் சிற்பங்கள் - நாட்டுப்புறத் தெய்வங்கள் - குமரிமுனையில் திருவள்ளுவர் சிலை - இசைக் கருவிகள் - மிருதங்கம், பறை, வீணை, யாழ், நாதஸ்வரம் - தமிழர்களின் சமூக பொருளாதார வாழ்வில் கோவில்களின் பங்கு.

**அலகு III நாட்டுப்புறக் கலைகள் மற்றும் வீர விளையாட்டுகள்: 3**

தெருக்கூத்து, கரகாட்டம், வில்லுப்பாட்டு, கணியான் கூத்து, ஒயிலாட்டம், தோல்பாவைக் கூத்து, சிலம்பாட்டம், வளரி, புலியாட்டம், தமிழர்களின் விளையாட்டுகள்.

**அலகு IV தமிழர்களின் திணைக் கோட்பாடுகள்: 3**

தமிழகத்தின் தாவரங்களும், விலங்குகளும் - தொல்காப்பியம் மற்றும் சங்க இலக்கியத்தில் அகம் மற்றும் புறக் கோட்பாடுகள் - தமிழர்கள் போற்றிய அறக்கோட்பாடு - சங்ககாலத்தில் தமிழத்தில் எழுத்தறிவும், கல்வியும் - சங்ககால நகரங்களும் துறை முகங்களும் - சங்ககாலத்தில் ஏற்றுமதி மற்றும் இறக்குமதி - கடல்கடந்த நாடுகளில் சோழர்களின் வெற்றி.

**அலகு V இந்திய தேசிய இயக்கம் மற்றும் இந்திய பண்பாட்டிற்குத் தமிழர்களின் பங்களிப்பு: 3**

இந்திய விடுதலைப்போரில் தமிழர்களின் பங்கு - இந்தியாவின் பிறப்பகுதிகளில் தமிழ்ப் பண்பாட்டின் தாக்கம் - சுயமரியாதை இயக்கம் - இந்திய மருத்துவத்தில், சித்த மருத்துவத்தின் பங்கு - கல்வெட்டுகள், கையெழுத்துப்படிகள் - தமிழ்ப் புத்தகங்களின் அச்சு வரலாறு.

**TOTAL : 15 PERIODS**

**TEXT-CUM-REFERENCE BOOKS**


1. தமிழக வரலாறு - மக்களும் பண்பாடும் - கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் - முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி - வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை - ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr. K. K. Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils – The Classical Period (Dr. S. Singaravelu)(Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr. S. V. Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies).
9. Keeladi – 'Sangam City Civilization on the banks of river Vaigai' (Jointly Published by: Department of archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Published by: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

| Subject Code | Subject Name (Lab oriented Theory Courses) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| EE23133 | BASIC ELECTRICAL AND ELECTRONICS ENGINEERING (COMMON TO AERO, CSE, CHEM, CIVIL, FT AND IT) | ES | 3 | 0 | 2 | 4 |

**Objectives:**

- To introduce electric circuits and provide knowledge on the analysis of circuits using network theorems.
- To impart knowledge on the analysis of AC circuits
- To expose the principles of electrical machines and electronic devices.
- To teach the concepts of different types of electrical measuring instruments and transducers.
- To experimentally analyze the electrical circuits and machines, electronic devices and transducers.

**UNIT-I DC CIRCUITS** 9

Electrical circuit elements (R, L and C), voltage and current sources, Kirchoff 's current and voltage laws, analysis of simple circuits with dc excitation. Superposition, Thevenin and Norton Theorems.

**UNIT-II AC CIRCUITS** 9

Representation of sinusoidal waveforms, peak and rms values, phasor representation, real power, reactive power, apparent power, power factor. Analysis of single-phase ac circuits consisting of R, L, C, RL, RC, RLC combinations series resonance. Three phase balanced circuits, voltage and current relations in star and delta connections

**UNIT-III ELECTRICAL MACHINES** 9

Construction, Principles of operation of DC machines, Single phase Transformers, Synchronous machines, Single phase induction motors.

**UNIT-IV ELECTRONIC DEVICES & CIRCUITS** 9

Types of Materials – Silicon & Germanium- N type and P type materials – PN Junction diode–Forward and Reverse Bias – Bipolar Junction Transistor – Common Emitter characteristics –Introduction to operational Amplifier –Inverting Amplifier –Non Inverting Amplifier.

**UNIT-V MEASUREMENTS & INSTRUMENTATION** 9

Introduction to transducers - Classification of Transducers: Resistive, Inductive, Capacitive, Piezoelectric, - Classification of instruments - PMMC and MI Ammeters and Voltmeters – Digital Storage Oscilloscope.

**Contact Hours : 45**

**List of Experiments**

1. Verification of Kirchhoff's Laws.
2. Load test on DC Shunt Motor.
3. Load test on Single phase Transformer.
4. Load test on Single phase Induction motor.
5. Characteristics of P-N junction Diode.
6. Characteristics of CE based NPN Transistor.
7. Characteristics of LVDT, RTD and Thermistor.

**Contact Hours : 30**
**Total Contact Hours : 75**

**Course Outcomes:**

On completion of the course, the students will be able to

- analyse DC and AC circuits and apply circuit theorems.
- calculate the power and power factor in AC circuits
- understand the principles of electrical machines.
- comprehend the principles of different types of electronic devices, electrical measuring instruments and transducers.
- experimentally analyze the electric circuits, electrical machines, electronic devices, and transducers.

**Suggested Activities**

- Problem solving sessions.

**Suggested Evaluation Methods**

- Quizzes

- Class Presentation / Discussion

**Text Book(s):**


1 J.B.Gupta, "Fundamentals of Electrical Engineering and Electronics" S.K.Kataria& Sons Publications, 2002.

2 Joseph A. Edminister, Mahmood, Nahri, "Electric Circuits" – Shaum Series and Systems", Schaum"s Outlines, Tata McGrawHill, Indian. 5th Edison , 2017

3 Thereja .B.L., "Fundamentals of Electrical Engineering and Electronics", S. Chand & Co. Ltd., 2008


**Reference Books(s) / Web links:**


1 Del Toro, "Electrical Engineering Fundamentals", Pearson Education, New Delhi, 2007

2 John Bird, "Electrical Circuit Theory and Technology", Elsevier, First Indian Edition, 2006

3 Allan S Moris, "Measurement and Instrumentation Principles", Elseveir, First Indian Edition, 2006

4 Rajendra Prasad, "Fundamentals of Electrical Engineering", Prentice Hall of India, 2006

5 A.E.Fitzgerald, David E Higginbotham and Arvin Grabel, "Basic Electrical Engineering", McGraw Hill Education(India) Private Limited, 2009

6 D P Kothari and I.J Nagarath, "Basic Electrical and Electronics Engineering", McGraw Hill Education(India) Private Limited, Third Reprint ,2016

7 https://nptel.ac.in/courses/108108076


**Lab Equipment Required:**

| Sl. No. | Name of the Equipment | Quantity Required (For a batch of 30 students) |
|---|---|---|
| **1.** | **Verification of ohms and Kirchhoff's Laws** | |
| | 1. DC Regulated Power supply (0 - 30 V variable) | 1 |
| | 2. Bread Board | 1 |
| | 3. Resistors | As per Circuit diagram1 |
| | 4. Multimeter | As Required |
| | 5. Connecting wires | |
| **2.** | **Load test on DC Shunt Motor.** | |
| | 1. Ammeter MC (0-20A) | 1 |
| | 2. Voltmeter MC (0-300)V | 1 |
| | 3. Tachometer | 1 |
| | 4. Field Rheostat 500 Ω, 1.5 A | 1 |
| | 5. Connecting wires | As Required |
| **3.** | **Load Test on Induction Motor** | |
| | 1. Ammeter MI (0-20A) | 1 |
| | 2. Voltmeter MI (0-300)V | 1 |
| | 3. Wattmeter – 300V, 30 A | 1 |
| | 4. Tachometer – Digital | 1 |
| | 5. Connecting Wires | As Required1 |
| | 6. Single phase Induction motor | |
| **4.** | **Load test on Single phase Transformer** | |
| | 1. Ammeter (0-30) A, (0-5 ) A | **1** |
| | 2. Voltmeter (0-150)V, (0-300)V | **1** |
| | 3. Wattmeter – 300V, 5A, UPF | **1** |
| | 4. Autotransformer | **1** |
| | 5. Single phase Transformer | **1** |
| | 6. Connecting Wires | As Required |

**5. Characteristics of PN and Zener Diodes**

| | |
|---|---|
| 1. PN Diode (IN4007), Zener diode (6.8V, 1A) | 1 |
| 2. Resistor 1 KΩ, 100Ω | 1 |
| 3. Bread Board | 1 |
| 4. DC Regulated Power supply (0 - 30 V variable) | 1 |
| 5. Multimeter | 1 |
| 6. Connecting wires | As Required |

**6. Characteristics of BJT**

| | |
|---|---|
| 1. Transistor (BC107) | 1 |
| 2. Resistors- 1kΩ, 470KΩ, 1MΩ | 1 |
| 3. Bread Board | 1 |
| 4. DC Regulated Power supply (0 - 30 V variable) | 1 |
| 5. Multimeter | 1 |
| 6. Connecting wires | As Required |

**7. Measurement of displacement of LVDT, RTD and Thermistor** 1

| | |
|---|---|
| 1. LVDT Kit | 1 |
| 2. RTD | 1 |
| 3. Thermistor | 1 |
| 4. Multimeter | 1 |

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **EE23133.1** | 3 | 3 | 3 | 3 | - | 3 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 |
| **EE23133.2** | 3 | 3 | 3 | 3 | - | 3 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 |
| **EE23133.3** | 3 | 3 | 3 | 3 | - | 3 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 2 |
| **EE23133.4** | 3 | 3 | 3 | 3 | - | 3 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 2 |
| **EE23133.5** | 3 | 3 | 3 | 3 | - | 3 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | - |
| **Average** | **3** | **3** | **3** | **3** | **-** | **3** | **1** | **1** | **2** | **1** | **1** | **1** | **1** | **2** | **2** |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **MC23112** | **ENVIRONMENTAL SCIENCE AND ENGINEERING** | MC | **3** | **0** | **0** | **0** |

**Objectives:**

- To develop the understanding of environmental and associated issues
- To develop an attitude of concern for the environment
- To promote enthusiasm in participating environmental protection initiatives
- To develop skills to solve environmental degradation issues.

## UNIT-I Air and Noise pollution

9

Definition –sources of air pollution –chemical and photochemical reactions in the atmosphere - formation of smog, PAN, acid rain, ozone depletion, particulate pollutants-Air quality standards-Air quality indices - control of particulate air pollutants-gravitational settling chambers, cyclone separators, wet collectors, fabric filters (Bag-house filter), electrostatic precipitators (ESP)-catalytic converters

Noise pollution -Sources; Health Effects-Standards- Measurement and control methods

## UNIT-II Water pollution and its management

9

Definition-causes-effects of water pollution-point and nonpoint sources of wastewater-marine pollution-thermal pollution-control of water pollution by physical, chemical and biological methods–wastewater treatment-primary, secondary and tertiary treatment-sources and characteristics of industrial effluents-wastewater recycling and zero liquid discharge

## UNIT-III Solid waste and Hazardous waste management

9

Solid waste – types- municipal solid waste management: Sources, characteristics, collection, and transportation- sanitary landfill, recycling, composting, incineration, energy recovery options from waste - Hazardous waste – Types, characteristics, and health impact - Hazardous waste management:Treatment Methods – neutralization, oxidation reduction, precipitation, solidification, stabilization,incineration and final disposal E-waste-definition-sources-effects on human health and environment- E-waste management- recovery of metals-Role of E-waste management within the initiatives of the Govt. of India- Swachh Bharat Mission-soil contamination and leaching of contaminants into groundwater.

## UNIT-IV Sustainable Development

9

Sustainable development- concept-dimensions-sustainable development goals-Value Education-Gender equality-Poverty-Hunger-Famine-Natural Hazards management- -Twelve principles of green chemistry, Green technology-definition, importance, factors affecting green technology-Cleaner development mechanism, role of industry; reuse, reduce and recycle, raw material substitution; wealth from waste; carbon credits, carbon trading, carbon sequestration, eco labeling-International conventions and protocols-Disaster management.

## UNIT-V Environmental Management and Legislation

9

Environmental Management systems - ISO 14000 series- Environmental audit-Environmental Impact Assessment- Life cycle assessment- Human health risk assessment-Environmental Law and Policy- Objectives; Polluter pays principle, Precautionary principle; The Water and Air Acts with amendments-The Environment (Protection) Act (EPA) 1986; Role of Information technology in environment and human health.

**Course Outcomes:**

On completion of the course, the students will be able to

- associate air and noise quality standards with environment and human health.
- illustrate the significance of water and devise control measures for water pollution.
- analyze solid wastes and hazardous wastes.
- outline the goals of sustainable development in an integrated perspective.
- comprehend the significance of environmental laws.

**Text Books:**

1. Benny Joseph, 'Environmental Science and Engineering', Tata McGraw-Hill, New Delhi, 2016
2. Anubha Kaushik and C. P. Kaushik's "Perspectives in Environmental Studies", 6th Edition, New Age International Publishers ,2018.
3. Johri R., E-waste: implications, regulations, and management in India and current global best practices, TERI Press, New Delhi

**Reference Books**

1. R.K. Trivedi, 'Handbook of Environmental Laws, Rules, Guidelines, Compliances and Standards', Vol. I and II, Enviro Media. 38. Edition 2010.
2. Cunningham, W.P. Cooper, T.H. Gorhani, 'Environmental Encyclopedia', Jaico Publ., House, Mumbai, 2001.
3. Fowler B, Electronic Waste – 1 st Edition (Toxicology and Public Health Issues), 2017Elsevier

**Web links:**

1. https://onlinecourses.nptel.ac.in/noc19_ge22/
2. NPTEL
3. https://news.mit.edu/2013/ewaste-mit

Suggested activities

1. Case studies presentation

Method of evaluation

1. Classroom presentations on case studies (or) Site visits, instead of CAT-I (or)CAT-II or CAT III

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MC23112.1** | 3 | 2 | 3 | 2 | 1 | 3 | 3 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| **MC23112.2** | 3 | 2 | 3 | 2 | 1 | 3 | 3 | 2 | 1 | 1 | 2 | 2 | 1 | 1 | 1 |
| **MC23112.3** | 3 | 2 | 3 | 1 | 1 | 3 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **MC23112.4** | 3 | 2 | 3 | 1 | 2 | 2 | 3 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 1 |
| **MC23112.5** | 3 | 2 | 2 | 1 | 1 | 2 | 3 | 1 | 1 | 2 | 1 | 1 | - | - | 1 |
| **Average** | 3 | 2 | 2.8 | 1.4 | 1.2 | 2.6 | 3 | 1.8 | 1.2 | 1.4 | 1.2 | 1.6 | 1 | 1 | 1 |

| Subject Code | Subject Name (Laboratory Course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| GE23121 | ENGINEERING PRACTICES – CIVIL & MECHANICAL | ES | 0 | 0 | 2 | 1 |

**Objectives:**

To provide exposure to the students with hands on experience on various basic engineering practices in Civil and Mechanical Engineering.

**List of Experiments**

## CIVIL ENGINEERING PRACTICE

1. Study of pipeline joints, its location and functions: valves, taps, couplings, unions, reducers, and elbows in household fittings.
2. Preparation of basic plumbing line sketches for wash basins, water heaters, etc.
3. Hands-on-exercise: Basic pipe connections – Pipe connections with different joining components.

### Carpentry Works:

4. Study of joints in roofs, doors, windows and furniture.
5. Hands-on-exercise: Woodwork, joints by sawing, planning and chiselling.

## MECHANICAL ENGINEERING PRACTICE

6. Preparation of butt joints, lap joints and T- joints by Shielded metal arc welding.
7. Gas welding practice.

### Basic Machining:

8. Simple Turning and Taper turning
9. Drilling Practice

### Sheet Metal Work:

10. Forming & Bending:
11. Model making – Trays and funnels
12. Different type of joints.

### Machine Assembly Practice:

13. Study of centrifugal pump
14. Study of air conditioner

**Total Contact Hours : 30**

**Course Outcomes:**

- Able to perform plumbing activities for residential and industrial buildings considering safety aspects while gaining clear understanding on pipeline location and functions of joints like valves, taps, couplings, unions, reducers, elbows, etc.
- Able to perform wood working carpentry activities like sawing, planning, cutting, etc. while having clear understanding of the joints in roofs, doors, windows and furniture.
- Able to produce joints like L joint, T joint, Lap joint, Butt joint, etc. through arc welding process while acquiring in depth knowledge in the principle of operation of welding and other accessories
- Able to perform operations like Turning, Step turning, Taper turning, etc. in lathe and Drilling operation in drilling machine
- Able to perform sheet metal operations like Forming, Bending, etc. and fabricating models like Trays, funnels, etc.

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GE23121.1** | 3 | 3 | 3 | 3 | 3 | 1 | 1 | - | 2 | 1 | 3 | 3 | 2 | 2 | 3 |
| **GE23121.2** | 3 | 3 | 3 | 3 | 2 | 2 | 2 | - | 2 | 1 | 3 | 3 | 1 | 2 | 2 |
| **GE23121.3** | 3 | 3 | 3 | 3 | 3 | 1 | 1 | - | 2 | 1 | 3 | 3 | 2 | 2 | 2 |
| **GE23121.4** | 3 | 3 | 2 | 2 | 2 | 1 | 1 | - | 2 | 1 | 3 | 3 | 1 | 2 | 2 |
| **GE23121.5** | 3 | 3 | 2 | 2 | 2 | 1 | 1 | - | 2 | 1 | 3 | 3 | 2 | 2 | 2 |
| **Average** | 3 | 3 | 2.6 | 2.6 | 2.6 | 1.2 | 1.2 | - | 2 | 1 | 3 | 3 | 1.4 | 2 | 2.2 |

# SEMESTER II

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **HS23221** | **TECHNICAL COMMUNICATION II** | Theory | 0 | 0 | 2 | 1 |

Common to all branches of B.E/B. Tech programmes –Second Semester

**Objectives:**

- To facilitate students to improve their vocabulary for a better communication
- To enable learners to understand and reproduce language
- To aid students to write technical reports in a convincing manner
- To expose students to different sentence structures
- To equip learners to present their ideas in an efficient manner

**UNIT-I VOCABULARY FOR BETTER COMMUNICATION** 6

**Listening:** Telephonic Conversations and TV News
**Reading:** Newspapers and Magazines
**Speaking**: Conversational Practice: Speaking in a given situation, Asking permission and requesting etc..,
**Writing:** Job Application Letter and Resume
**Grammar:** Reference words: pronouns and determiners
**Vocabulary:** Guessing meanings of words in different contexts.

**UNIT-II FUNCTIONAL LANGUAGE ASPECTS** 6

**Listening:** Motivational listening – listening to real life challenges
**Reading:** Articles and Technical reports
**Speaking:** Using Polite Expressions, Indirect Questions
**Writing:** Paraphrasing a Text, Poem
**Grammar:** Purpose Statements, Cause and Effect Expressions
**Vocabulary:** Neologisms.

**UNIT-III TECHNICAL REPORTWRITING** 6

**Listening:** Empathetic Listening – Giving Solutions to Problems
**Reading:** Inferential Reading
**Speaking:** Dialogues – Interviewing Celebrities / Leaders / Sportspersons, etc..,
**Writing:** Report Writing
**Grammar:** Functional Usage of Expressions – used to, gone / been, etc..,
**Vocabulary:** Words Often Confused

**UNIT-IV STRUCTURAL GRAMMAR** 6

**Listening:** Comprehension (IELTS practice tests)
**Reading:** Intensive Reading for specific information
**Speaking:** Pick and Talk
**Writing:** Proposals
**Grammar:** Sentence Structures – Simple, Compound, Complex Sentences
**Vocabulary:** Replacing dull words with vivid ones

**UNIT-V PRESENTATION SKILLS** 6

**Listening:** Discriminative listening – sarcasm, irony, pun, etc..,
**Reading:** Practice of chunking – breaking up reading materials
**Speaking:** Mini presentation on some topic
**Writing:** Minutes of the meeting
**Grammar:** Correction of Errors
**Vocabulary:** Advanced vocabulary – fixing appropriate words in the given context.

**Total Contact Hours: 30**

**Course Outcomes:**

On completion of the course students will be able to

- communicate effectively using appropriate vocabulary
- use the acquired language skills to comprehend various types of language contents
- evaluate different texts and write effective technical content
- use appropriate sentence structures to convey their thoughts in varied contexts
- present their concepts and ideas in an effective manner

**SUGGESTED ACTIVITIES**

- Story Lines
- One truth and two lies
- Hang Man
- Pictionary
- Word Scramble
- Case study

**SUGGESTED EVALUATION METHODS**

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous Assessment Tests

**Text Book(s):**

1. Raymond Murphy, "Intermediate English Grammar," Second Edition , Cambridge University Press, 2018
2. Meenakshi Raman & Sangeeta Sharma, "Technical Communication" Third Edition, Oxford University Press, 2015
3. Teaching Speaking: A Holistic Approach, Book by Anne Burns and Christine ChuenMeng Goh, Cambridge University Press

**Reference Books(s) / Web links:**

1. Michael McCarthy (Author), Felicity O'Dell (Author), John D. Bunting (Contributor), "Basic Vocabulary in Use: 60 Units of Vocabulary Practice in North American English with Answers" 2nd Edition
2. Dale Carnegie, "The Art of Public Speaking," Insight Press
3. Jack C. Richards & Theodore S. Rodgers, "Approaches and Methods in Language Teaching, Second Edition, Cambridge University Press

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **HS23222.1** | 1 | 3 | - | 2 | - | 2 | 1 | - | 3 | 3 | - | 1 | 1 | 1 | 1 |
| **HS23222.2** | - | - | 2 | 2 | 1 | 2 | 3 | 3 | 3 | 1 | - | 3 | 2 | - | 2 |
| **HS23222.3** | - | - | - | 1 | - | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 1 | - | 1 |
| **HS23222.4** | - | - | 1 | - | - | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | - | 1 |
| **HS23222.5** | - | - | - | 1 | - | 2 | 2 | - | 1 | 2 | 3 | 3 | 1 | 1 | - |
| **Average** | 1 | 3 | 1.5 | 1.5 | 1 | 1.8 | 1.8 | 2 | 2.4 | 2.2 | 3 | 2.4 | 1.4 | 1 | 1.25 |

| Course Code | Course Title | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **MA23212** | **DIFFERENTIAL EQUATION AND COMPLEX VARIABLES** | **BS** | **3** | **1** | **0** | **4** |

**Common to** II Sem. B.E. –AERO, AUTO, BME, CIVIL, EEE, ECE, MECH, MCT, Robotics and Automation and B. Tech. – BIOTECH, FOODTECH. & CHEM

**Objectives:**

To handle practical problems arising in the field of engineering and technology using differential equations.

To solve problems using the concept of Vectors calculus, Complex analysis, Laplace transforms.

**UNIT-I ORDINARY DIFFERENTIAL EQUATIONS 12**

Second and higher order Linear differential equations with constant coefficients – Method of variation of parameters – Legendre's linear equations – Numerical solution of ODE – Single Step methods: Taylor's series method, Euler's method.

**UNIT-II PARTIAL DIFFERENTIAL EQUATIONS 12**

Formation of partial differential equations – Singular integrals – Solutions of standard types of first order partial differential equations – Lagrange's linear equation – Linear homogeneous partial differential equations of second and higher order with constant coefficients- Classification of PDE.

**UNIT-III LAPLACE TRANSFORM 12**

Laplace transform –Basic properties – Transforms of derivatives and integrals of functions Transforms of unit step function and impulse functions, periodic functions. Inverse Laplace transform – Problems using Convolution theorem – Solution of linear ODE of second order with constant coefficients using Laplace transformation techniques

**UNIT-IV VECTOR CALCULUS 12**

Gradient, divergence and curl – Directional derivative – Irrotational and Solenoidal vector fields – Vector integration – Green's theorem in a plane, Gauss divergence theorem and Stokes' theorem (excluding proofs) – Simple applications involving cubes and rectangular parallelopipeds.

**UNIT-V COMPLEX VARIABLES 12**

Analytic functions — Construction of analytic function – Bilinear transformation –Singularities – Cauchy's integral theorem (without proof) – Residues – Residue theorem (without proof) - Simple problems – Contour integral over $|z|=1$.

**Total Contact Hours: 60**

**Course Outcomes:**

On completion of the course students will be able to:

- Apply various techniques in solving ordinary differential equations.
- Develop skills to solve different types of partial differential equations.
- Use Laplace transform and inverse transform techniques in solving differential equations.
- Use the concept of Gradient, divergence and curl to evaluate line, surface and volume integrals.
- Use the concept of Analytic functions, conformal mapping and complex integration for solving Engineering problems.

**SUGGESTED ACTIVITIES**

Problem solving sessions.

Activity Based Learning (https://www.geogebra.org/?lang=en )

**SUGGESTED EVALUATION METHODS**

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

**Text Book(s):**

1. Grewal B.S., "Higher Engineering Mathematics", Khanna Publishers, New Delhi, 44th Edition, 2015.
2. Veerarajan. T, Engineering Mathematics –II, Mc Graw Hill Education, 2018.
3. http://library.lol/main/67F2BE1AE06780C5A5BC684EB23A18F7

**Reference Books(s) / Web links:**

1. Ramana. B.V., "Higher Engineering Mathematics ", McGraw Hill Education Pvt. Ltd, New Delhi, 2016.
2. http://library.lol/main/753072EA7A0A4404C0C70587330B28AB
3. Erwin Kreyszig," Advanced Engineering Mathematics ", John Wiley and Sons, 10th Edition, New Delhi, 2016.
4. Bali, N.P. and Manish Goyal, A Text Book of Engineering Mathematics, Lakshmi Publications Pvt. Ltd., New Delhi, 4th Edition 2012.
5. T Veerarajan, Transforms and Partial Differential Equations, Third Edition, 2018.

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MA23212.1** | 3 | 3 | 3 | 3 | 3 | 2 | - | - | - | - | 2 | 2 | 3 | 2 | 1 |
| **MA23212.2** | 3 | 3 | 3 | 3 | 3 | 2 | - | - | - | - | 2 | 2 | 3 | 2 | 1 |
| **MA23212.3** | 3 | 3 | 3 | 3 | 2 | 1 | - | - | - | - | 2 | 2 | 3 | 2 | 1 |
| **MA23212.4** | 3 | 3 | 2 | 2 | 2 | 1 | - | - | - | - | 1 | 1 | 3 | 1 | 1 |
| **MA23212.5** | 3 | 3 | 2 | 2 | 2 | 1 | - | - | - | - | 1 | 1 | 3 | 1 | 1 |
| **Average** | 3 | 3 | 2.6 | 2.6 | 2.4 | 1.4 | - | - | - | - | 1.6 | 1.6 | 3 | 1.6 | 1 |

| Subject Code | Subject Name (Theory Laboratory embedded course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| CY23324 | **ENGINEERING CHEMISTRY** (Common to B.E. – AERONAUTICAL, AUTOMOBILE, MECH and CIVIL ENGG.) | BS | 3 | 0 | 2 | 4 |

**Objectives:**

- To understand the types of corrosion and its prevention
- To develop an understanding of the basic concepts of phase rule and its applications
- To provide a brief outline of polymers and composites in mechanical sciences
- To interpret the different types of batteries and fuel cells
- To provide an insight on nanomaterials and lubricants

**UNIT-I CORROSION SCIENCE AND CONTROL** 9

**Corrosion:** Introduction- chemical and electrochemical theory of corrosion- types of corrosion-galvanic, differential aeration (waterline and pitting) and stress corrosion (caustic embrittlement)-corrosion penetration rate (CPR)

**Corrosion control:** Cathodic protection- Metallic coatings- Electroplating- electroplating of chromium (hard and decorative)- Electroless plating-electroless plating of nickel- Chemical conversion coatings-Organic coatings-paints-constituents-functions - special paints.

**UNIT-II PHASE RULE AND THERMAL ANALYSIS** 9

**Phase rule -** Introduction, definition of terms - phase, components and degree of freedom - phase diagram- one component system -water system - reduced phase rule - thermal analysis and cooling curves - two component systems - lead-silver system. Alloys - significance of alloying - heat treatment of steel

**Thermal analysis** - Thermogravimetric analysis- Differential thermal analysis- Differential scanning calorimetry- instrumentation (block diagram) and applications

**UNIT-III POLYMERS AND COMPOSITES** 9

**Plastics -** Types-preparation, properties and uses of Teflon, polycarbonate and PMMA

**Rubbers** - Types-vulcanization-synthetic rubber-Buna N rubber, Butyl rubber

**Composite Materials** - Introduction-Types– MMC, CMC and PMC-Fiber-Reinforced composites-preparation, properties, and applications

**UNIT-IV FUELS AND ENERGY STORAGE DEVICES** 9

**Fuels** - Introduction, calorific value- numerical problems GCV and NCV-Green fuels-Introduction, synthesis and applications of power alcohol and biodiesel-High energy fuels-Production of hydrogen by electrolysis of water and its advantages.

**Energy devices -** Electrode potential-electrochemical series - construction, working and applications of lead acid battery, Lithium-ion battery-Fuel Cell-Hydrogen-Oxygen ($H_2$-$O_2$) fuel cell, proton exchange membrane and solid oxide fuel cells.

**UNIT-V NANOMATERIALS AND LUBRICANTS** 9

**Nanomaterials -** Introduction, size-dependent properties - Synthesis of Nanomaterials-sol-gel, precipitation, hydrothermal and solvothermal methods - Carbon based nano materials - Introduction to CNT, Graphene and Fullerenes- synthesis, properties and applications of CNT.

**Lubricants**: Classification- properties of lubricants- mechanism of lubrication- additives to lubricants- solid lubricants (graphite and $MoS_2$)

**Contact Hours:45**

**Description of the Experiments** **Contact Hours:15**

1. Estimation of the acid by pH metry
2. Determination of corrosion rate on mild steel by weight loss method
3. Estimation of mixture of acids by conductometry
4. Estimation of extent of corrosion of Iron pieces by potentiometry
5. Determination of flash and fire points of lubricating oil
6. Determination of cloud and pour points of lubricating oil
7. Determination of molecular weight of a polymer by viscometry method
8. Synthesis of nanomaterials by simple precipitation method
9. Determination of phase change temperature of a solid
10. Determination of strength of an acid in Pb acid battery
11. Synthesis of biodiesel
12. Determination of acid value of biofuel

**Total Contact Hours:60**

**Course Outcomes:** At the end of the course the student will be able to:

CY23324.1: explain and the fundamental concepts of corrosion, its control and surface modification methods such as electroplating and electroless plating

CY23324.2: apply the concept of phase rule in alloying and predict its thermal properties

CY23324.3: identify the different types of plastics and composite materials of industrial importance

CY23324.4: categorize the types of fuels and the energy storage devices

CY23324.5: synthesize nanomaterials for modern engineering and technology

**SUGGESTED ACTIVITIES**

Electroplating of desired metal on substrate.

Synthesis of biodiesel

**SUGGESTED EVALUATION METHODS**

- Continuous assessment tests
- Assignments
- Model lab examination
- End semester examination

**Text Book(s):**

1. P. C. Jain and Monika Jain, “Engineering Chemistry”, 17th Edition, Dhanpat Rai Publishing Company (P) Ltd, New Delhi, 2018.
2. O.G.Palanna, “Engineering Chemistry”, McGraw Hill Education (India) Pvt, Ltd, New Delhi, 2nd Edition, 2017.
3. Shikha Agarwal “Engineering Chemistry-Fundamentals and applications”, Cambridge University Press, New Delhi, 2019

**Reference Books(s)**

- Polymer Science, V R Gowariker, N V Viswanathan, Jayadev, Sreedhar, Newage Int. Publishers,4th Edition, 2021
- A Text Book Engineering Chemistry, Sunita Rattan, S.K. Kataria & Sons, 1st 2018
- A Text Book of Engg. Chemistry, Shashi Chawla, Dhanpat Rai & Co. (P) Ltd.2011

- PradeepT, “A Text Book of Nanoscience and Nanotechnology”, Tata McGraw Hill, New Delhi, 2012

- Laboratory Manual Engg. Chemistry, Anupma Rajput, Dhanpat Rai & Co

**Weblinks**

- **http://libgen.rs/**
- https://nptel.ac.in/courses/104/103/104103019/
- https://ndl.iitkgp.ac.in/
- https://www.youtube.com/watch?v=j5Hml6KN4TI
- https://www.youtube.com/watch?v=1xWBPZnEJk8

**Lab equipment required:**

| S. No | Name of the Equipment | Quantity Required |
|---|---|---|
| 1. | Conductivity meter | 10 |
| 2. | Potentiometer | 10 |
| 3 | pH meter | 10 |
| 4 | Magnetic stirrer with hot plate | 1 |
| 5 | Flash and Fire point apparatus | 2 |
| 6 | Cloud and pour point apparatus | 2 |

**SUGGESTED EVALUATION METHODS**

- Experiment based viva
- Quizzes

**Web links for virtual lab (if any)**

**https://drive.google.com/drive/folders/1k8g7fGRJ0Dl8FpbjQYg4l5jS1U9qIXnJ**

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CY23324.1** | 3 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 |
| **CY23324.2** | 3 | 2 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 1 | 1 |
| **CY23324.3** | 3 | 2 | 2 | 2 | 2 | 1 | 1 | - | 1 | 1 | 1 | 1 | 1 | 1 | - |
| **CY23324.4** | 2 | 1 | 1 | 1 | 1 | - | - | - | 1 | - | - | 1 | 1 | - | - |
| **CY23324.5** | 3 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 1 | 1 |
| **Average** | 2.8 | 1.8 | 1.8 | 1.6 | 1.6 | 1 | 1.75 | 1 | 1.2 | 1 | 1.5 | 1.6 | 1.6 | 1 | 1 |

| Subject Code | ENGINEERING MECHANICS | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **GE 23211** | **(Common to Mech, Aero, Auto Civil and MCT)** | ES | 2 | 1 | 0 | 3 |

**Objectives:**

- To understand the basics of mechanics and apply the concept of equilibrium to solve problems of concurrent forces.
- To understand the concept of equilibrium and to solve problems of rigid bodies.
- To learn about the center of gravity and moment of inertia of surfaces and solids.
- To learn the basic concepts of friction.
- To learn the concepts in kinematics and kinetics of rigid bodies in plane motion.

**UNIT-I STATICS OF PARTICLES** 9

Introduction – Units and Dimensions – Laws of Mechanics – Lami's theorem, Parallelogram and triangular Law of forces – Vectorial representation of forces – Vector operations of forces -additions, subtraction, dot product, cross product – Coplanar Forces – rectangular components – Equilibrium of a particle – Forces in space – Equilibrium of a particle in space – Equivalent systems of forces – Principle of transmissibility.

**UNIT-II EQUILIBRIUM OF RIGID BODIES** 9

Free body diagram – Types of supports –Action and reaction forces –stable equilibrium – Moments and Couples – Moment of a force about a point and about an axis – Vectorial representation of moments and couples – Scalar components of a moment – Varignon's theorem – Single equivalent force -Equilibrium of Rigid bodies in two dimensions – Equilibrium of Rigid bodies in three dimensions – (Descriptive treatment only)

**UNIT-III PROPERTIES OF SURFACES AND SOLIDS** 9

Centroids and centre of mass – Centroids of lines and areas - Rectangular, circular, triangular areas by integration – T section, I section, - Angle section, Hollow section by using standard formula –Theorems of Pappus - Area moments of inertia of plane areas – Rectangular, circular, triangular areas by integration – T section, I section, Angle section, Hollow section by using standard formula – Parallel axis theorem and perpendicular axis theorem – Principal moments of inertia of plane areas – Principal axes of inertia-Mass moment of inertia –mass moment of inertia for prismatic, cylindrical and spherical solids from first principle – Relation to area moments of inertia.

**UNIT-IV DYNAMICS OF PARTICLES** **9**

Displacements, Velocity and acceleration, their relationship – Relative motion – Curvilinear motion - Newton's laws of motion – Work Energy Equation– Impulse and Momentum – Impact of elastic bodies.

**UNIT-V FRICTION AND RIGID BODY DYNAMICS** **9**

Friction force – Laws of sliding friction – equilibrium analysis of simple systems with sliding friction –wedge friction, Ladder friction, Rolling resistance -Translation and Rotation of Rigid Bodies – Velocity and acceleration – General Plane motion of simple rigid bodies such as cylinder, disc/wheel and sphere.

**Total Contact Hours : 45**

**Course Outcomes:** On the successful completion of the course, students will be able to

| | |
|---|---|
| **GE 23211.1** | Comprehend and analysis the forces in the system. |
| **GE 23211.2** | Solve problems in engineering systems using the concept of static equilibrium. |
| **GE 23211.3** | Determine the centroid of objects such as areas and volumes, center of mass of body and moment of inertia of composite areas. |
| **GE 23211.4** | Solve problems involving kinematics and kinetics of rigid bodies in plane motion. |
| **GE 23211.5** | Solve problems involving frictional phenomena in machines. |

**Text Book (s):**


**1** Beer, F.P and Johnston Jr. E.R, Cornwell and Sanghi ., "Vector Mechanics for Engineers (In SI Units): Statics and Dynamics", 11thEdition, McGraw-Hill Publishing company, New Delhi (2017).

**2** Rajasekaran S and Sankarasubramanian G., "Engineering Mechanics Statics and Dynamics", 3rd Edition, Vikas Publishing House Pvt. Ltd., 2005.

**Reference Books(s) / Web links:**


**1** Meriam J.L. and Kraige L.G., "Engineering Mechanics- Statics - Volume 1, Dynamics- Volume 2", Third Edition, Wiley India,2017.

**2** Hibbeller, R.C and Ashok Gupta, "Engineering Mechanics: Statics and Dynamics", 11th Edition, Pearson Education 2010.

**3** Irving H. Shames and Krishna Mohana Rao. G., "Engineering Mechanics – Statics and Dynamics" 4thEdition, Pearson Education 2006.

**4** S S Bhavikatti, Engineering Mechanics, New Age International Publishers, 2016

**5** Vela Murali, "Engineering Mechanics", Oxford University Press (2010)


| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GE 23211.1** | 3 | 2 | 2 | 2 | 1 | 1 | - | - | - | - | - | 1 | 3 | 2 | 3 |
| **GE 23211.2** | 3 | 2 | 2 | 2 | 1 | 1 | - | - | - | - | - | 1 | 3 | 2 | 3 |
| **GE 23211.3** | 3 | 2 | 2 | 2 | 1 | 1 | - | - | - | - | - | 1 | 3 | 2 | 3 |
| **GE 23211.4** | 3 | 2 | 2 | 2 | 1 | 1 | - | - | - | - | - | 1 | 3 | 2 | 3 |
| **GE 23211.5** | 3 | 2 | 2 | 2 | 1 | 1 | - | - | - | - | - | 1 | 3 | 2 | 3 |
| **Average** | 3 | 2 | 2 | 2 | 1 | 1 | - | - | - | - | - | 1 | 3 | 2 | 3 |

| Subject Code | Subject Name | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| AE23211 | FUNDAMENTALS OF AEROSPACE ENGINEERING | PC | 3 | 0 | 0 | 3 |

**Objectives:**

To introduce the concepts and evolution of flight.
To understand different types of flying vehicles**.**
To introduce basic aerodynamics, structural elements and propulsion of aircrafts
To introduce the fundamental space mechanics.

**UNIT-I AIRCRAFT CONFIGURATIONS 9**

History of flight-different types of flight vehicles, classification, components and functions of typical transport aircraft, three view diagram, helicopter and UAV parts and functions. Physical properties and structure of the atmosphere, ISA, temperature, pressure and altitude relationships,

**UNIT-II BASICS OF AERODYNAMICS 10**

Newton's law of motions applied to aeronautics - aerofoil and wing geometry, NACA series airfoils, generation of lift, Mach number and ranges, aerodynamic center, pressure coefficients, aspect ratio, types of drag- induced drag, lift and drag curves, sweepback on wing, basics of pitot tube.

**UNIT-III AIRPLANE STRUCTURES AND MATERIALS 9**

General types of construction, monocoque and semi-monocoque, typical wing and fuselage structure. metallic and non-metallic materials, use of aluminium alloy, magnesium alloy, titanium, stainless steel, plastics, composite materials and smart structures, applications.

**UNIT-IV POWER PLANTS 10**

Classification of propulsive engines -basics about piston, turbojet, turboprop and turbofan - use of propeller and jets for thrust production -equations, principles of operation of rocket, types of rockets and typical applications, exploration into space- India.

**UNIT-V BASICS OF SPACE MECHANICS 7**

Keplar laws, equation, two body problem, fundamentals of orbital mechanics, orbital elements. Orbital transfers, space environment-atmosphere, radiation and magnetic field, space debris.

**Total Contact Hours : 45**

**Course Outcomes:**

On completion of the course students will be able to

**AE23211.1** Identify the component of aircraft
**AE23211.2** Develop the knowledge on basic aerodynamics
**AE23211.3** Identify suitable materials for aircraft structure
**AE23211.4** Analyze the different types of power plants used in aircraft propulsion.
**AE23211.5** Understanding the basics of space mechanics

**Text Books:**

**1** Anderson, J.D., "Introduction to Flight", Tata McGraw-Hill, 2010.

**2** Ethirajan Rathakrishnan., "Introduction to Aerospace Engineering", John Wiley & Sons, Inc.2021

**Reference Books / Web links:**

**1** Kermode, A.C., "Mechanics of Flight", Pearson Education; 11th edition

**2** Kermode, A.C, "Flight without Formula", Pearson Education; 5th edition

**3** NPTEL Course: Introduction to Aerospace Engineering, IIT Bombay Prof. Rajkumar Pant

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **AE23211.1** | 2 | 1 | 1 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 0 |
| **AE23211.2** | 3 | 2 | 1 | 3 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 2 | 3 | 1 | 1 |
| **AE23211.3** | 3 | 2 | 2 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 2 | 3 | 1 | 0 |
| **AE23211.4** | 3 | 1 | 2 | 1 | 0 | 1 | 1 | 0.5 | 0 | 0 | 0 | 2 | 3 | 1 | 0 |
| **AE23211.5** | 3 | 2 | 1 | 0 | 0 | 2 | 3 | 1 | 0 | 0 | 0 | 3 | 2 | 0 | 0 |
| **Average** | 2.8 | 1.6 | 1.4 | 1.4 | 1 | 1.67 | 1.67 | 0.87 | 0 | 0 | 1 | 2.25 | 2.8 | 1 | 1 |

| Subject Code | Subject Name (Laboratory Course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **GE23233** | **PROBLEM SOLVING AND PYTHON PROGRAMMING** | **ES** | **2** | **0** | **4** | **4** |

**Course Objectives:**

- To understand computers, programming languages and their generations and essential skills for a logical thinking for problem solving.
- To write, test, and debug simple Python programs with conditionals, and loops and functions
- To develop Python programs with defining functions and calling them
- To understand and write python programs with compound data- lists, tuples, dictionaries
- To search, sort, read and write data from/to files in Python.

**List of Experiments**

1. Study of algorithms, flowcharts and pseudocodes.
2. Introduction to Python Programming and Demo on Python IDLE / Anaconda distribution.
3. Experiments based on Variables, Datatypes and Operators in Python.
4. Coding Standards and Formatting Output.
5. Algorithmic Approach: Selection control structures.
6. Algorithmic Approach: Iteration control structures.
7. Experiments based on Strings and its operations.
8. Experiments based on Lists and its operations.
9. Experiments based on Tuples and its operations.
10. Experiments based on Sets and its operations.
11. Experiments based on Dictionary and its operations.
12. Functions: Built-in functions.
13. Functions: User-defined functions.
14. Functions: Recursive functions.
15. Searching techniques: Linear and Binary.
16. Sorting techniques: Bubble and Merge Sort.
17. Experiments based on files and its operations.

**Contact Hours : 75**

**Course Outcomes:**

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

- Understand the working principle of a computer and identify the purpose of a computer programming language and ability to identify an appropriate approach to solve the problem.
- Write, test, and debug simple Python programs with conditionals and loops.
- Develop Python programs step-wise by defining functions and calling them.
- Use Python lists, tuples, dictionaries for representing compound data.
- Apply searching, sorting on data and efficiently handle data using flat files.

**Textbooks:**

1. Allen B. Downey, Think Python: How to Think Like a Computer Scientist, Second edition, Updated for Python 3, Shroff/O'Reilly Publishers, 2016 (http://greenteapress.com/wp/think-python/)
2. Guido Van Rossum and Fred L. Drake Jr, An Introduction to Python - Revised and updated for Python 3.2, NetworkTheory Ltd., 2011.

**Reference Books:**

1. John V Guttag, Introduction to Computation and Programming Using Python, Revised and expanded Edition, MIT Press , 2013.

2. Robert Sedgewick, Kevin Wayne, Robert Dondero, Introduction to Programming inPython: An Inter-disciplinary
Approach, Pearson India Education Services Pvt. Ltd., 2016.
3. Timothy A. Budd, Exploring Python, Mc-Graw Hill Education (India) Private Ltd., 2015.
4. Kenneth A. Lambert, Fundamentals of Python: First Programs, Cengage Learning, 2012.
5. Charles Dierbach, Introduction to Computer Science using Python: A Computational ProblemSolving Focus, Wiley
India Edition, 2013.
6. Paul Gries, Jennifer Campbell and Jason Montojo, Practical Programming: An Introduction to Computer Scienceusing Python 3, Second edition, Pragmatic Programmers, LLC, 2013.

## Platform Needed:

Python 3 interpreter for Windows/Linux

**CO - PO – PSO matrices of course**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 | PSO 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GE23233.1 | 2 | 2 | 2 | 2 | 1 | - | - | - | 1 | 1 | 1 | 1 | 3 | 3 | - |
| GE23233.2 | 2 | 1 | 1 | 1 | 1 | - | - | - | - | - | 1 | 1 | 3 | 2 | - |
| GE23233.3 | 1 | 1 | 2 | 1 | 2 | - | - | - | - | - | 1 | 1 | 2 | 3 | 2 |
| GE23233.4 | 2 | 2 | 3 | 2 | 2 | - | - | - | - | - | 2 | 1 | 2 | 2 | 2 |
| GE23233.5 | 2 | 2 | 3 | 2 | 3 | - | - | - | - | - | 2 | 1 | 2 | 2 | 2 |
| **Average** | **1.8** | **1.6** | **2.2** | **1.6** | **1.8** | **-** | **-** | **-** | **1** | **1** | **1.4** | **1** | **2.4** | **2.4** | **2** |

| Subject Code | தமிழரும ததொழிலநுட்பமும / Tamils and Technology | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| GE23217 | Common to all branches of B.E / B.Tech programmes | HS | 1 | 0 | 0 | 1 |

**அலகு I நெசவு மற்றும் பானைத் தொழில்நுட்பம்: 3**

சங்க காலத்தில் நெசவுத் தொழில் - பானைத் தொழில்நுட்பம் - கருப்பு சிவப்பு பாண்டங்கள் - பண்டங்களில் கீறல் குறியீடுகள்.

**அலகு II வடிவமைப்பு மற்றும் கட்டிடத் தொழில்நுட்பம்: 3**

சங்க காலத்தில் வடிவமைப்பு மற்றும் கட்டுமானங்கள் & சங்க காலத்தில் வீட்டுப்பொருட்களில் வடிவமைப்பு - சங்க காலத்தில் கட்டுமான பொருட்களும் நடுகல்லும் - சிலப்பதிகாரத்தில் மேடை அமைப்பு பற்றிய விவரங்கள் - மாமல்லபுரச் சிற்பங்களும், கோவில்களும் - சோழர் காலத்துப் பெருங்கோயில்கள் மற்றும் பிற வழிபாட்டுத் தலங்கள் - நாயக்கர் காலக் கோயில்கள் - மாதிரி கட்டமைப்புகள் பற்றி அறிதல், மதுரை மீனாட்சி அம்மன் ஆலயம் மற்றும் திருமலை நாயக்கர் மஹால் - செட்டிநாடு வீடுகள் - பிரிட்டிஷ் காலத்தில் சென்னையில் இந்தோ - சாரோசெனிக் கட்டிடக் கலை.

**அலகு III உற்பத்தித் தொழில் நுட்பம்: 3**

கப்பல் கட்டும் கலை - உலோகவியல் - இரும்புத் தொழிற்சாலை - இரும்பை உருக்குதல், எஃகு - வரலாற்றுச் சான்றுகளாக செம்பு மற்றும் தங்க நாணயங்கள் - நாணயங்கள் அச்சடித்தல் - மணி உருவாக்கும் தொழிற்சாலைகள் - கல்மணிகள், கண்ணாடி மணிகள் - சுடுமண் மணிகள் - சங்கு மணிகள் - எலும்புத்துண்டுகள் - தொல்லியல் சான்றுகள் - சிலப்பதிகாரத்தில் மணிகளின் வகைகள்.

**அலகு IV வேளாண்மை மற்றும் நீர்ப்பாசனத் தொழில் நுட்பம்: 3**

அணை, ஏரி, குளங்கள், மதகு - சோழர்காலக் குமுழித் தூம்பின் முக்கியத்துவம் - கால்நடை பராமரிப்பு - கல்நடைகளுக்காக வடிவமைக்கப்பட்ட கிணறுகள் - வேளாண்மை மற்றும் வேளாண்மைச் சார்ந்த செயல்பாடுகள் - கடல்சார் அறிவு - மீன்வளம் - முத்து மற்றும் முத்துக்குளித்தல் - பெருங்கடல் குறித்த பண்டைய அறிவு - அறிவுசார் சமூகம்.

**அலகு V அறிவியல் தமிழ் மற்றும் கணித்தமிழ் : 3**

அறிவியல் தமிழின் வளர்ச்சி - கணித்தமிழ் வளர்ச்சி - தமிழ் நூல்களை மின்பதிப்பு செய்தல் - தமிழ் மென்பொருட்கள் உருவாக்கம் - தமிழ் இணையக் கல்விக்கழகம் - தமிழ் மின் நூலகம் - இணையத்தில் தமிழ் அகராதிகள் - சொற்குவைத் திட்டம்.

**TOTAL : 15 PERIODS**

**TEXT-CUM-REFERENCE BOOKS**


1. தமிழக வரலாறு - மக்களும் பண்பாடும் - கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் - முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி - வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை - ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr. K. K. Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils – The Classical Period (Dr. S. Singaravelu)(Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr. S. V. Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies).
9. Keeladi – 'Sangam City Civilization on the banks of river Vaigai' (Jointly Published by: Department of archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Published by: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| MC23111 | INDIAN CONSTITUTION AND FREEDOM MOVEMENT | MC | 3 | 0 | 0 | 0 |

**Objectives:** To inculcate the values enshrined in the Indian constitution.

- To create a sense of responsible and active citizenship.
- To know about Constitutional and Non- Constitutional bodies.
- To understand sacrifices made by the freedom fighters.

**UNIT-I** INTRODUCTION: Historical Background – Constituent Assembly of India – Philosophical foundations of the Indian Constitution – Preamble – Fundamental Rights – Directive Principles of State Policy – Fundamental Duties – Citizenship – Constitutional Remedies for citizens. Constitution' meaning of the term, Indian Constitution: Sources and constitutional history, Features: Citizenship, Preamble, Fundamental Rights and Duties, Directive Principles of State Policy. 9

**UNIT-II** Structure and Function of Central Government: Union Government – Structures of the Union Government and Functions – President – Vice President – Prime Minister – Cabinet – Parliament – Supreme Court of India – Judicial Review. 9

**UNIT-III** Structure And Function Of State Government And Local Body: State Government – Structure and Functions – Governor – Chief Minister – Cabinet – State Legislature – Judicial System in States – High Courts and other Subordinate Courts- Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation, Pachayati Raj: Introduction, Elected officials and their roles, ,Village level: Role of Elected and Appointed officials. **9**

**UNIT-IV** Constitutional Functions and Bodies: Indian Federal System – Center – State Relations – President's Rule – Constitutional Functionaries – Assessment of working of the Parliamentary System in India- CAG, Election Commission, UPSC, GST Council and other Constitutional bodies-. NITI Aayog, Lokpal, National Development Council and other Non –Constitutional bodies. 9

**UNIT-V** Indian Freedom Movement: British Colonialism in India-Colonial administration till 1857- Revolt of 1857- Early Resistance to British Rule-Rise of Nationalism in India-Indian Freedom Struggle under Mahatma Gandhi-Non- Cooperation Movement-Civil Disobedience Movement- Quit India Movement-British Official response to National movement- Independence of India Act 1947-Freedom and Partition. 9

**Total Contact Hours : 45**

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

| | |
|---|---|
| **MC23111.1** | Understand the functions of the Indian government. |
| **MC23111.2** | Understand and abide the rules of the Indian constitution. |
| **MC23111.3** | Gain knowledge on functions of state Government and Local bodies. |
| **MC23111.4** | Gain Knowledge on constitution functions and role of constitutional bodies and non-constitutional bodies. |
| **MC23111.5** | Understand the sacrifices made by freedom fighters during freedom movement. |

**Text Book (s):**


1 Durga Das Basu, "Introduction to the Constitution of India ", Lexis Nexis, New Delhi., 21st ed 2013.
2 Bipan Chandra, History of Modern India, Orient Black Swan, 2009.
3 Bipan Chandra, India's Struggle for Independence, Penguin Books, 2016.
4 Maciver and Page, " Society: An Introduction Analysis ", Mac Milan India Ltd., New Delhi.2nd ed, 2014.
5 P K Agarwal and K N Chaturvedi , Prabhat Prakashan, New Delhi, 1st ed , 2017.


**Reference Books(s) / Web links:**


1 Sharma, Brij Kishore, " Introduction to the Constitution of India:, Prentice Hall of India, New Delhi.
2 U.R.Gahai, "Indian Political System ", New Academic Publishing House, Jalaendhar.

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MC23111.1** | - | - | - | - | - | - | 2 | 2 | - | - | - | 1 | - | - | - |
| **MC23111.2** | - | - | - | - | - | - | 2 | 2 | - | - | - | 1 | - | - | - |
| **MC23111.3** | - | - | - | - | - | - | 2 | 2 | - | - | - | 1 | - | - | - |
| **MC23111.4** | - | - | - | - | - | - | 2 | 2 | - | - | - | 1 | - | - | - |
| **MC23111.5** | - | - | - | - | - | - | 2 | 2 | - | - | - | 1 | - | - | - |
| **Average** | - | - | - | - | - | - | 2 | 2 | - | - | - | 1 | - | - | - |

| Subject Code | Subject Name (Laboratory Course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| GE23122 | ENGINEERING PRACTICES - ELECTRICAL AND ELECTRONICS | ES | 0 | 0 | 2 | 1 |

**Objectives:**

To provide hands-on experience on various basic engineering practices in Electrical Engineering.
To impart hands-on experience on various basic engineering practices in Electronics Engineering.

**List of Experiments**

**A. ELECTRICAL ENGINEERING PRACTICE**

1. Residential house wiring using switches, fuse, indicator, lamp and energy meter.
2. Fluorescent lamp wiring.
3. Staircase wiring.
4. Measurement of electrical quantities – voltage, current, power & power factor in RL circuit.
5. Measurement of resistance to earth of electrical equipment.
6. Study of Ceiling Fan and Iron Box

**B. ELECTRONICS ENGINEERING PRACTICE**

1. Study of electronic components and equipment's – Resistor, colour coding, measurement of AC signal parameter (peak-peak, rms period, frequency) using CRO.
2. (a) Study of Multimeter
   (b) Testing of electronic components.
3. Study of logic gates AND, OR, EXOR and NOT.
4. Generation of Clock Signals.
5. Soldering practice – Components Devices and Circuits – Using general purpose PCB.
6. Measurement of ripple factor of HWR and FWR.

**Total Contact Hours : 30**

**Course Outcomes:**

On completion of the course, the students will be able to

- fabricate the electrical circuits
- construct the house wiring circuits
- fabricate the electronic circuits
- verify the truth table of logic gates
- design the AC-DC converter using diodes and passive components

**SUGGESTED EVALUATION METHODS**

- Experiment based Viva

**REFERENCE**


1. Bawa H.S., "Workshop Practice", Tata McGraw – Hill Publishing Company Limited, 2007.
2. Jeyachandran K., Natarajan S. & Balasubramanian S., "A Primer on Engineering Practices Laboratory", Anuradha Publications, 2007.
3. Jeyapoovan T., Saravanapandian M. &Pranitha S., "Engineering Practices Lab Manual",Vikas Publishing House Pvt.Ltd, 2006.
4. Rajendra Prasad A. &Sarma P.M.M.S., "Workshop Practice", SreeSai Publication, 2002.


**Lab Equipment Required:**

| S. | Name of the Equipment | Quantity Required |
|---|---|---|
| 1 | Residential house wiring using switches, fuse, indicator, lamp and energy | 3 Nos |
| 2 | Fluorescent lamp wiring. | 3 Nos |
| 3 | Stair case wiring | 3 Nos |
| 4 | Measurement of electrical quantities – voltage, current, power & power | 2 Nos |

| | | |
|---|---|---|
| 5 | Study purpose items: Iron box, Ceiling fan. | 2 each |
| 6 | Megger (250V/500V) | 2 Nos. |
| 7 | Soldering guns | 10 Nos. |
| 8 | Assorted electronic components for making circuits | 50 Nos. |
| 9 | Small PCBs | 10 Nos. |
| 10 | Multimeters | 10 Nos. |
| 11 | Digital trainer kit | 5 Nos. |
| 12 | CRO | 8 Nos. |
| 13 | Transformer | 8 Nos. |
| 14 | Function Generator | 8 Nos. |

| **COs/POs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** | **PSO1** | **PSO2** | **PSO3** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GE23122.1** | 3 | 3 | 3 | 2 | - | - | 2 | - | 3 | 2 | - | 3 | 1 | 2 | 1 |
| **GE23122.2** | 3 | 3 | 2 | 2 | - | - | 2 | - | 3 | 2 | - | 3 | 1 | 2 | 1 |
| **GE23122.3** | 3 | 3 | 3 | 2 | - | - | 2 | - | 3 | 2 | - | 3 | 1 | 2 | 1 |
| **GE23122.4** | 3 | 3 | 3 | 2 | - | - | | - | 3 | 2 | - | 3 | 1 | 1 | 1 |
| **GE23122.5** | 3 | 3 | 3 | 2 | - | - | | - | 3 | 2 | - | 3 | 1 | 2 | 1 |
| **Average** | **3** | **3** | **2.67** | **2** | **-** | **-** | **2** | **-** | **3** | **2** | **-** | **3** | 1 | 2 | 1 |

# SEMESTER III

| Course Code | Course Title | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| MA23311 | TRANSFORMS AND APPLIED PARTIAL DIFFERENTIAL EQUATIONS | BS | 3 | 1 | 0 | 4 |

**Common to III sem. B.E. - AERO, MCT, R&A and B.Tech. – BT, FT and CHEM**

**Objectives:**

- To express Fourier series to study the behaviour of periodic functions and their applications in system communications, digital signal processing and field theory.
- To show continuous function arising in wave and heat propagation, signals and systems using Fourier Transforms.
- To obtain solution of one dimensional wave equation with finite difference techniques.
- To solve one and two dimensional heat flow equations using finite difference methods and numerical techniques.
- To make use of Z-transform to illustrate discrete function arising in wave and heat propagation, signals and systems.

**UNIT-I FOURIER SERIES 12**

Dirichlet's conditions – General Fourier series – Odd and even functions – Half range sine series – Half range cosine series –Parseval's identity – Harmonic analysis.

**UNIT-II FOURIER TRANSFORMS 12**

Statement of Fourier integral theorem – Fourier transform pair – Fourier sine and cosine transforms – Properties – Transforms of simple functions – Convolution theorem – Parseval's identity - Application to boundary value problems.

**UNIT-III WAVE EQUATION 12**

Solution of one dimensional wave equation - Finite difference techniques for the solution for PDE- One Dimensional Wave Equation by Explicit method

**UNIT-IV HEAT EQUATION 12**

One dimensional equation of heat conduction – Steady state solution of two dimensional equation of heat conduction (excluding insulated edges)- Numerical computation :One dimensional heat flow equation by implicit and explicit methods

**UNIT-V Z-TRANSFORMS 12**

Z- transforms - Elementary properties – Inverse Z - transform (using residues) - Formation of difference equations – Solution of difference equations using Z- transform.

**Total Contact Hours: 60**

**Course Outcomes:**

On completion of the course, students will be able to

- Demonstrate Fourier series to study the behaviour of periodic functions and their applications in engineering problems such as system communications, digital signal processing and field theory.
- Apply the shifting theorems, Fourier integral theorems, Inverse Fourier sine and cosine transforms appropriate problems in engineering and technology.
- Evaluate solution of one dimensional wave equation arising in various field of engineering using finite difference techniques.
- Apply the numerical techniques of differentiation to solution of heat flow equations arising in various branches of engineering.
- Use Z-transform to illustrate discrete function arising in wave and heat propagation, signals and systems.

**SUGGESTED ACTIVITIES**

- Problem solving sessions
- Activity Based Learning
- Online MATLAB session can be implemented

**SUGGESTED EVALUATION METHODS**

- Problem solving in Tutorial sessions
- Assignment problems
- Quizzes and class test
- Discussion in classroom

**Text Books:**


1. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India, 2015.
2. Veerarajan. T., "Transforms and Partial Differential Equations", Tata McGraw Hill Education Pvt.Ltd.,New Delhi, Second reprint, 2012.
3. Grewal B.S., "Higher Engineering Mathematics", 43rd Edition, Khanna Publishers, Delhi, 2014.
4. Ramana B.V., "Higher Engineering Mathematics", Tata McGraw Hill Publishing Company Limited, New Delhi, 2008.
5. P. Kandasamy, K. Gunavathy, Thilagavathy., "Engineering Mathematics Transforms and Partial Differential Equations", S.Chand & Company, 2002.


**Reference Books / Web links:**


1. N. Subramaniam, K. S. Ramaswami ., "Transforms and Partial Differential Equations", Pearson Education, 2018.
2. Glyn James, "Advanced Modern Engineering Mathematics", 3rd Edition, Pearson Education, 2007.
3. Ray Wylie C and Barrett.L.C, "Advanced Engineering Mathematics" Tata McGraw Hill Education Pvt Ltd, Sixth Edition, New Delhi, 2012.
4. Bali N., Goyal M. and Watkins C., “Advanced Engineering Mathematics”, Firewall Media (An imprint of Lakshmi Publications Pvt., Ltd.,), 7th Edition, New Delhi, 2009.
5. Peter V.O’Neil, “Advanced Engineering Mathematics”, Cengage Learning India Pvt., Ltd, 7 th Edition, New Delhi, 2012. https://drspmaths.files.wordpress.com/2020/01/advanced-engineering-mathematics-peter-v.-o-neil.pdf


| COs / POs & PSOs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MA23311.1 | 3 | 3 | 3 | 2 | 1 | - | - | - | - | - | - | 1 | 2 | 1 | 2 |
| MA23311.2 | 3 | 3 | 3 | 2 | 1 | - | - | - | - | - | - | 1 | 2 | 1 | 2 |
| MA23311.3 | 3 | 3 | 3 | 3 | 2 | - | - | - | - | - | - | 2 | 1 | 2 | 2 |
| MA23311.4 | 3 | 3 | 2 | 3 | 2 | - | - | - | - | - | - | 2 | 1 | - | 1 |
| MA23311.5 | 2 | 3 | 2 | - | - | - | - | - | - | - | - | - | 1 | 1 | - |
| Average | 2.8 | 3 | 2.6 | 2.5 | 1.5 | - | - | - | - | - | - | 1.5 | 1.4 | 1.3 | 2 |

| Subject Code | Subject Name | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **AE23331** | **SOLID MECHANICS** (Integrated Course) | PC | 2 | 1 | 2 | 4 |

**Objectives:**

- Understand the theoretical basis about the stress, strain and elastic modulus concepts in various components
- Assess shear stresses, bending moments and stress variation through mathematical models of beams subjected to axial load, transverse load, couples and combination of loads.
- Understand the principles underlying in the deflection of solid structural member such as a beam subjected to different types of loads.
- Apply the basic mechanical principles to solve practical problems related to springs and shafts subjected to axial load, torsion, bending, transverse shear and combined loading.
- Analyze the state of stress and strain at any point in a member.

**UNIT-I STRESS STRAIN RELATIONS 9**

Introduction – Stress-Strain Relation –Poisson's ratio – Elastic moduli - Composite bars – Temperature stresses

**UNIT-II STRESSES IN BEAMS 9**

Shear force and bending moment diagrams for statically determinate beam structures - bending and shear stress variation in beams of symmetric cross sections

**UNIT-III DEFLECTION OF BEAMS 9**

Deflection of statically determinate beam structures - Double integration method – Macaulay's method

**UNIT-IV TORSION – SPRINGS 9**

Torsion of solid and hollow circular shafts - Stresses in open and closed-coiled helical springs

**UNIT-V BIAXIAL STRESSES 9**

Determination of principal stresses - Stresses in thin-walled pressure vessels – Combined loading of circular shaft with bending, torsion and axial loadings

**Total Contact Hours : 45**

**List of Experiments**

1. Tension test on a Metal / Composite specimen
2. Shear force and bending moment diagram using software packages
3. Determination of deflection of simply supported and cantilever beam using software packages.
4. Torsion test on mild steel rod
5. Deflection of open and closed coil helical springs.
6. Unsymmetrical bending of cantilever beam

**Contact Hours : 15**
**Total Contact Hours : 60**

**Course Outcomes:**

| | |
|---|---|
| AE23331.1 | Design and conduct experiments on mechanical testing and also could analyze and interpret data |
| AE23331.2 | Apply shear force and bending moment diagrams to analyse the resistance offered by the beam and able to solve practical problems and through the software. |
| AE23331.3 | Apply computational skills to formulate and solve problems related to the deflections of beams subjected to mechanical loads. |
| AE23331.4 | Describe and recognize the behaviour of materials upon normal external loads on springs and shafts |
| AE23331.5 | Identify, formulate, and solve structural engineering problems. |

**SUGGESTED ACTIVITIES (if any)** (UNIT/ Module Wise) – Could suggest topic

- **Case Study 1:** Analyze the stress distribution on the wing skin of an aircraft due to aerodynamic loads. Investigate the stress-strain behavior of composite materials used in aircraft construction.
- **Case Study 2:** Analyze the effect of temperature changes on the structural elements of an aircraft, such as engine mounts. Assess the stresses generated due to differential thermal expansion and contraction.
- **Case Study 3:** Calculate the deflection of aircraft wing components, such as ailerons or flaps, subjected to aerodynamic loads.
- **Case Study 4:** Analyze the torsional behavior of the engine shaft in an aircraft's propulsion system.
- **Case Study 5**: Study the stresses in landing gear springs, which absorb impact forces during landings. Calculate the stresses to ensure their durability and reliable performance.

**SUGGESTED EVALUATION METHODS (if Any)** (UNIT/ Module Wise) – could suggest topic

- Tutorial problems
- Assignment problems / Case study
- Quizzes
- Class Presentation/Discussion

**Text Book(s):**

1. Strength of Materials, R Subramanian, Oxford University Press, Third edition (2016). ISBN-10-9780199464739
2. Mechanics of Materials, Egor G. Popov, Pearson Education India; Second edition (2015), ISBN-10: 9789332559547
3. Mechanics of Materials, R C Hibbeler, Pearson Education, Tenth Edition (2022). ISBN-10-9354492258

**Reference Books(s) / Web links:**

- Srinath, L. S., Advanced Mechanics of Solids, 2nd ed., Tata McGraw-Hill (2003).
- Timoshenko and Gere, “Mechanics of Materials", Tata McGraw Hill, 1993.

**Lab equipment required:**

| S. No | Name of the Equipment | Quantity Required | Remarks |
|---|---|---|---|
| 1. | Universal Testing Machine – up to 50 KN load capacity | 1 | Expt. 1 |
| 2. | Computers with Python / MATLAB / Ansys installed packages | 30 | Expt. 2 & 3 |
| 3. | Torsion Testing Machine (60 NM Capacity) | 1 | Expt. 4 |
| 4. | Spring Testing Machine for tensile and compressive loads (2500 N) | 1 | Expt. 5 |
| 5. | Unsymmetrical bending set up | 1 | Expt. 6 |
| 6. | Dial gauge with dial stand | 2 | Expt. 6 |

| CO-PO/PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AE23331.1 | 2 | 3 | 2 | 1 | 1 | 0 | - | - | - | - | - | 1 | 2 | 2 | - |
| AE23331.2 | 3 | 3 | 2 | 1 | 1 | 1 | - | - | - | - | - | 1 | 3 | 2 | - |
| AE23331.3 | 3 | 3 | 3 | 2 | 1 | 1 | - | - | - | - | - | 1 | 3 | 2 | - |
| AE23331.4 | 3 | 3 | 3 | 2 | 0 | 1 | - | - | - | - | - | 2 | 3 | 2 | - |
| AE23331.5 | 3 | 3 | 3 | 2 | 0 | 1 | - | - | - | - | - | 2 | 3 | 1 | - |
| Average | 2.8 | 3 | 2.6 | 1.6 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1.4 | 2.8 | 1.8 | 0 |

| Subject Code | Subject Name | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **AE23332** | **FLUID MECHANICS AND FLUID MACHINERY** | **PC** | **2** | **1** | **2** | **4** |

**Objectives:**

- To define Fluid properties commonly used in the analysis of fluid flow.
- To understand forces applied by fluids at rest or in rigid-body motion and to present conservation equations of fluid flow
- To imbibe fundamental principles of dimensional analysis and to introduce important methods of dimensional analysis
- To provide a general physical description of internal flow and introduce pressure drop correlations for pipe flow.
- To Apply dimensional analysis for preliminary design of turbomachinery

**Unit I Fluid Statics** 9

Introduction and Basic concepts – Properties of fluids- Pressure- Pressure measurement devices-Buoyancy and stability.

**Unit -II Fluid Kinematics and conservation equations.** 9

Lagrangian and Eulerian Description of fluid flow - Reynolds Transport Theorem –Continuity, Bernoulli and Energy Equations

**Unit -III Dimensional Analysis and Modelling** 9

Dimensional Homogeneity – Method of repeating variables- Buckingham Pi Theorem- Experimental Testing and Incomplete Similarity

**Unit -IV Flow in pipes** 9

Entrance Region-Laminar and Turbulent flow in pipes-Minot Losses –Pipes in parallel and series– Orifice, Venturi and Nozzle Meters.

**Unit -V Turbomachinery** 9

Classification and Terminology – Hydrodynamic force of jets, Hydraulic Turbines- Euler's turbine equations -Francis, and Pelton Turbines - Turbine scaling laws.

**Contact Hours : 45**

**List of Experiments**

| | |
|---|---|
| **1** | Determination of friction factor for a given set of pipes. |
| **2** | Flow visualization studies on various models at different Reynolds number |
| **3** | Determination of the coefficient of discharge for given orifice and venturi meters |
| **4** | Determination of performance curves for Pelton wheel turbine. |
| **5** | Experimental verification of Bernoulli's theorem |
| **6** | Determination of metacentric height |

**Contact Hours : 15**
**Total Contact Hours : 60**

**Course Outcomes:**

On completion of the course students will be able to

| | |
|---|---|
| **AE23332.1** | Define, Distinguish and Evaluate Fluid properties. And analyse the stability of floating and submerged bodies |
| **AE23332.2** | Apply conservation principles to formulate governing equations for fluid flows. |
| **AE23332.3** | Apply Bernoulli equation to solve fluid flow problems and Work with energy equation to determine turbine power output. |
| **AE23332.4** | Calculate the major and minor losses associated with pipe flow in piping networks and Understand various velocity and flow rate measurement techniques |
| **AE23332.5** | Apply dimensional analysis to design new hydraulic turbines that are geometrically similar to existing turbines. |

**Suggested Activities**

Problem solving sessions
Flipped classroom – Comparing characteristics of each category of missiles

**Suggested Evaluation Methods**

Tutorial problems
Assignment problems
Quizzes
Class Presentation/Discussion

**Text Books:**

**1** Yunus A. Cengel and John M. Cimbala. "Fluid Mechanics Fundamentals and Applications", McGraw Hill Edition 2006, Sixth Reprint 2009.

**Reference Books:**

**1** Dr. R. K. Bansal "A Textbook of Fluid Mechanics and Hydraulic Machines", Laxmi Publications, New Delhi, Revised Ninth Edition.
**2** Frank M White, "Fluid Mechanics", McGraw Hill, 8th Edition, 2015
**3** Robert W. Fox, Alan T. McDonald, Philip J. Pritchard, "Fluid Mechanics and Machinery", 2011.

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **AE23332.1** | 3 | 3 | - | - | 2 | - | - | - | - | - | - | 1 | 2 | 2 | 1 |
| **AE23332.2** | 3 | 2 | 1 | 1 | 1 | 1 | 1 | - | - | - | - | 1 | - | - | - |
| **AE23332.3** | 3 | 3 | 2 | 1 | - | 1 | 1 | - | - | - | - | - | 2 | 2 | - |
| **AE23332.4** | 3 | 3 | - | 3 | 2 | - | - | - | - | - | - | 2 | 2 | 2 | 1 |
| **AE23332.5** | 3 | 3 | 2 | 1 | - | 1 | 1 | - | - | - | - | 1 | 2 | 2 | - |
| **Average** | 3 | 3 | 1.7 | 1.5 | 2 | 1 | 1 | - | - | - | - | 1.25 | 2 | 2 | 1 |

| Subject Code | Subject Name (Integrated Course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **AE 23333** | **AERO ENGINEERING THERMODYNAMICS** | **PC** | **2** | **1** | **2** | **4** |

Thermodynamics is the science of energy transfer and its effect on physical properties of the substances. This course deals with the thermodynamic laws and its applications, properties of pure substances and its applications and basics of heat transfer. Practical experiments are included in this course to make the subject understanding better.

**Objectives:**

- To introducing the basic concepts of systems and the application of first law of thermodynamics to open and closed systems.
- To make the students to understand the concept of second law of thermodynamics and entropy.
- To analyse the various forms of energy in flow and non-flow processes.
- To understand the various cycle performance and working of Brayton cycle.
- To make students analyse heat of combustion and heat transfer methods.

**UNIT-I BASIC CONCEPTS OF THERMODYNAMIC SYSTEMS AND FIRST LAW** 9

Concept of Continuum, Microscopic and Macroscopic Approach, Thermodynamic Systems, Boundaries of Systems, Properties of Thermodynamics Systems, State, Path, Process and Cycle, Heat and Work, Zeroth Law of Thermodynamics, Enthalpy and Internal energy, First Law of Thermodynamics - Applications to Closed and Open Systems, Numerical Problems.

**UNIT-II SECOND LAW AND ENTROPY** 9

Second Law of Thermodynamics – Kelvin Planck and Clausius Statements of Second Law. Reversibility and Irreversibility - Carnot Theorem - Carnot Cycle, Reversed Carnot Cycle, Efficiency, COP, Clausius Inequality, Concept of Entropy, Entropy of Ideal Gas, Principle of Increase Of Entropy, Numerical Problems

**UNIT-III EXERGY** 9

Basics – energy in non-flow processes: expressions for the energy of a closed system – equivalence between mechanical energy forms and exergy – flow of energy associated with heat flow – exergy consumption and entropy generation, Numerical Problems

**UNIT-IV VAPOUR AND GAS POWER CYCLE** 9

Thermodynamic properties of steam - Standard Rankine cycle, Air standard cycles, Otto, diesel and dual cycle – Thermal efficiency - mean effective pressure – Brayton cycles with reheat and regeneration operations, Numerical Problems.

**UNIT-V REACTIVE SYSTEM AND HEAT TRANSFER** 9

Reaction, Degree of reaction, law of Mass action, Fuel and combustion, Heat of formation, enthalpy of combustion, Heating value, Basic of Conduction, convective and radiation heat transfer, Steady heat conduction in plane, cylindrical and composite wall, Numerical Problems.

**Contact Hours : 45**

**List of Experiments**

| | |
|---|---|
| **1** | Draw the Valve timing diagram of 4-Stroke engine and the Port timing diagram of 2-Stroke engine. |
| **2** | Performance test on a 4-Stroke engine (Load test) |
| **3** | Determination of specific heat of solid by Bomb calorimeter. |
| **4** | Determine the COP of a Refrigeration unit and the Air-conditioning unit. |
| **5** | Determination of effectiveness of a parallel flow and counter flow heat exchanger and calculate the overall heat transfer coefficient (u) in the parallel flow heat exchanger. |
| **6** | Determination of convective heat transfer coefficient during free and forced convection. |
| **7** | Determination of thermal conductivity of a composite wall and a metal by Guarded hot plate method. |

**Contact Hours : 15**
**Total Contact Hours : 60**

**Course Outcomes:**

On completion of the course, the students will be able to

| | |
|---|---|
| AE23333.1 | Apply first law of thermodynamics to solve problems related to open and closed systems. |
| AE23333.2 | Estimate the COP for both heat pump and refrigeration systems. |
| AE23333.3 | Analysis the exergy for the flow and non-flowing processes. |
| AE23333.4 | Demonstrate the working of piston engine and perform the thermodynamic analysis of various cycles. |
| AE23333.5 | Estimate the heating value of various fuels and rate of heat transfer of the given system. |

**SUGGESTED ACTIVITIES (if any)** (UNIT/ Module Wise) – Could suggest topic

- Problem solving sessions
- Activity Based Learning
- Implementation of small module

**SUGGESTED EVALUATION METHODS (if Any)** (UNIT/ Module Wise) – could suggest topic

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

**Text Book(s):**

1. Nag. P. K., "Engineering Thermodynamics", 6th Edition, Tata McGraw-Hill, New Delhi, 2017.
2. Cengel, Y, M. Boles and M. Kanoğlu,, Thermodynamics - An Engineering Approach, Tata McGraw Hill,8th Edition, 2015.
3. Rathakrishnan E., "Fundamentals of Engineering Thermodynamics", 2nd Edition, Prentice-Hall India, 2011.

**Reference Books(s) / Web links:**

1. R.K.Rajput, "A text book of Engineering Thermodynamics", Fifth Edition, Lakshmi Publications, New Delhi, 2016.
2. Holman.J.P., "Thermodynamics", 3rd Edition, McGraw-Hill, 2007.
3. Arora C.P, "Thermodynamics", Tata McGraw-Hill, New Delhi, 2017.
4. Engineering Thermodynamics by D.P.Mishra https://nptel.ac.in/courses/101104063
5. Engineering Thermodynamics, IIT Madras by Prof. Babu Viswanathan https://nptel.ac.in/courses/112106310

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **AE23333.1** | 3 | 3 | 2 | 3 | 1 | 2 | 1 | - | - | 1 | 2 | - | 3 | 3 | 1 |
| **AE23333.2** | 3 | 3 | 2 | 2 | 1 | 2 | 1 | - | - | 1 | 2 | - | 3 | 3 | 1 |
| **AE23333.3** | 3 | 1 | 2 | 2 | 1 | 1 | 1 | - | - | 1 | 2 | - | 3 | 3 | 1 |
| **AE23333.4** | 3 | 1 | 2 | 3 | 1 | 1 | 1 | - | - | 1 | 2 | - | 3 | 3 | 1 |
| **AE23333.5** | 3 | 3 | 3 | 3 | 1 | 2 | 1 | - | - | 1 | 2 | 2 | 3 | 3 | 3 |
| **Average** | 3 | 2.2 | 2.2 | 2.6 | 1 | 1.6 | 1 | 0 | 0 | 1 | 2 | 2 | 3 | 3 | 1.4 |

| Subject Code | Subject Name (Laboratory Course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| CS23422 | PYTHON PROGRAMMING FOR MACHINE LEARNING | ES | 0 | 0 | 4 | 2 |

(With effect from 2021 batch onwards)
Common to all branches of B.E / B.Tech programmes
(Except – CSE, CSBS, CSD, IT, AI/ML)

**Course Objectives:**

- To understand the relationship of the data collected for decision making.
- To know the concept of principle components, factor analysis and cluster analysis for profiling and interpreting the data collected.
- To lay the foundation of machine learning and its practical applications.
- To develop self-learning algorithms using training data to classify or predict the outcome of future datasets.
- To prepare for real-time problem-solving in data science and machine learning.

**List of Experiments**

1. NumPy Basics: Arrays and Vectorized Computation
2. Getting Started with pandas
3. Data Loading, Storage, and File Formats
4. Data Cleaning and Preparation
5. Data Wrangling: Join, Combine, and Reshape
6. Plotting and Visualization
7. Data Aggregation and Group Operations
8. Time Series
9. Supervised Learning
10. Unsupervised Learning
11. Representing Data and Engineering Features
12. Model Evaluation and Improvement

**Contact Hours : 60**

**Course Outcomes:**

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

- Develop a sound understanding of current, modern computational statistical approaches and their application to a variety of datasets.
- Use appropriate packages for analyzing and representing data.
- Analyze and perform an evaluation of learning algorithms and model selection.
- Compare the strengths and weaknesses of many popular machine learning approaches.
- Apply various machine learning algorithms in a range of real-world applications.

**Text Books:**

1. Wes McKinney, Python for Data Analysis - Data wrangling with pandas, Numpy, and ipython, Second Edition, O'ReillyMedia Inc, 2017.
2. Andreas C. Müller and Sarah Guido, Introduction to Machine Learning with Python - A Guide for Data Scientists,
First Edition, O'Reilly Media Inc, 2016.

**Reference Books:**

1. AurélienGéron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 2nd Edition, O'Reilly Media
Inc, 2019.

**Platform Needed:**

Python 3 interpreter for Windows/Linux

**CO - PO – PSO matrices of course**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CS23422.1 | 2 | 2 | 2 | 2 | 1 | - | - | - | 1 | 2 | - | 1 | 3 | 3 | 3 |
| CS19422.2 | 2 | 2 | 1 | 1 | 2 | - | - | - | - | - | - | 1 | 2 | 1 | 3 |
| CS19422.3 | 2 | 3 | 2 | 1 | 2 | - | - | - | 1 | 1 | - | 1 | 2 | 3 | 2 |
| CS19422.4 | 1 | 1 | 1 | - | 1 | - | - | - | - | 1 | 1 | - | 1 | 2 | 3 |
| CS19422.5 | 3 | 3 | 2 | 3 | 3 | - | - | - | 2 | 1 | - | 1 | 2 | 3 | 3 |
| Average | 2 | 2.2 | 1.6 | 1.75 | 1.8 | - | - | - | 1.33 | 1.25 | 1 | 1 | 2 | 2.4 | 2.8 |

| Subject Code | Subject Name (Laboratory Course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **AE23321** | **COMPUTER AIDED MODELING LABORATORY** (Industry Collaboration Course with TANCAM) | PC | 0 | 0 | 4 | 2 |

**Prerequiste:**

20 hrs practical session on 2D drawing & drafting using AutoCAD

**Objectives:**

- Use the CATIA software program to create drawings from scratch and to modify, manipulate, copy, delete and save drawings.
- Design simple and critical components using CATIA modeling software.
- Assemble and animate the three-dimensional complex parts.
- Design the surface model of critical shape components.
- Use the full range of CATIA commands and options and employ shortcuts and time- saving strategies to operate the program at a level of efficiency acceptable for employment as a CAD Engineer.

**List of Experiments**

| | |
|---|---|
| **1** | Study of modeling software |
| **2** | Design and drafting of simple mechanical components. |
| **3** | Design and drafting of upper housing of a blower |
| **4** | Design and drafting of helical gear. |
| **5** | Drafting and assembly of universal coupling. |
| **6** | Drafting and assembly of plummer block |
| **7** | Study of surface modeling |
| **8** | Design and drafting of aircraft wing using surface modeler |
| **9** | Design and drafting of aircraft engine using surface modeler |
| **10** | Introduction to geometric dimensioning and tolerance |
| **11** | Mini Project |

**Total Contact Hours : 30**

**Course Outcomes:**

| | | |
|---|---|---|
| **AE23321.1** | Exposure to computer aided design and drafting software | L2 |
| **AE23321.2** | Learn part design and assembly by design | L6 |
| **AE23321.3** | Learn to design aircraft components in catia workbench | L6 |
| **AE23321.4** | Exposure to Geometric Dimensioning and Tolerance | L6 |
| **AE23321.5** | Learn to draft design drawings | L6 |

**SUGGESTED EVALUATION METHODS (if Any)** (UNIT/ Module Wise) – could suggest topic

**Direct**

1. Pre-or Post-experiment Test/Viva; Experimental Report for each Pre-or Post-experiment Test/Viva; Experimental Report
2. Mini Project

**Indirect**

Course-end survey

**REFERENCE BOOKS:**

1. http://www.ehu.eus/asignaturasKO/DibujoInd/Manuales/R12_manual_catia_v5.pdf

2. http://www.engr.psu.edu/xinli/edsgn497k/TeaPotAssignment.pdf

3. http://file1.engineering.com/pdf/PartDesign.pdf

CO-PO-PSO Mapping

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **AE23321.1** | 3 | 2 | 3 | 1 | 3 | 1 | - | 1 | 2 | 1 | 1 | 3 | 3 | 2 | 1 |
| **AE23321.2** | 3 | 2 | 3 | 1 | 3 | 1 | - | 1 | 2 | 1 | 1 | 3 | 3 | 2 | 1 |
| **AE23321.3** | 3 | 2 | 3 | 1 | 3 | 1 | - | 1 | 2 | 1 | 1 | 3 | 3 | 2 | 1 |
| **AE23321.4** | 3 | 2 | 2 | 1 | 3 | 1 | - | 1 | 2 | 1 | 1 | 3 | 3 | 2 | 1 |
| **AE23321.5** | 3 | 2 | 2 | 1 | 3 | 1 | - | 1 | 2 | 1 | 1 | 3 | 3 | 2 | 1 |
| **Average** | 3 | 2 | 2.6 | 1 | 3 | 1 | - | 1 | 2 | 1 | 1 | 3 | 3 | 2 | 1 |

# SEMESTER IV

| Course Code | Course Title | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| MA23432 | STATISTICS AND NUMERICAL METHODS | BS | 3 | 0 | 2 | 4 |
| | Common to IV sem. B.E. - AERO, MCT and R&A | | | | | |

**Objectives:**

- To apply numerical methods to obtain approximate solutions to mathematical problems.
- To derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of linear equations, and the solution of differential equations.
- To analyse statistical experiments leading to reliability modelling and to identify reliability testing components for assessment of reliability in engineering design.
- To solve the problems those are faced in testing of a hypothesis with reference to the errors in decision making.
- To analyse the different mathematical models with the help of statistical deigns and appropriate data and made valuable conclusions by proper evaluation.

**UNIT-I SOLUTION OF EQUATIONS AND EIGEN VALUE PROBLEM 9**

Newton Raphson method – Secant method – Gauss Jordan method – Iterative method of Gauss Seidel –Eigen value of a matrix by Jacobi method for symmetric matrix.

**UNIT-II INTERPOLATION, NUMERICAL DIFFERENTIATION AND INTEGRATION 9**

Lagrange's interpolations – Newton's forward and backward difference interpolation – Approximation of derivates using interpolation polynomials – Numerical integration – Simpsons 1/3 rule – Gaussian three point quadrature.

**UNIT-III RELIABLITY 9**

Reliability Concepts: Reliability definitions, Importance of Reliability, Quality Assurance and Reliability, Bath Tub Curve - Failure Data Analysis: Hazard rate, failure density, Failure Rate, Mean Time To Failure (MTTF), MTBF, Reliability Functions - Reliability Hazard Models: Constant Failure Rate, Linearly increasing, Time Dependent Failure Rate, Weibull Model- Distribution functions and reliability analysis.

**UNIT-IV STATISTICAL TESTING 9**

Maximal Likelihood estimation – Parameters of Binomial and Poisson distribution - Tests of significance – Z test: Single mean, difference of means- Chi square - F test.

**UNIT-V ANOVA 9**

Design of Experiments - Completely randomized design – Randomized block design –Latin square design.

**Contact Hours: 45**

| S.No | List of Experiment (using R Software) |
|---|---|
| 1 | Basic Functions in R and plotting |
| 2 | Mathematical functions in R – Integration |
| 3 | Control flow – Loops in R |
| 4 | Probability Distributions using R- PDF, CDF for Binomial and Poisson. |
| 5 | Testing of Hypothesis – Z, F and chi-square testing |
| 6 | ANOVA – one way and two way |
| 7 | Reliability – MTTF, MTBF |
| 8 | Solution of equations – system of linear equations, Newton Raphson method |
| 9 | Linear regression and cubic spline interpolation |
| 10 | Reading , writing data in R and working with inbuilt data sets in R |

**Contact Hours: 15**

**Total Contact Hours: 60**

**Course Outcomes:**

on completion of the course, the students will be able to

- Demonstrate common numerical methods and used to obtain approximate solutions of linear and system of equations.
- Derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of linear equations, and the solution of differential equations.
- Illustrate the basic concepts and techniques of modern reliability engineering tools.
- Apply the different testing tools like t-test, F-test, chi-square test to analyse the relevant real life problems.
- Analyse the different mathematical models with the help of statistical deigns and appropriate data and made valuable conclusions by proper evaluation.

**SUGGESTED ACTIVITIES**

- Problem solving sessions
- Smart Class room sessions
- Activity Based Learning

**SUGGESTED EVALUATION METHODS**

- Problem solving in Tutorial sessions
- Assignment problems
- Quizzes and class test
- Discussion in classroom

**Text Book(s):**


4. Veerarajan T., ‘Probability, Statistics and Random Processes with Queueing Theory and Queueing Networks’, Mc Graw Hill, 2016
5. Burden, R.L and Faires, J.D, "Numerical Analysis”, 9th Edition, Cengage Learning, 2016.
6. Kandasamy P., Thilagavathi and K. Gunavathi., “Statistics and Numerical Methods”, S. Chand & Company Ltd. (2010).
7. Sastry S.S, “Introductory Methods of Numerical Analysis”, Prentice- Hall of India PVT. LTD., 4th edition, New Delhi, 2006.


**Reference Books(s) / Web links:**


- Johnson R.A., "Miller and Freund’s Probability and Statistics for Engineers",11th Edition, Pearson Education, Asia, 2011.
- Walpole R.E., Myers. R.H., Myers. S.L., and Ye. K., "Probability and Statistics for Engineers and Scientists", 8th Edition, Pearson Education, Asia, 2007.
- Spiegel M.R., Schiller. J., and Srinivasan. R.A., "Schaum’s Outlines on Probability and Statistics", Tata McGraw Hill Edition, 2004.
- Grewal B.S., and Grewal. J.S., "Numerical Methods in Engineering and Science", 9th Edition, Khanna.


| PO-PSO/ CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MA23432.1 | 2 | 2 | 1 | - | - | - | - | - | - | - | 1 | - | 1 | 1 | - |
| MA23432.2 | 2 | 2 | 1 | - | - | - | - | - | - | - | 1 | - | 1 | - | - |
| MA23432.3 | 2 | 2 | 1 | - | - | - | - | - | - | - | 1 | - | 1 | - | - |
| MA23432.4 | 2 | 2 | 1 | - | - | - | - | - | - | - | 1 | - | 1 | 1 | - |
| MA23432.5 | 2 | 2 | 2 | - | - | - | - | - | - | - | 1 | - | 1 | 1 | - |
| Average | 2 | 2 | 1.2 | - | - | - | - | - | - | - | 1 | - | 1 | 1 | - |

| Subject Code | Subject Name | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **AE23411** | **AIRCRAFT STRUCTURES - I** | PC | **2** | **1** | **0** | **3** |

**Objectives:**

- To provide the students an understanding on the linear static analysis of determinate and indeterminate aircraft structural components.
- To make the students understand the various energy methods to compute the strain energy in axial, bending, torsion and shear loadings.
- To impart the knowledge on column structural member
- To interpret the failure behavior of materials using failure theories.
- To make the students understand the various induced stresses.

**UNIT-I STATICALLY DETERMINATE & INDETERMINATE STRUCTURES 10**

Plane truss analysis – method of joints – method of sections – Principle of super position, Clapeyron"s three moment equation and moment distribution method for indeterminate beams.

**UNIT-II ENERGY METHODS 9**

Strain Energy in axial, bending, torsion and shear loadings. Castigliano"s theorems and their applications. Energy theorems – dummy load & unit load methods – energy methods applied to statically determinate and indeterminate beams, frames, rings & trusses.

**UNIT-III COLUMNS 10**

Columns with different end conditions – Euler's column curve – inelastic buckling – effect of initial curvature – columns with eccentricity – theory of beam columns – beam columns with different end and loading conditions

**UNIT-IV FAILURE THEORIES AND IT'S APPLICATIONS 9**

Ductile and brittle materials – maximum principal stress theory – maximum principal strain theory – maximum shear stress theory – distortion energy theory – octahedral shear stress theory.

**UNIT-V INDUCED STRESSES 7**

Impact loading – Fatigue – Types of Fatigue – Fatigue Life Curves — Creep – Various stages of creep – Stress Relaxation.

**Total Contact Hours : 45**

**Course Outcomes:**

| | | |
|---|---|---|
| AE23411.1 | Analyse the statically determinate and indeterminate using the principle of iterative methods and theorem of three moments. | L5 |
| AE23411.2 | Make use of classical methods determine the deflections of beams, frames and arches | L3 |
| AE23411.3 | Understand the stability, Euler buckling load and problems in column design. | L2 |
| AE23411.4 | Analyse the failure of the brittle and ductile materials in comparison with simple mechanical tests. | L4 |
| AE23411.5 | Interpret and Predict material failure for the induced stresses caused due to the dynamic and other environmental effects. | L2 |

**Text Books:**

**1** Timoshenko and Gere, "Mechanics of Materials", Tata McGraw Hill, 1993.
**2** R. Subramanian, "Strength of Materials", Oxford University Press, Third edition.

**Reference Books:**


1. Donaldson, B.K., "Analysis of Aircraft Structures - An Introduction", McGraw Hill, 1993.
2. Bruhn E F, "Analysis and Design of Flight Vehicle Structures", Tri-State Off-set Company, USA, 1985
3. Peery, D.J. and Azar,J.J., "Aircraft Structures", 2nd Edition, McGraw – Hill, N.Y, 1999.


| CO-PO/PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AE23411.1 | 3 | 2 | 2 | 3 | 2 | 0 | - | - | - | 2 | - | 1 | 2 | 2 | - |
| AE23411.2 | 3 | 2 | 2 | 2 | 2 | 0 | - | - | - | 2 | - | 1 | 2 | 2 | - |
| AE23411.3 | 3 | 2 | 1 | 2 | 2 | 1 | - | - | - | 2 | - | 1 | 2 | 2 | - |
| AE23411.4 | 3 | 2 | 2 | 2 | 2 | 2 | - | - | - | 2 | - | 1 | 2 | - | - |
| AE23411.5 | 3 | 2 | 2 | 2 | 2 | 1 | - | - | - | 2 | - | 1 | 2 | 2 | - |
| Average | 3 | 2 | 1.8 | 2.2 | 2 | 1.3 | - | - | - | 2 | - | 1 | 2 | 1.6 | - |

| Subject Code | Subject Name | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| AE23412 | CONTROL ENGINEERING | PC | 3 | 0 | 0 | 3 |

**OBJECTIVES**

- To introduce the mathematical modelling of systems, open loop and closed loop systems and analyses in time domain and frequency domain.
- To impart knowledge on the concept of stability and various methods to analyze stability in both time and frequency domain.
- To introduce sampled data control system.
- To explain the concept of stability
- Analyzing digital controllers.

**UNIT I INTRODUCTION 9**

Simple pneumatic, hydraulic and thermal systems, Series and parallel system, Analogies, mechanical and electrical components, Development of flight control systems. APM 2.8 Flight controller

**UNIT II OPEN AND CLOSED LOOP SYSTEMS 9**

Feedback control systems – Control system components - Block diagram representation of control systems, Reduction of block diagrams, Signal flow graphs, Procedure for convert block diagram to signal flow graph.

**UNIT III CHARACTERISTIC EQUATION AND FUNCTIONS 9**

Laplace transformation, Response of systems to different inputs viz., Step impulse, pulse, parabolic and sinusoidal inputs, Time response of first and second order systems, steady state errors and error constants of unity feedback circuit.

**UNIT IV CONCEPT OF STABILITY 9**

Necessary and sufficient conditions, Routh-Hurwitz criteria of stability, Root locus and Bode techniques, - polar plot-Nyquist stability criterion-Concept and construction, frequency response.

**UNIT V SAMPLED DATA SYSTEMS 9**

Z-Transforms ,sampling and quantization,Introduction to digital control system, converters, sensors and Actuators,Digital Controllers and Digital PID controllers-Adaptive Control.

**Total Contact Hours :45**

**TEXT BOOKS**

1. OGATO, Modern Control Engineering, Prentice-Hall of India Pvt. Ltd., New Delhi, 1998.
2. Azzo, J.J.D. and C.H. Houpis Feed back control system analysis and synthesis, McGraw-Hill international 3rs Edition, 1998.

**REFERENCES**

1. Kuo, B.C. "Automatic control systems", Prentice-Hall of India Pvt. Ltd., New Delhi, 1998.
2. Houpis, C.H. and Lamont, G.B. "Digital control Systems", McGraw Hill Book co., U.S.A. 1995.
3. Naresh K Sinha, "Control Systems", New Age International Publishers, New Delhi, 1998.

**SUGGESTED ACTIVITIES**

- Problem solving sessions
- Activity Based Learning
- Mini Projects

**SUGGESTED EVALUATION METHODS**

- Assignment problems
- Quizzes
- Class Presentation/Discussion

**Course Outcomes:**

On completion of the course students will be able to

**AE23412.1** Apply mathematical knowledge to model the systems and analyse the frequency domain

**AE23412.2** Check the stability of both time and frequency domain.

**AE23412.3** Solve simple pneumatic, hydraulic , Mechanical and electrical component analogies-based problems

**AE23412.4** Solve the Block diagram representation of control systems, Reduction of block diagrams, Signal flow graph and problems based on it.

**AE23412.5** Explain the digital control system, Digital Controllers and Digital PID Controllers, Adaptive control.

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AE23412.1 | 3 | 1 | - | - | - | - | - | - | - | - | - | 1 | 3 | 2 | 1 |
| AE23412.2 | 3 | 1 | - | 1 | - | - | - | - | - | - | - | 1 | 3 | 2 | 1 |
| AE23412.3 | 3 | 1 | 2 | 1 | 2 | - | - | - | - | - | - | 1 | 3 | 2 | 1 |
| AE23412.4 | 3 | 1 | 2 | 1 | 2 | - | - | - | - | - | - | 1 | 3 | 2 | 1 |
| AE23412.5 | 3 | 1 | - | - | - | - | - | - | - | - | - | 1 | 3 | 2 | 1 |
| Average | 3 | 1 | 2 | 1 | 2 | - | - | - | - | - | - | 1 | 3 | 2 | 1 |

| Subject Code | Subject Name | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| AE23431 | INCOMPRESSIBLE AERODYNAMICS | PC | 2 | 1 | 2 | 4 |

**Course Objectives:**

- To introduce fundamental aerodynamic theories and aerodynamic characteristics of airfoils and wings
- To familiarize students with viscous flows

**UNIT-I AERODYNAMIC FORCES AND MOMENTS 9**

Review of fundamental equations of fluid flows, Euler equation, Bernoulli's equation and applications. Streamlined and bluff-bodies. generation of lift, drag and moment, incompressible flows over airfoils, calculation of lift and drag from measured pressure distribution. Centre of pressure, aerodynamic centre and aerodynamic moment.

**UNIT-II POTENTIAL FLOWS 9**

Vorticity, Stoke's theorem, streamline, stream function. Irrotational flow, potential function, equipotential lines, Potential flow equation, Elementary flows and their combinations.

**UNIT-III AIRFOIL THEORY 9**

Kutta-Joukowski theorem. Low speed aerodynamic characteristics of symmetric and cambered airfoils. vortex sheet, Kutta condition, Kelvins circulation theorem and starting vortex, Classical thin airfoil theory - symmetric & cambered airfoils. Types of drag.

**UNIT-IV WINGS THEORY 9**

Wing geometry and terminology, flow over wing, downwash, induced drag. Type of drag, Prandtl's lifting line theory and limitations. Lift distribution over wings: elliptical, rectangular, and trapezoidal. Effect of aspect ratio on lift distribution and induced drag. High lift devices.

**UNIT-V VISCOUS FLOWS 9**

Boundary layer equations for a steady, two-dimensional incompressible flow, boundary layer growth over a flat plate, Boundary layer properties, Blasius solution - self-similar solutions and other important results. Basics of turbulent flow .

Case study – Boundary Layer Control for improvised aerodynamics of wings, high-lift systems and control surfaces

**Total Hours : 45**

**Case study 1:** Comparative Analysis of Airfoils for Different Aircraft Applications NACA 2412 - General Aviation NACA 64A-206 - High-Speed Jets, S822 - Wind Turbine Blades, Eppler 387 - Unmanned Aerial Vehicles

**Case Study 2 :** Analysis of Wing Geometry and Aspect Ratio Effects on Lift Distribution and Induced Drag in Different Aircraft Types: Glider (elliptical) Commercial Airliners (rectangular, or trapezoidal), and Fighter Jets (trapezoidal).

**Case study 3:** Boundary Layer Behavior and Transition on High-Lift Devices for Aircraft Wings - To analyze boundary layer behavior on high-lift devices (such as flaps and slats) and understand their role in enhancing lift by manipulating boundary layer characteristics and controlling flow separation on an aircraft wing.

**Course Outcomes:**

On completion of the course students will be able to

AE23431.1 **classify** airfoils and label their nomenclature; **apply** governing equations to formulate necessary subsidiary equation in order to determine the aerodynamic forces

AE23431.2 **explain** potential flow theories and **solve** their combinations.

AE23431.3 **estimate** the aerodynamic characteristics of airfoils

AE23431.4 **estimate** the aerodynamic characteristics of wings

AE23431.5 **formulate** and **solve** boundary layer problems

**Textbooks:**

**1** Anderson, Jr., J.D., Fundamentals of Aerodynamics, McGraw-Hill Education; 7th edition, 2023

**Reference Books:**

**1** Bertin, J.J., Aerodynamics for Engineers, Sixth edition, Pearson Education, 2021
**2** Arnold M. Kuethe and Chuen–Yen Chow, "Foundations of Aerodynamics: Bases of Aerodynamic Design", John Wiley & Sons; 5th edition, 1997
**2** McCormick, B.W., Aerodynamics, Aeronautics, & Flight Mechanics, second edition, John Wiley, 2009
**3** Jan Roskam and Chuan-Tau Lan, Airplane Aerodynamics and Performance, DAR corporation, third edition, 1997

## List of Experiments

1. Calibration of subsonic wind tunnel
2. Flow visualization at low speeds (smoke, tuft and water channel).
3. Surface pressure distribution on a symmetrical airfoil at an angle of incidence and calculation of lift and pressure drag.
4. Surface pressure distribution on a cambered airfoil at an angle of incidence and calculation of lift and pressure drag.
5. Measurement of aerodynamic loads using wind tunnel force balance.
6. Surface pressure distribution on an airfoil (infinite wing) with flap.
7. Pressure distribution over smooth and rough circular cylinders.

**Contact Hours: 15**
**Total Contact Hours:60**

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AE23431.1 | 3 | 2 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23431.2 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23431.3 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23431.4 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23431.5 | 3 | 2 | 2 | - | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **Average** | 3 | 2 | 2 | 1 | 1.8 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |

| Subject Code | Subject Name | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| AE23432 | AIRCRAFT MATERIALS AND PROCESSES | PC | 3 | 0 | 2 | 4 |

**Objectives:**

- To provide students with a comprehensive understanding of ferrous and non-ferrous materials,
- focusing on the properties, applications, and manufacturing processes.
- To introduce students to various casting methods, core making techniques, and welding processes,
- focusing on their principles, applications, and associated defects in manufacturing.
- To provide students with an understanding of the principles, operations, and applications of various

**UNIT-I FERROUS AND NON-FERROUS MATERIALS 9**

Ferrous materials: Steels: Plain and low carbon steels, various low alloy steels, aircraft steel specifications, corrosion and heat resistant steels, structural applications. Maraging Steels: Properties and Applications. Super Alloys: Use -Nickel base-Cobalt base- Iron base - Forging and Casting of Super alloys

Non-ferrous materials: Aluminum and its Alloys-Types and identification. Properties, Magnesium and its alloys - Cast and Wrought alloys - Aircraft application, features specification, fabrication problems, Special treatments. Titanium and its alloys - Applications, machining, heat treatment, Copper Alloys.

**UNIT-II CASTING AND JOINING 9**

Casting types, types of core making, moulding tools- permanent moulding- pressure die casting, centrifugal casting.

Classification of welding processes. Principles of oxy acetylene gas welding, submerged arc welding, TIG – MIG, Laser beam welding, Electron beam welding, and defects in welding.

**UNIT-III MACHINING 9**

General principles (with schematic diagrams only) of working and commonly performed operations in the following machines: Lathe, Shaper, Planer, Horizontal milling machine, Universal drilling machine, Cylindrical grinding machine, Capstan and Turret lathe. General principles and applications of the following processes: Abrasive jet machining, Ultrasonic machining, Electric discharge machining, Electro chemical machining, Plasma arc machining, Electron beam machining and Laser beam machining.

**UNIT-IV HEAT TREATMENT OF ALLOYS 9**

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.

**UNIT-V CNC MACHINING AND ADVANCED MANUFACTURING 9**

Numerical Control machine tools – CNC types, Construction details, Special features, Machining centre – Tool magazines and transfer systems, Automatic tool changer – Part Programming Fundamentals – CNC and Manual part programming – Micro machining – Wafer manufacturing process, Rapid prototyping Technology: 3D Printing, Additive layer manufacturing –Rapid Manufacturing, applications and advancements.

**Total Contact Hours : 45**

**List of Experiments**

1. Preparation of welded butt joints using MIG welding
2. Preparation of welded Lap joints using TIG welding
3. Step turning, drilling and boring using Capstan / Turret lathe
4. Keyway cutting in slotter
5. Spur gear cutting in milling machine
6. CNC machining - part programming – facing and turning
7. CNC Machining- part programming – step turning
8. Study of 3D Printing technology

**Contact Hours : 15**

**Total Contact Hours : 60**

**Course Outcomes:**

On completion of the course students will be able to

AE23432.1 Distinguish ferrous and non-ferrous materials by corelating its applications.
AE23432.2 Know the various casting and welding processes.
AE23432.3 Use different machining process for component production.
AE23432.4 Have a clear knowledge on the various heat treatment processes and its need.
AE23432.5 Understand and carry out simple experiments in CNC machines and also have a knowledge on additive manufacturing.

**SUGGESTED ACTIVITIES**

Flipped classroom – non-conventional machining process, 3D printing technology.
Experimentation – gathering knowledge through experience in laboratory.
Activity Based Learning

**SUGGESTED EVALUATION METHODS**

Assignment
Quizzes
Class Presentation/Discussion

**Text Books:**

1. Hajra Choudhury, "Elements of Workshop Technology", Vol. I and II, Media Promoters and Publishers Pvt., Ltd., Mumbai, 2005
2. Roy. A. Linberg, "Process and Materials of Manufacture", PHI, 2000.

**Reference Books / Web links:**

1. Jain. R.K. and S.C. Gupta, "Production Technology", Khanna Publishers. 16 th Edition,2001
2. Serope Kalpajian, Steven R.Schmid, "Manufacturing Processes for Engineering Materials", Fourth Edition, Pearson Education, Inc. 2007

**Lab equipment required:**

| S. No | Name of the Equipment | Quantity Required | Remarks |
|---|---|---|---|
| 1 | Capstan / Turret lathe | 1 | |
| 2 | MIG welding machine | 1 | |
| 3 | TIG welding machine | 1 | |
| 4 | Milling machine | 1 | |
| 5 | Slotting machine | 1 | |

**Web links for virtual lab (if any)**

- http://vlabs.iitkgp.ac.in/psac/newlabs2020/vlabiitkgpAM/#
- https://3dp-dei.vlabs.ac.in/List%20of%20experiments.html

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AE23432.1 | 2 | 1 | 3 | 2 | 3 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 3 | 1 | 1 |
| AE23432.2 | 3 | 2 | 3 | 3 | 3 | 1 | 1 | 2 | 3 | 1 | 2 | 1 | 3 | 3 | 1 |
| AE23432.3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| AE23432.4 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| AE23432.5 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 1 | 2 | 1 | 2 | 3 | 1 |
| Avg. | 2.4 | 1.2 | 1.8 | 1.6 | 1.8 | 1 | 1 | 1.6 | 1.8 | 1 | 1.4 | 1 | 2.2 | 1.8 | 1 |

| Subject Code | Subject Name | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| AE23433 | AIRCRAFT SYSTEMS AND INSTRUMENTS | PC | 3 | 0 | 2 | 4 |

Objectives:

- To impart knowledge of the aircraft modern control systems
- To apply knowledge on hydraulic and pneumatic systems for aircraft brake system.
- To gain knowledge on piston and jet engine of an aircraft.
- To impart knowledge on aircraft environment systems
- To gain knowledge on various instruments such as air data instruments, Gyroscope instruments and engine instruments

UNIT-I **AIRPLANE CONTROL SYSTEMS** 9

Basics of aircraft control surfaces -open loop control system-closed loop control system– fully powered flight controls – modern control systems – FBW and FBL systems –Fly by wireless flight control system-Displacement autopilot –lateral autopilot

UNIT-II **AIRCRAFT SYSTEMS** 9

Hydraulic systems and its components –Boeing 757 hydraulic systems – pneumatic systems– independent brake system -Power boost brake system- debooster value-– landing gear systems- landing gear systems in flying boat.

UNIT-III **ENGINE SYSTEMS** 9

Typical fuel systems – piston and jet engines – components –Types of lubrication system– starting and ignition systems – piston and jet engines -FADEC

UNIT-IV **AIRCONDITIONING AND PRESSURIZING SYSTEM** 9

Basic air cycle systems – vapour cycle systems – cooling pack-Fire detection systems-fire protection systems-anti-icing system-deicing system.

UNIT-V **AIRCRAFT INSTRUMENTS** 9

Overview of Link- Flight simulator-Air data instruments–air speed indicators – Mach meters – altimeters – vertical speed indicator - gyroscopic instruments– turn and bank indicator, turn coordinator–engine instruments – tachometers -EGT-EPR-Electronic instrument -EADI –EHSI.,Mach warning system,stall warning system

**Contact Hours:45**

**List of Experiments**

1. Aircraft “Jacking Up” procedure
2. Aircraft “Levelling” procedure
3. Control System “Rigging check” procedure
4. Aircraft “Symmetry Check” procedure
5. “Flow test” to assess of filter element clogging
6. “Pressure Test” To assess hydraulic External/Internal Leakage
7. “Functional Test” to adjust operating pressure
8. “Pressure Test” procedure on fuel system components
9. “Brake Torque Load Test” on wheel brake units
10. Maintenance and rectification of snags in hydraulic and fuel systems.
11. Identification of Ignition system in Cessna Aircraft.

**Contact Hours : 15**
**Total Contact Hours : 60**

**Course Outcomes:**

On completion of the course students will be able to

**AE23433.1** Design and develop aircraft control system from primary and secondary control surfaces.
**AE23433.2** Acquires knowledge on hydraulic and pneumatic systems of aircraft
**AE23433.3** Understands piston and jet engine fuel and lubrication systems
**AE23433.4** Understands the aircraft environment systems
**AE23433.5** Identify flight and engine instruments

**SUGGESTED ACTIVITIES**

Problem solving sessions
Activity Based Learning
Implementation of small module

**SUGGESTED EVALUATION METHODS**

- Assignment problems
- Quizzes
- Class Presentation/Discussion

**Textbook:**

1. Kroes, Watkins and Delp, "Aircraft Maintenance and Repair", Tata McGraw Hill, (2010).

**Reference Books(s) / Web links:**

1. Pallet, E.H.J, "Aircraft Instruments & Principles", Pitman & Co (1993).
2. Kroes and Wild,"Aircraft Power plants", Tata McGraw Hill (2010).
3. Instrument Flying Handbook: FAA-H-8083-15B, Sky Pony Press; Clr Csm edition, (2017).

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AE23433.1 | 3 | 2 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23433.2 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23433.3 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23433.4 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23433.5 | 3 | 2 | 2 | - | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **Average** | 3 | 2 | 2 | 1 | 1.8 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |

| Subject Code | Subject Name | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| GE23421 | SOFT SKILLS - I | EEC | 0 | 0 | 2 | 1 |

## Program Learning Goals:

This program will help our students to build confidence and improve their English communication in order to face the corporate world as well as providing them with opportunities to grow within an organisation.

## Course Objectives:

The major course objectives are:

a. To help students break out of shyness.

b. To build confidence

c. To enhance English communication skills.

d. To encourage students' creative thinking to help them frame their own opinions,

## Learning and Teaching Strategy:

The program is completely student centric where the focus is on activities led by students which include role plays, discussions, debates other games as well. These activities would be supplemented by interactive use of technology and brief trainer input.

| Week | Activity Name | Description | Objective |
|---|---|---|---|
| 1 | Introduction | The trainer and the college facilitator talk to the students about the course and in turn the students introduce themselves. | To set expectations about the course and the students are made aware of the rules and regulations involved in this program |
| 2 | If I ruled the world | This is a quick and useful game by getting students to form a circle and provide their point of view. Each student then repeats what the other has said and comes up with their own opinion. | The aim of this activity is to for students to get to know each other and also develop their listening skills as well as learning how to agree and disagree politely. |
| 3 | Picture Narrating | This activity is based on several sequential pictures. Students are asked to tell the story taking place in the sequential pictures by paying attention to the criteria provided by the teacher as a rubric. Rubrics can include the vocabulary or structures they need to use while narrating. | The aim of this activity is to make the students develop creative way of thinking. |
| 4 | Brainstorming | On a given topic, students can produce ideas in a limited time. Depending on the context, either individual or group brainstorming is effective and learners generate ideas quickly and freely. The good characteristics of brainstorming are that the students are not criticized for their ideas so students will be open to sharing new ideas. | The activity aims at making the students speak freely without the fear of being criticized. It also encourages students to come up with their own opinions. |

| | | | |
|---|---|---|---|
| 5 | Debate | Is competition necessary in regards to the learning process? | The aim of this activity is to develop the students ability to debate and think out of the box |
| 6 | Short Talks | Here the students are given topics for which they take one minute to prepare and two minutes to speak. They can write down points but can't read them out they can only use it as a reference. | The activity aims at breaking the students' shyness and encouraging them to standup in front of the class and speak. It also aims at creating awareness that they are restricted for time so they only speak points that are relevant and important. |
| 7 | Debate | Will posting students' grades on bulletin boards publicly motivate them to perform better or is it humiliating? | This activity aims at enhancing the students unbiased thought process when it comes to exams and grades as well as develop their skills to debate |
| 8 | The Art of diplomacy | The facilitator proceeds to share multiple concepts of conversation and helps the participants to identify the various methods of being diplomatic and how do deal with misinformation. | The aim of the lesson is to provide an opportunity for the participants to learn about body language and choosing the appropriate words for conversation. |
| 9 | Debate | Are humans too dependent on computers? | The aim of this activity is to test the students debating skills and thought process with a topic that affects everybody in daily life. |
| 10 | Story Completion | The teacher starts to tell a story but after 2 sentences he/she asks students to work in groups to create the rest of the story which includes the plot and the ending. | This activity aims at building their narrating skills as well as their creativity and ability to work in a team. |
| 11 | Role play debate | Students scrutinize different points of view or perspectives related to an issue. For example, a debate about the question "Should students be required to wear uniforms at school?" might yield a range of opinions. Those might include views expressed by a student (or perhaps two students – one representing each side of the issue), a parent, a school principal, a police officer, a teacher, the owner of a clothing store, and others. | The aim of this activity is to get students to speak based on other people's perspective instead of their own. The students take the role of various characters and debate accordingly. |
| 12 | I Couldn't Disagree More | This is a game where students practice rebuttal techniques where one student provides a thought or an idea and the other students starts with the phrase I couldn't disagree more and continues with his opinion | The aim of this activity is to improve general communication skills and confidence. |
| | Feedback | At the end of the session in the final week (12) the trainer would provide feedback to the students on best practices for future benefits | The aim is to do both give feedback to students as well as obtain feedback on the course from them. |

**Course Learning Outcome:**

On successful completion of the course, students should be able to:

1. Be more confident
2. Speak in front of a large audience
3. Be better creative thinkers
4. Be spontaneous
5. Know the importance of communicating in English.

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GE23421.1 | - | - | - | - | - | - | - | - | 1 | 3 | - | 1 | - | 1 | 2 |
| GE23421.2 | 1 | - | - | - | - | - | 1 | - | 1 | 3 | 1 | 1 | - | 1 | 2 |
| GE23421.3 | - | - | - | - | - | - | - | - | - | 3 | - | - | - | - | 1 |
| GE23421.4 | - | - | - | - | - | - | - | - | - | 3 | - | - | - | - | - |
| GE23421.5 | - | - | - | - | - | - | - | - | - | 3 | - | - | - | - | 2 |
| **Average** | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 3 | 1 | 1 | 0 | 1 | 1.75 |

# SEMESTER V

| Subject Code | Subject Name | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| AE23511 | **AIRCRAFT PROPULSION** | PC | **2** | **1** | **0** | **3** |

**Objectives:**

- To make the students learn thermodynamics principle of cycles of various jet propulsion engines and their performance characteristics.
- To impart knowledge on subsonic and supersonic inlet operating characteristics and nozzle performance characteristics.
- To make the students familiarize themselves with the combustion processes in gas turbine engine, operating characteristics and pollutants and emissions.
- To give exposure to various types of air compressor, operating characteristics and various design parameter of compressor to students.
- To make the students learn the principle of operation of turbine and turbine design parameter along with matching of compressor and turbine.

## **UNIT-I** FUNDAMENTALS OF AIR BREATHING ENGINES **9**

Operating principles of piston engines – thermal efficiency calculations – classification of piston engines - illustration of working of gas turbine engine – the thrust equation – factors affecting thrust — methods of thrust augmentation – characteristics of turboprop, turbofan and turbojet - Performance parameter calculation.

## **UNIT-II** INLETS AND NOZZLES **9**

Internal flow and Stall in subsonic inlets – relation between minimum area ratio and eternal deceleration ratio – diffuser performance – Boundary layer separation - supersonic inlets – starting problem on supersonic inlets –shock swallowing by area variation – modes of inlet operations - buzz instability – effect unstart - real flow in nozzles and nozzle efficiency – losses in nozzles – equilibrium flow and frozen flow in nozzles– ejector and variable area nozzles - thrust reversal.

## **UNIT-III** JET ENGINE COMBUSTORS **9**

Classification of combustion chambers – combustion chamber performance – effect of operating variables on performance – stoichiometric calculation - Combustion efficiency - Droplet and Spray Evaporation - Atomizer - flame stabilization – Combustion Cooling - Aircraft Fuels - Emissions and Pollutants – Afterburner.

## **UNIT-IV** COMPRESSORS FOR JET ENGINES **9**

Principle of operation of centrifugal compressor and axial flow compressor– Work done and pressure rise – velocity diagrams – degree of reaction – three dimensional equilibrium theory - free vortex and constant reaction designs of axial flow compressor – performance characteristics of centrifugal and axial flow compressors– stage efficiency calculations - cascade testing.

## **UNIT-V** TURBINES FOR JET ENGINES **9**

Principle of operation of axial flow turbines– limitations of radial flow turbines- Work done and pressure rise – Velocity diagrams – degree of reaction – free vortex and constant nozzle angle designs – performance characteristics of axial flow turbine– turbine blade cooling methods – stage efficiency calculations – basic blade profile design considerations – matching of compressor and turbine.

**Total Contact Hours:45**

**SUGGESTED EVALUATION METHODS (if Any)** (UNIT/ Module Wise) – could suggest topic

- Assignments
- Quizzes/MCQ
- Seminar Presentation/Discussion
- Assessment Tests

## TEXTBOOKS

1. Hill, P.G. & Peterson, C.R. "Mechanics & Thermodynamics of Propulsion" Addison – Wesley Longman INC, 2nd Edition, 2009.
2. Ahmed F. El – Sayed, "Aircraft Propulsion and Gas turbine engines", CRC Press Taylor and Francis group, 2nd Edition, 2017.
3. **Thomas A. Ward,** "Aerospace Propulsion System", John Wiley & Sons, 1ST Edition 2010.
4. Arthur H. Lefebvre and Dilip R. Ballal, "GAS Turbine Combustion Alternative Fuels and Emissions" CRC Press Taylor and Francis group, 3rd Edition, 2010.

## REFERENCES

1. Cohen, H. Rogers, G.F.C. and Saravana muttoo, H.I.H. "Gas Turbine Theory", Longman, 7TH Edition 2017.
2. Oates, G.C., "Aero thermodynamics of Aircraft Engine Components", AIAA Education Series, New York, 1985.
3. Ganesan, V., "Gas Turbines", McGraw Hill Education, 2017.
4. Jack D. Mattingly, Hans von Ohain, "Elements of Propulsion: Gas Turbines and Rockets", American Institute of Aeronautics & Astronautics, 2000.
5. M.J. Zucrow, "Aircraft and Missile Propulsion – Volume I & II ", John Wiley & Sons, I.nc, 1969.
6. Introduction to Propulsion, IIT Kanpur by Dr. D.P. Mishra, https://nptel.ac.in/courses/101104018.
7. Jet Aircraft Propulsion, IIT Bombay by Prof. Bhaskar Roy, Prof. A M Pradeep, https://nptel.ac.in/courses/101101002.
8. Introduction to Propulsion Systems by Prof. Manuel Martinez-Sanchez, https://ocw.mit.edu/courses/16-50-introduction-to-propulsion-systems-spring-2012/pages/lecture-notes/
9. https://nptel.ac.in/courses/101104018.

## COURSE OUTCOMES:

On completion of the course, students will be able to

AE23511.1 differentiate various jet propulsion engines and their performance characteristics.
AE23511.2 understand different types of inlets and nozzles operating principles and performance characteristics.
AE23511.3 analyse the combustion processes in gas turbine engine, operating characteristics.
AE23511.4 understand various types of compressors and their operating principles.
AE23511.5 understand various types of turbines and their operating principles.

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AE23511.1 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 3 |
| AE23511.2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 3 |
| AE23511.3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 3 |
| AE23511.4 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 3 |
| AE23511.5 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 3 |
| **Average** | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 3 |

| Subject Code | Subject Name | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| AE23512 | COMPRESSIBLE AERODYNAMICS | PC | 2 | 1 | 0 | 3 |

**Objectives:**

- Grasp compressible flow fundamentals and nozzle dynamics.
- Analyze supersonic wave phenomena, focusing on shocks and interactions.
- Explore two-dimensional compressible flow using linearized methods.
- Examine high-speed flow over airfoils and design supersonic profiles.
- Gain practical knowledge of experimental and CFD techniques for high-speed flows.

**UNIT-I FUNDAMENTAL ASPECTS OF COMPRESSIBLE FLOW AND NOZZLE DYNAMICS 9**

Compressibility, 1D flow continuity, momentum, and energy equations. Compressible Bernoulli's equation, area-Mach-velocity relation, Mach cone, and Mach angle. 1D isentropic flow, critical Mach number, maximum discharge velocity, nozzle characteristics, and introduction to hypersonic flows.

**UNIT-II SUPERSONIC WAVE PHENOMENA 9**

Normal and oblique shock relations, Hugoniot equation, Rayleigh Pitot tube equation. Shock interactions, boundary-layer interactions, Rayleigh and Fanno flows, expansion waves, Prandtl-Meyer expansion, and turning angles.

**UNIT-III TWO-DIMENSIONAL COMPRESSIBLE FLOW 9**

Potential equations for 2D compressible flows, linearized Pressure Coefficient. Prandtl-Glauert rule for subsonic flow, linearized supersonic flow, and Method of Characteristics.

**UNIT-IV HIGH-SPEED FLOW CHARACTERISTICS OVER AIRFOILS 9**

Critical Mach number, drag-divergence Mach number, shock stall. Supercritical airfoils, transonic area rule, swept wings, supersonic airfoil design, and wave drag.

**UNIT-V EXPERIMENTAL TECHNIQUES FOR HIGH-SPEED FLOWS 9**

Wind tunnels for transonic, supersonic, and hypersonic flows, shock tubes, gun tunnels. Supersonic flow visualization methods and introduction to CFD methods for compressible flows.

**Total Contact Hours:45**

**SUGGESTED EVALUATION METHODS (if Any)** (UNIT/ Module Wise) – could suggest topic

- Assignments
- Quizzes
- Class Presentation/Discussion
- Assessment Tests

**TEXTBOOKS**

1. Anderson, J.D., Modern compressible Flow with Historical Perspective, third ed., McGraw-Hill, 2017.
2. Instrumentation, Measurements, and Experiments in Fluids, Second Edition- Ethirajan Rathakrishnan, CRC Press, 2017

**REFERENCES**


1. Rathakrishnan E., Gas Dynamics, Prentice- Hall of India, 2017.
2. Robert D. Zucker & Oscar Biblarz, "Fundamentals of Gas Dynamics", John Wiley & Sons, 2nd Ed, 2002
3. James E. A. John & Theo G., "Gas Dynamics", Pearson; 3rd edition, 2006.
4. Carscallen, William E. Oosthuizen, Patrick H, “Introduction to Compressible Fluid Flow”, CRC Press, II Edition, 2014.
5. Liepmann, H. W., and Roshko, A., Elements of Gas Dynamics, John Wiley, 2013.
6. Zucrow, Hoffman - Gas Dynamics Vol.1 – Wiley, 1976


**CASE STUDIES:**

1. Analysis of the Space Shuttle Main Engine (SSME) Nozzle Operation [1]
2. Oblique Shock Waves on the Concorde Supersonic Transport [2]
3. Aerodynamic Analysis of the Busemann Bi-Plane in Supersonic Flow [3]
4. Design and Evolution of the Supercritical Airfoil [4]
5. Use of Schlieren Photography in Supersonic Wind Tunnels [5]

**COURSE OUTCOMES:**

On completion of the course, students will be able to

AE23512.1 apply compressible flow equations to analyze Mach cone, angle, and nozzle characteristics.
AE23512.2 evaluate supersonic wave phenomena, including shock and Rayleigh-Fanno flows.
AE23512.3 use potential equations and linearized methods for two-dimensional compressible flows.
AE23512.4 analyze Mach effects, shock stall, and wave drag in high-speed airfoil and wing designs.
AE23512.5 demonstrate proficiency in experimental methods and CFD for high-speed flow analysis.

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AE23512.1 | 3 | 2 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23512.2 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23512.3 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23512.4 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23512.5 | 3 | 2 | 2 | - | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **Average** | 3 | 2 | 2 | 1 | 1.8 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| AE23513 | **FLIGHT DYNAMICS** | PC | 3 | 1 | 0 | 4 |

**Objectives:**

- To introduces the basic concept of drag polar and level flight conditions.
- To describe the gliding, climbing and turning flights and the parameters that decide those performances.
- To impart knowledge on the criteria for longitudinally stable and its control aspects.
- To impart knowledge of directional and lateral stability and its control requirements.
- To introduce the concept of dynamic stability, autorotation and spin and Dutch roll motions of airplanes.

**UNIT-I CRUISING FLIGHT PERFORMANCE** 12

Forces and moments acting on a flight vehicle - Equation of motion of a rigid flight vehicle – Different types of drag –Estimation of drag polar - Drag polar of vehicles from low speed to high speeds - Variation of thrust, power with velocity and altitudes for air breathing engines. Performance of airplane in level flight - Conditions for minimum drag and power required - Power available and power required curves. Maximum speed in level flight - Numerical Problems

**UNIT-II MANOEUVERING FLIGHT PERFORMANCE** 12

Range and endurance - gliding flight - hodograph - minimum rate of sink - shallowest angle of glide – Climbing - Maximum rate of climb - steepest angle of climb -Turning performance Bank angle and load factor – maximum rate of turn – minimum radius of turn- limitations on turn - V-n diagram and load factor.

**UNIT-III STATIC LONGITUDINAL STABILITY** 13

Degree of freedom of rigid bodies in space - Static and dynamic stability - Purpose of controls in airplanes - Inherently stable and marginal stable airplanes – Static, Longitudinal stability - Stability criterion - Stick fixed stability - Basic equilibrium equation - Effects of fuselage and nacelle - Influence of CG location - Power effects - Stick fixed neutral point - Stick free stability-Hinge moment coefficient - Stick free neutral points - Stick force gradients - Stick force per 'g' - Aerodynamic balancing.

**UNIT-IV LATERAL AND DIRECTIONAL STABILITY** 12

Static directional stability - Component contribution - Coupling between rolling and yawing moments-Rudder requirements - Adverse yaw effects-Weather cocking effect - Rudder requirements – One engine inoperative condition - Rudder lock – Dorsal fin - Lateral static stability – Component contribution - Dihedral effect - Lateral control- Aileron control power - Aileron control reversal.

**UNIT-V INTRODUCTION TO DYNAMICS STABILITY** 11

Introduction to dynamic longitudinal stability- Equation of motion - Modes of stability – Routh's criteria - Phugoid motion, Spiral, divergence, Dutch roll, auto rotation and spin.

**Total Contact Hours: 60**

**Course Outcomes:**

On completion of the course students will be able to

AE23513.1 An understanding of drag polar equation and cruising flight performance
AE23513.2 An understanding of manoeuvring flight performance
AE23513.3 Obtain static margin of airplane in stick fixed and free aspects.
AE23513.4 An understanding of the dihedral effect, rolling power and control effectiveness of aileron
AE23513.5 Determine the natural frequency and phugoid and short period motions

**SUGGESTED EVALUATION METHODS (if Any)** (UNIT/ Module Wise) – could suggest topic

- Assignments
- Quizzes
- Class Presentation/Discussion
- Assessment Tests

**Text Book(s):**

1. Anderson, Jr., J.D. Aircraft Performance and Design, McGraw-Hill International Edition, 1999
2. Houghton,E.L. and Carruthers, N.B. Aerodynamics for engineering students, Edward Arnold Publishers, 1988.
3. Perkins C.D. & Hage R.E. Airplane performance, stability and control, John Wiley & Sons1967

**Reference Books(s) / Web links:**

1. Babister, A.W. Aircraft Stability and response, Pergamon Press, 1980
2. McCormick, B.W. Aerodynamics, Aeronautics & Flight Mechanics John Wiley, 1995.
3. Nelson, R.C. Flight Stability & Automatic Control, McGraw Hill, 1998.
4. Pamadi, B.N. Performance, Stability, Dynamics, and Control of Airplanes, AIAA Education Series, 2004
5. NPTEL Course : Flight dynamics I - Airplane performance, IIT Madras Prof. E.G. Tulapurkara
6. NPTEL Course : Introduction to airplane performance, IIT Kanpur Prof. A.K. Ghosh, Prof Deepu Philip
7. NPTEL Course : Aircraft Stability and Control, IIT Kanpur Dr. A.K. Ghosh
8. NPTEL Course : Flight dynamics II - Airplane stability and control, IIT Madras Prof. E.G. Tulapurkara

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AE23513.1 | 3 | 2 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23513.2 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23513.3 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23513.4 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23513.5 | 3 | 2 | 2 | - | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **Average** | 3 | 2 | 2 | 1 | 1.8 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| AE23531 | **AIRCRAFT STRUCTURES – II** | | 2 | 1 | 2 | 4 |

**Objectives:**

- Understand bending of symmetric beams under skew loads, analyze bending stresses in unsymmetrical sections, and study the generalized "K", neutral axis, and principal axis methods.
- Understand shear flow concepts in thin-walled beams, determine the shear center in symmetrical and unsymmetrical sections, and analyze shear flow distribution and structural idealization.
- Learn Bredt-Batho theory for torsion in thin-walled tubes, analyze shear flow in single-cell and multi-cell tubes under combined loads, and determine shear centers of closed sections.
- Understand the bending of thin plates, local buckling stress in thin-walled sections, and estimation of crippling strength and load-carrying capacity of sheet stiffener panels.
- Understand loads on aircraft, the V-n diagram, and analyze shear force and bending moment distribution over the wing and fuselage, shear flow in thin-webbed beams, and tension field beam theory.

**UNIT-I UNSYMMETRICAL BENDING** 9

Bending of symmetric beams subject to skew loads - bending stresses in beams of unsymmetrical sections – generalized "K" method, neutral axis method, principal axis method.

**UNIT-II SHEAR FLOW IN OPEN SECTIONS** 9

Thin-walled beams – concept of shear flow – the shear centre and its determination – shear flow distribution in symmetrical and unsymmetrical thin-walled sections – structural idealization – shear flow variation in idealized sections.

**UNIT-III SHEAR FLOW IN CLOSED SECTIONS** 9

Bredt - Batho theory – single-cell and multi-cell tubes subject to torsion – shear flow distribution in thin-walled single & multi-cell structures subject to combined bending torsion – with walls effective and ineffective in bending – shear centre of closed sections.

**UNIT-IV BUCKLING OF PLATES** 9

Bending of thin plates – rectangular sheets under compression - local buckling stress of thin-walled sections – crippling strength estimation — load carrying capacity of sheet stiffener panels – effective width.

**UNIT-V STRESS ANALYSIS OF WING AND FUSELAGE** 9

Loads on an aircraft – the V-n diagram – shear force and bending moment distribution over the aircraft wing and fuselage – shear flow in thin-webbed beams with parallel and non-parallel flanges – complete tension field beams – semi-tension field beam theory.

**Contact Hours: 45**

**Course Outcomes:**

- Analyze bending in symmetric beams under skew loads, calculate bending stresses in unsymmetrical beams, and apply generalized "K", neutral axis, and principal axis methods.
- Explain shear flow in thin-walled beams, determine the shear center for various sections, and analyze shear flow distribution in idealized structures.
- Apply Bredt-Batho theory to torsion in thin-walled tubes, analyze shear flow in single-cell and multi-cell structures under combined loads, and determine shear centers of closed sections.
- Analyze bending of thin plates, calculate local buckling stress in thin-walled sections, and estimate the crippling strength and load-carrying capacity of sheet stiffener panels.
- Explain loads on aircraft and the V-n diagram, analyze shear force and bending moment distribution over the wing and fuselage, and apply shear flow analysis in thin-webbed beams and tension field beam theory.

**SUGGESTED EVALUATION METHODS (if Any)** (UNIT/ Module Wise) – could suggest topic

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

**Textbook(s):**

1. Megson T M G , "Aircraft Structures for Engineering Students", Elsevier Ltd, 2007
2. Bruhn. E.H., "Analysis and Design of Flight Vehicles Structures", Tri-state off-set Company, USA, 1985.
3. Peery, D.J., and Azar, J.J., "Aircraft Structures", 2nd edition, McGraw – Hill, N.Y., 1999

**Reference Books(s) / Web links:**

1. Timoshenko and Gere, “Mechanics of Materials", Tata McGraw Hill, 1993.
2. Donaldson, B.K., "Analysis of Aircraft Structures - An Introduction", McGraw Hill, 1993.
3. Howard D Curtis, "Fundamentals of Aircraft Structural Analysis", WCB-McGraw Hill, 1997
4. Rivello, R.M., "Theory and Analysis of Flight Structures", McGraw Hill, 1993.

**Aircraft Structures Laboratory**

| S. No | Name of the Equipment |
|---|---|
| 1 | Determination of deflection of a beam under different end conditions |
| 2 | Determination of principal stresses due to combined loading in circular cross-sectional beam |
| 3 | Determination of Shear centre of a closed section |
| 4 | Determination of Shear centre of an open channel section |
| 5 | Estimation of buckling load in column with both ends is hinged. |
| 6 | Determination of natural frequency in Forced vibration of a cantilever beam |

**Contact Hours:15**

**Total Contact Hours:60**

| CO-PO/PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AE23531.1 | 3 | 2 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23531.2 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23531.3 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23531.4 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23531.5 | 3 | 2 | 2 | - | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| Average | 3 | 2 | 2 | 1 | 1.8 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |

| Subject Code | Subject Name | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| GE23521 | SOFT SKILLS - II | EEC | 0 | 0 | 2 | 1 |

**Course Objectives:**

The major course objectives are:

e. To help students break out of shyness.
f. To build confidence
g. To enhance English communication skills.
h. To encourage students' creative thinking to help them frame their own opinions,

**Learning and Teaching Strategy:**

The program is completely student centric where the focus is on activities led by students which include role plays, discussions, debates other games as well. These activities would be supplemented by interactive use of technology and brief trainer input.

| Week | Activity Name | Description | Objective |
|---|---|---|---|
| 1 | The News hour | Students are made to read news articles from the English newspapers. The students also have to find words and their meaning from the article they have not come across before and share it with the group. They then use these words in sentences of their own | The aim of this activity is not only to get the students to read the newspaper but also aims at enhancing the students' vocabulary. |
| 2 | Court Case | The facilitator provides the participants the premise of a story and proceeds to convert the story into a court case. The students are required, department-wise to debate and provide their points to win the case for their clients. | The aim of the lesson is to encourage creative and out-of-the -box thinking to ensure a good debate and defense skills. |
| 3 | The ultimate weekend | The students design activities they are going to do over the weekend and they have to invite their classmates to join in the activity. The students move around the class and talk to other students and invite them. | The aim of this activity is to develop the art of conversation among students. It also aims at practicing the grammatical structures of "going to" "have to" and asking questions. |
| 4 | The Four Corners | This is a debate game that uses four corners of the classroom to get students moving. The following is written on the 4 corners of the room "Strongly Agree, Somewhat Agree, Somewhat Disagree and Strongly Disagree". The topics are then given to the class and students move to the corner that they feel best explains their opinions | This activity aims at getting students to come up with their own opinions and stand by it instead of being overshadowed by others and forcing themselves to change based on others opinions. |
| 5 | Debate | Boarding school or day school? Which is more beneficial for a student? | The aim of this activity is to encourage students to draw up feasible points on the advantages and benefits of both. And enhance their debating ability |
| 6 | Grand Master | The facilitator starts the session by keeping an individual in mind, upon which the students guess it only through "Yes or No" questions. Post few trials the students are given same opportunity to do the same with the crowd. | The aim of the lesson is designed to teach the art of questioning. It also helps to enhance the students' speaking and listening skills. |
| 7 | Debate | Does violence on the TV and Video games influence children negatively? | This activity aims at encouraging the students to debate on real life scenarios that most students spend a lot of time on. |
| 8 | Turn Tables | This is a speaking activity where the students need to speak for and against the given topics when the facilitator shouts out 'Turn Table'. | The aim of this activity is to make the participants become spontaneous and have good presence of mind. |
| 9 | Debate | Do marks define the capabilities of a student? | This debate activity aims at allowing the students to argue on this worrisome adage of marks. |

| | | | |
|---|---|---|---|
| 10 | FictionAD | The Participants are asked to create an Ad for a challenging topic only using fictional characters. | The activity aims at developing their creativity and presentation skills. |
| 11 | Debate | Are social networking sites effective, or are they just a sophisticated means for stalking people? | This activity aims at refining the students debating skills on a very real life situation |
| 12 | Talent Hunt | Talent Hunt is a fun activity where the students are selected at random and supported to present any of their own skills. | The aim of this activity is designed to evoke their inner talents and break the shyness and the fear of participating in front of a crowd |
| | Feedback | At the end of the session in the final week (12) the trainer would provide feedback to the students on best practices for future benefits. | The aim is to do both give feedback to students as well as obtain feedback on the course from them. |

**Course Learning Outcome:**

On successful completion of the course, students should be able to:

1. Be more confident
2. Speak in front of a large audience without hesitation
3. Think creatively
4. Speak impromptu
5. Communicate in English

**CO-PO-PSO Mapping**

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GE23521.1 | - | - | - | - | - | - | - | - | 1 | 3 | - | 1 | - | 1 | 2 |
| GE23521.2 | 1 | - | - | - | - | - | 1 | - | 1 | 3 | 1 | 1 | - | 1 | 2 |
| GE23521.3 | - | - | - | - | - | - | - | - | - | 3 | - | - | - | - | 1 |
| GE23521.4 | - | - | - | - | - | - | - | - | - | 3 | - | - | - | - | - |
| GE23521.5 | - | - | - | - | - | - | - | - | - | 3 | - | - | - | - | 2 |
| **Average** | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 3 | 1 | 1 | 0 | 1 | 1.75 |

| AE23521 | COMPUTATIONAL SIMULATION LABORATORY<br>(Industry Collaboration Course with TANCAM) | L<br>0 | T<br>0 | P<br>4 | C<br>2 |
|---|---|---|---|---|---|

**OBJECTIVES**

- Familiarize with commercial and open-source simulation tools like ANSYS, OpenFOAM, and MATLAB for aerospace applications.
- Analyze structural components of aircraft (wings, fuselage, landing gear) using FEA techniques.
- Understand and simulate fluid flow characteristics around aerodynamic bodies and through internal flow systems.
- Developing skills in interpreting simulation results in visualizing complex phenomena like flows, stresses, and vibrations.
- Prepare for industry-standard practices in aerospace design, focusing on performance and structural integrity.

## LIST OF EXPERIMENTS

**STRUCTURAL SIMULATION**

1. Static structural analysis of a truss.
2. Structural analysis of a composite laminate structure
3. Modal and Harmonic analysis of beams
4. Static structural analysis of an aircraft wing
5. Structural analysis of landing gear
6. Conjugate heat transfer analysis of a flow through a T-junction

**FLOW SIMULATION**

7. Simulation of laminar-turbulent flow over flat plate
8. Simulation subsonic flow over an aircraft wing
9. Simulation of unsteady flow over airfoil
10. Simulation of supersonic over blunt body
11. Simulation of flow through convergent divergent nozzle
12. Heat Transfer Analysis in turbine blade using fluids-solid interface

**Total Contact Hours: 60**

## LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS

| Sl.No | Equipment | Qty |
|---|---|---|
| 1 | Internal server (or) Workstation | 1 |
| 2 | Computers | 30 |
| 3 | Software tools (i) CATIA (ii) ANSYS (iii) OpenFOAM (iv) Matlab (v) Origin/Tecplot | 30 licenses |
| 4 | UPS | 1 |

After successful completion of the course students will demonstrate the following outcomes:

**Course Outcomes:**

On completion of the course students will be able to

**AE23521.1** Use simulation tools effectively for analyzing aerospace structures and fluid flows.
**AE23521.2** Conduct structural analyses on key aircraft components under various loading conditions.
**AE23521.3** Simulate aerodynamic and internal flow behaviours for streamlined, bluff bodies, and nozzle flows.
**AE23521.4** Interpret and visualize simulation data to understand complex aerospace phenomena.
**AE23521.5** Apply industry-relevant skills in computational analysis for aerospace engineering solutions.

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AE23521.1 | 3 | 3 | 1 | 1 | 3 | 1 | 1 | - | 1 | 1 | - | 1 | 3 | 2 | 3 |
| AE23521.2 | 3 | 3 | 1 | 1 | 3 | 1 | 1 | - | 2 | 1 | - | 1 | 3 | 2 | 3 |
| AE23521.3 | 3 | 3 | 2 | 2 | 3 | 1 | 1 | - | 2 | 1 | - | 1 | 3 | 2 | 3 |
| AE23521.4 | 3 | 3 | 2 | 2 | 3 | 1 | 1 | - | 2 | 1 | - | 1 | 3 | 2 | 3 |
| AE23521.5 | 3 | 3 | 2 | 2 | 3 | 1 | 1 | - | 2 | 1 | - | 1 | 3 | 2 | 3 |
| **Average** | 3 | 3 | 1.6 | 1.6 | 3 | 1 | 1 | - | 1.8 | 1 | - | 1 | 3 | 2 | 3 |

| Subject Code | Subject Name | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| AE23522 | **SUMMER INTERNSHIP** | **EEC** | **0** | **0** | **0** | **1** |

A 4-week industry internship is a compulsory course requirement during summer vacation (pre-semester). Evaluation marks to be carried over to present semester. Every student of the course is expected to work in the industry for a period of 4 weeks, during the months of May to June, after completing four semesters of the academic program. The Industry Internship Placement process is held to help the students find internships and at the same time, help recruiters find students to intern with their firms' challenging projects.

**Course Outcomes:**

On completion of the course students will be able to

AE23522.1 Understand the working procedures in industry
AE23522.2 Gain knowledge about contemporary technologies
AE23522.3 Gain hand on experience on various processes
AE23522.4 Apply new methods to investigate complex engineering problems
AE23522.5 Gain motivation towards lifelong learning

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AE23522.1 | 3 | 2 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23522.2 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23522.3 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23522.4 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23522.5 | 3 | 2 | 2 | - | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **Average** | 3 | 2 | 2 | 1 | 1.8 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |

# SEMESTER VI

| Subject Code | Subject Name (Lab Oriented Theory Course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| AE23611 | ROCKET PROPULSION | PC | 2 | 1 | 0 | 3 |

**Course Objectives**

- Understand principles and components of ramjet and scramjet engines.
- Learn fundamentals of chemical rocket propulsion and propellants.
- Study solid rocket propulsion, burning rates, and stability.
- Explore liquid and hybrid rocket components and combustion.
- Understand rocket testing and advanced propulsion methods.

**UNIT I RAMJET AND SCRAMJET 9**

Operating principle of ramjet engine – various components of ramjet engines and their efficiencies –performance characteristics – sample ramjet design calculations – Introduction to Scramjet- Components of scramjet –various types scramjet combustors - need for supersonic combustion – fuel injection schemes in scramjet combustor - problems associated with supersonic combustion - single expansion ramp nozzle - introduction to detonation engine – Combined cycle engines.

**UNIT II FUNDAMENTALS OF CHEMICAL ROCKET PROPULSION 9**

Introduction to rocket propulsion - Operating principle - classification of rocket propulsion - chemical rocket propulsion - applications of chemical rocket motors with advantages and disadvantages — specific impulse – thrust equation - thrust coefficient – C* efficiency – Propellants - classification of propellants – Selection criteria of propellants – adiabatic flame temperature calculation – Gelled propellants.

**UNIT III SOLID ROCKET PROPULSION 9**

Solid rocket motor construction – internal ballistics of solid rocket – burning rate – methods for burning rate calculation – factor affecting burning rate - equilibrium pressure calculations – burning surface area evaluation – igniters - types of igniters - propellant grain design considerations - erosive burning in solid propellant rockets – combustion instability – T-burner.

**UNIT IV LIQUID AND HYBRID ROCKET PROPULSION 9**

Components of liquid rocket engine – propellant tank - peculiar problems associated with operation of cryogenic - classification of feeding systems - atomization process - injectors for liquid propellant rockets - design of injector elements - cooling in liquid propellant rockets and the associated heat transfer problems – combustion instability in liquid propellant rockets – hybrid rockets and its types - combustion mechanism in hybrid propellant rockets – applications and limitations.

**UNIT V ROCKET TESTING AND ADVANCE PROPULSION TECHNIQUES 9**

Static testing of rockets & instrumentation – safety considerations - preliminary concepts in nozzle less propulsion – air augmented rockets – pulse rocket motors – Electric rocket propulsion - Ion propulsion – Nuclear rocket – comparison of performance of these propulsion systems with chemical rocket propulsion systems –Solar sail.

**Total Contact Hours:45**

**TEXTBOOKS**

1. David H. Heiser and David T. Pratt., “Hypersonic Air breathing Propulsion”, AIAA Education Series, 1999.
2. Sutton, G.P., “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 9th Edition, 2017.
3. Ramamurthi K, “Rocket Propulsion”, Laxmi Publications Ltd, 2nd edition, 2016.

REFERENCES

1. Dwarka Prasad Mishra, “Fundamentals of Rocket Propulsion”, CRC Press, 2017.
2. Martin J. Chiaverini and Kenneth K. Kuo, “Fundamentals of Hybrid Rocket Combustion and Propulsion”, Progress in Astronautics and Aeronautics, 2007. .
3. Vigor Yang, Mohammed Habiballah, James Hulka, Michael Popp, “Liquid Rocket Thrust Chambers: Aspects of Modeling, Analysis, and Design”, American Institute of Aeronautics and Astronautics, Inc. 2004.

4. M.J. Zucrow, "Aircraft and Missile Propulsion – Volume II", John Wiley & Sons, I.nc, 1969.
5. Rocket Propulsion, by Prof. S. Varunkumar, Prof. K. Ramamurthi, IIT Madras https://nptel.ac.in/courses/101106082
6. Introduction to Rocket Propulsion, IIT Kanpur, by Dr. D.P. Mishra, https://nptel.ac.in/courses/101104078.
7. Rocket Propulsion by Prof. Manuel Martinez-Sanchez, https://ocw.mit.edu/courses/16-512-rocket-propulsion-fall-2005/pages/lecture-notes/

**SUGGESTED EVALUATION METHODS (if Any)** (UNIT/ Module Wise) – could suggest topic

- Assignments
- Quizzes/MCQ
- Seminar Presentation/Discussion
- Assessment Tests

**Course Outcomes:**

On completion of the course students will be able to

**AE23611.1** understand principles and components of ramjet and scramjet engines.
**AE23611.2** distinguish different types of chemical rocket propulsion and propellants.
**AE23611.3** understand the burning rates of solid rocket propulsion.
**AE23611.4** analyse the liquid and hybrid rocket motors.
**AE23611.5** understand rocket testing and advanced propulsion methods.

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **AE23611.1** | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 3 |
| **AE23611.2** | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 3 |
| **AE23611.3** | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 3 |
| **AE23611.4** | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 3 |
| **AE23611.5** | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 3 |
| **Average** | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 3 |

| Subject Code | Subject Name | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| AE23631 | FLIGHT VEHICLE DESIGN | PC | 3 | 0 | 2 | 4 |

**Course Objectives**

- Understand initial sizing and weight estimation methods for aircraft design.
- Develop skills in configuration layout and lofting for optimized aerodynamic shapes.
- Learn aerodynamic principles for calculating drag, lift, and performance.
- Study structural load analysis and material selection for durability and safety.
- Understand subsystem integration and control for power management and stability.

**UNIT I CONCEPTUAL DESIGN AND SIZING 9**

Conceptual Design: Requirements, phases, key considerations for various aircraft. Initial Sizing: Methods for estimating empty, fuel, and take-off weights, iterative take-off weight calculation. Wing Loading (W/S) and Thrust-to-Weight Ratio (T/W): Importance, performance impact, and mission-based selection.

**UNIT II CONFIGURATION LAYOUT AND LOFTING 9**

Fuselage and Wing Layout: Conic lofting, aerofoil selection, tail configuration. Lofting in CAD: Conic, linear, and flat-wrap techniques for optimized shapes. Aerodynamic Layout: Wetted area, drag reduction, lift distribution, generative and parametric design for adaptive shapes.

**UNIT III AERODYNAMICS AND PERFORMANCE 9**

Aerodynamic Calculations: Drag, lift, and lift augmentation. Engine Selection and Sizing: Turbojet, turboprop, hybrid options for mission needs. Lift/Drag Control: Distributed propulsion, boundary layer control. Performance Dynamics: Ground roll, take-off, landing, balanced field length. Stability estimates and sizing of control surfaces. Flying qualities. Cooper Harper scale.

**UNIT IV STRUCTURAL LOADS AND MATERIALS 9**

Load Analysis: V-n diagrams, load paths, distribution on wings and fuselage. Composite Materials: Modern composites, biomaterials, smart materials and adaptive structures. Safety and Redundancy: Load redundancy, environmental resilience.

**UNIT V SYSTEM INTEGRATION AND CONTROL 9**

Subsystem Integration: Propulsion, fuel, avionics, UAV considerations. Power Management: Electric/hybrid aircraft, energy storage, solar. Control Systems: UAV flight control, sensors, actuators. Testing and Certification: Ground, environmental testing, electric/hybrid certification.

**Contact Hours:45**

**List of Exercises**

**1. Comparative Aircraft Study and Parameter Selection [1-5]**
Conduct a comparative study of different aircraft configurations, specifications, and performance data.
Prepare comparative graphs and select key design parameters based on mission requirements.

**2. Preliminary Design and Sizing [1]**
To the chosen aircraft configuration: finalize the mission profile, including operational requirements and performance objectives.
Perform preliminary weight estimations, selecting key parameters such as wing loading (W/S) and thrust-to-weight ratio (T/W).
Complete initial airfoil selection and develop the basic wing and fuselage layouts.

**3. Drag Estimation and Flight Envelope Analysis [2]**
Estimate drag for the selected configuration and optimize the design to minimize drag for various flight regimes.
Develop V-n diagrams and gust/maneuverability envelopes.

**4. Engine Selection and Performance Calculations [3]**
Select an appropriate powerplant based on mission needs, comparing turbojet, turboprop, or hybrid systems.
Conduct detailed performance calculations, including thrust requirements for take-off, cruise, and climb.

**5. Control Surface Sizing and Stability Estimates [3]**
Calculate stability requirements, size tail and control surfaces (horizontal and vertical stabilizers).
Balance and estimate Maneuvering loads on control surfaces, including tailplane, ailerons, and rudders.

**6. Structural Load Analysis [4]**
Perform load estimations for wings and fuselage, considering structural distribution for different flight conditions.
Create a load distribution model and evaluate material selection for primary components.

**7. Subsystem Selection and Integration [5]**
Choose suitable subsystems such as avionics, landing gear, and fuel systems, considering integration with other components.
Design a layout for efficient integration, focusing on power management and control systems.

**8. Comprehensive Design Report [1-5]**
Prepare a detailed design report covering all aspects of the design process, including calculations, graphs, layouts, and drawings. This report should summarize findings from all previous exercises, providing a holistic view of the flight vehicle design.

**Contact Hours:30**

**Total Contact Hours:75**

**TEXTBOOKS**

1. Aircraft Design - A Conceptual Approach- Daniel P. Raymer, AIAA Education Series, IV Edition © 2006
2. Design of Aircraft-Thomas C. Corke, Pearson Edition. Inc. © 2003.

**REFERENCES**

1. Snorri Gudmundsson, General Aviation Aircraft Design: Applied Methods and Procedures, Butterworth-Heinemann Inc; 2nd edition (2022)
2. Aeroplan Design -VOL 1 to 9 - J Roskam, Roskam Aviation & Engineering Corporation, (1989)
3. Megson T M G , "Aircraft Structures for Engineering Students", Butterworth-Heinemann; 7th ed (2021)
4. Reg Austin, Unmanned Aircraft Systems: UAVS Design, Development and Deployment, Wiley; 1st ed (2011)

**SUGGESTED EVALUATION METHODS (if Any)** (UNIT/ Module Wise) – could suggest topic

- Assignments
- Quizzes/MCQ
- Seminar Presentation/Discussion
- Assessment Tests

**Course Outcomes:**

On completion of the course students will be able to

AE23631.1 Estimate take-off, fuel, and empty weights for aircraft sizing.
AE23631.2 Design basic fuselage and wing configuration using lofting techniques.
AE23631.3 Calculate lift and drag for optimized aircraft performance.
AE23631.4 Analyze load distributions and select suitable materials.
AE23631.5 Integrate propulsion, avionics, and power management systems effectively.

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AE23631.1 | 3 | 2 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23631.2 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23631.3 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23631.4 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23631.5 | 3 | 2 | 2 | - | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **Average** | 3 | 2 | 2 | 1 | 1.8 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |

| Subject Code | Subject Name | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| GE23627 | Design Thinking and Innovation (Type - Project based learning) | EEC | 0 | 0 | 4 | 2 |

**Objectives:**

- To understand the design thinking concepts and deep understanding of user needs and experiences.
- To find the problem statement and To develop innovative design solutions that address identified user challenges
- To master the process of prototyping and iterating on designs.
- To conduct thorough market analysis and financial planning
- To effectively communicate design concepts and findings.

**UNIT-I: INTRODUCTION TO DESIGN THINKING:** The design thinking concepts - Different design thinking models - Details of Stanford Design thinking process: Empathize, Define, Ideate, Prototype, Test

**Activities:**

- Case studies of successful domain-based Design Thinking and Innovative projects
- Group discussions on design thinking

**UNIT 2: EMPATHIZE AND DEFINE:** User research methods (interviews, surveys, observation, contextual inquiry) - Persona development- Journey mapping – Brainstorming Defining the design problem statement

**Activities:**

- Conducting user interviews and surveys
- Creating user personas and journey maps
- Identifying key user needs and pain points
- Analyze the user needs and Brainstorming to define problem statement

**UNIT 3: IDEATE AND CREATE:** Brainstorming techniques (e.g., mind mapping, SCAMPER) - Ideation tools (e.g., design thinking tools, concept sketching) - Concept generation and evaluation ( e.g. Brainstorming)

**Activities:**

- Group brainstorming sessions to select the best idea
- Creating concept sketches and prototypes
- Evaluating ideas based on user needs and feasibility

**UNIT 4: PROTOTYPE AND TEST:** Low, Medium and high level fidelity for prototyping-Usability testing - Iterative design

**Activities:**

- Building low-fidelity prototypes (e.g., paper prototypes)
- Conducting usability tests with users
- Iterating on designs based on feedback

**UNIT 5: MARKET ANALYSIS AND IMPLEMENTATION:** Market research and analysis - Business model development- Financial planning-Implementation strategies

**Activities:**

- Conducting market research
- Developing a business model canvas
- Creating a financial projection
- Developing an implementation plan

**Total Contact Hours:30**

**Course Outcomes:** On completion of the course, the students will be able to

| | |
|---|---|
| GE23627.1 | Construct design challenge and reframe the design challenge into design opportunity. |
| GE23627.2 | Interview the user and know the feelings of users to foster deep user understanding and be able to uncover the deep user insights and needs. |
| GE23627.3 | Develop ideas and prototypes by brainstorming. |
| GE23627.4 | Organize the user walkthrough experience to test prototype |
| GE23627.5 | Develop smart strategies and implementation plan that will deliver/achieve the idea/solution deduced from earlier phases. |

**Assessment:**

- Encourage students to work on real-world design challenges based on the user's needs
- Group presentations
- Quizzes and exams
- Evaluation of Project report and viva and also encourage the students for filing patent/ copyright / presenting in conference / publishing in journal

**Textbook(s):**

1 Handbook of Design Thinking by Christian Müller-Roterberg, Kindle Direct Publishing, 2018**.**

2 Design Thinking – A Beginner's Perspective, by E Balagurusamy, Bindu Vijakumar, MC Graw Hill, 2024

**Reference Books:**

1 Design Thinking for Entrepreneurs and Small Businesses: Putting the Power of Design to Work – by Beverly Rudkin Ingle, Apress; 1st ed. Edition, 2013

2 Design Thinking: Understanding How Designers Think and Work by Nigel Cross, Bloomsbury Visual Arts; 2 edition 2023

**Web links**

1 Design thinking Guide https://www.rcsc.gov.bt/wp-content/uploads/2017/07/dt-guide-book-master-copy.pdf

2 NPTEL Course on Design Thinking and Innovation By Ravi Poovaiah ; https://onlinecourses.swayam2.ac.in/aic23_ge17/preview

3 IITB Design course tools and Resources https://www.dsource.in/

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GE23627.1 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 1 | 3 | 2 |
| GE23627.2 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 1 | 3 | 2 |
| GE23627.3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 1 | 3 | 2 |
| GE23627.4 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 1 | 3 | 2 |
| GE23627.5 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 1 | 3 | 2 |
| **Average** | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 1 | 3 | 2 |

| Subject Code | Subject Name | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| AE23622 | JET PROPULSION LABORATORY | PC | 0 | 0 | 4 | 2 |

**OBJECTIVES**

- To enable the students, understand the behavior supersonic flows
- To study the different expansion levels of jets.

**LIST OF EXPERIMENTS**

1. Principle of operation and calibration of supersonic jet rig.
2. Effect of inlet total pressure on the flow development of supersonic C-D nozzle.
3. Mach number distribution in C-D nozzle for un-choked inlet total pressure(s).
4. Mach number distribution in C-D nozzle for choked inlet total pressure(s).
5. Pitot Pressure study of an over-expanded jet.
6. Pitot Pressure study of correctly expanded jet.
7. Pitot Pressure study of an under-expanded jet.
8. Pitot Pressure measurements to study characteristic decay of subsonic jet.
9. Pitot Pressure measurements to study radial spread of subsonic jet.
10. Use of Shadow graph system to visualize shock waves.
11. Noise Characteristics of jets.

**Total Contact Hours:30**

**LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS**

| Sl.No. | Name of the Equipment | Quantity |
|---|---|---|
| 1 | Supersonic Jet Rig Setup (includes compressors, reservoir and settling chamber and pressure gauges) | 1 |
| 2 | Pressure Regulating Valves | 2 |
| 3 | C-D nozzle models | 2 |
| 4 | Gang manometer | 1 |
| 5 | Pitot tube | 1 |
| 6 | Multi-Channel Pressure scanner | 1 |
| 7 | Flow Visualization setup | 1 |
| 8 | Anechoic Chamber with microphone and DAQ | 1 |

**Course Outcomes:**

On completion of the course students will be able to

AE23622.1 Be able to perform experiments using supersonic free jet facility
AE23622.2 Be able to identify the flow features of jets at different expansion levels
AE23622.3 Be able to perform experiments to estimate jet decay and spread character
AE23622.4 Be able to visualize various flow features of jets using optical techniques
AE23622.5 Be able to perform preliminary aero-acoustic experiments

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AE23622.1 | 3 | 2 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23622.2 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23622.3 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23622.4 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23622.5 | 3 | 2 | 2 | - | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **Average** | 3 | 2 | 2 | 1 | 1.8 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |

| Subject Code | Subject Name | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| AE23623 | AIRFRAME REPAIR AND AERO ENGINE LABORATORY | PC | 0 | 0 | 4 | 2 |

## OBJECTIVES

- To develop ability to join the different types of aircraft wood
- To develop skills on riveting, mooring and patch work
- To understand welding process and weld the materials
- To build ability to dismantle piston and jet engine, clean, and perform NDT test
- To build ability to perform the checks for aircraft symmetry, levelling and jacking

## LIST OF EXPERIMENTS

1. Patch repair work on Perspex plate.
2. Riveting of lap and butt joints on an aluminum plate.
3. Bending and flaring of aluminum tube.
4. Making a channel and angle section by bending aluminum strip.
5. Performing aircraft magnetic compass swing (direct reading type).
6. Performing mooring on bolted and riveted joints
7. Dismantling of a piston engine and components identification
8. Inspection of Piston Engine - cleaning and perform NDT checks.
9. Identification of Jet Engine – components & defects.
10. Static balancing of Propeller.
11. Starting procedure of Piston engine in Cessna Aircraft.

**Total Contact Hours:30**

## LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS

| Sl.No. | Name of the Equipment | Quantity |
|---|---|---|
| 1 | Shear cutter pedestal type | 1 |
| 2 | Drilling Machine | 1 |
| 3 | Bench Vices | 1 |
| 4 | Radius Bend bars | 1 |
| 5 | Pipe Flaring Tools | 1 |
| 6 | Welding machine | 1 |
| 7 | Glass fibre, epoxy resin | 1 |
| 8 | Strain gauges and strain indicator | 1 |

**Course Outcomes:**

On completion of the course students will be able to

**AE23623.1** Ability to join the different types of aircraft wood
**AE23623.2** Develop skills on riveting, mooring and patch work
**AE23623.3** Differentiate the welding process and weld the materials
**AE23623.4** Able to dismantle piston and jet engine, clean, and perform NDT test
**AE23623.5** Able to perform the checks for aircraft symmetry, levelling and jacking

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **AE23623.1** | 3 | 2 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **AE23623.2** | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **AE23623.3** | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **AE23623.4** | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **AE23623.5** | 3 | 2 | 2 | - | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **Average** | 3 | 2 | 2 | 1 | 1.8 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |

| GE23621 | PROBLEM SOLVING TECHNIQUES | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 2 | 1 |

Course Objectives:

- To improve the numerical ability
- To improve problem-solving skills.

**Course topics:**

| S.No. | Topics |
|---|---|
| 1 | Numbers system |
| 2 | Reading comprehension |
| 3 | Data arrangements and Blood relations |
| 4 | Time and Work |
| 5 | Sentence correction |
| 6 | Coding & Decoding, Series, Analogy, Odd man out and Visual reasoning |
| 7 | Percentages, Simple interest and Compound interest |
| 8 | Sentence completion and Para-jumbles |
| 9 | Profit and Loss, Partnerships and Averages |
| 10 | Permutation, Combination and Probability |
| 11 | Data interpretation and Data sufficiency |
| 12 | Logarithms, Progressions, Geometry and Quadratic equations. |
| 13 | Time, Speed and Distance |

**Course Outcome:**

On successful completion of the course, students should be able to:

- Solve basic numerical problems using arithmetic concepts.
- Analyze and interpret data effectively.
- Apply verbal reasoning to language-based questions.
- Solve logical and quantitative reasoning problems.
- Enhance critical thinking in real-world problem scenarios.

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GE23621.1** | 3 | 2 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **GE23621.2** | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **GE23621.3** | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **GE23621.4** | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **GE23621.5** | 3 | 2 | 2 | - | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **Average** | 3 | 2 | 2 | 1 | 1.8 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |

# SEMESTER VII

| AE23731 | AVIONICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 2 | 4 |

**OBJECTIVES**

- To learn about the subsystems of avionics systems.
- To impart knowledge about the avionic architecture and various avionics data buses
- To gain more knowledge on display technology and aircraft data entry system
- To learn about the different types of navigation systems used in aviation.
- To gain knowledge about the software assessment and autopilot.

**UNIT I : INTRODUCTION TO AVIONICS** **9**

Need for avionics in civil and military aircraft – integrated avionics and weapon systems – typical avionics subsystems, Avionics top down design approach – Introduction to Microprocessor and memories,Overview of Avionics in Rafale fighter jet.

**UNIT II : DIGITAL AVIONICS ARCHITECTURE** **9**

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

**UNIT III : FLIGHT DECKS AND COCKPITS** **9**

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

**UNIT IV: INTRODUCTION TO NAVIGATION SYSTEMS** **9**

Radio navigation – VOR/DME, Hyperbolic navigation-LORAN and OMEGA, Landing system-ILS, MLS, Inertial Navigation Systems (INS)– Satellite navigation systems – GPS, Radar-Pulsed and continuous wave, SAR.

**UNIT V : SOFTWARE ASSESSMENT AND AUTO PILOT** **9**

Fault tolerant systems -Software Assessment and Validation -Civil and Military standards - Certification of Civil Avionics. Auto pilot – Basic principles, Longitudinal and lateral auto pilot,A320 fly-by-wire system detailed case study.

**Total Contact Hours:45**

**TEXTBOOKS**

1. Collinson.R.P.G. "Introduction to Avionics", Chapman and Hall, 1996.
2. Spitzer, C.R. "Digital Avionics Systems", Prentice-Hall, Englewood Cliffs, N.J., U.S.A. 1993.

**REFERENCES**

1. Albert Helfrick.D., "Principles of Avionics", Avionics Communications Inc., 2004
2. Spitzer. C.R. "The Avionics Hand Book", CRC Press, 2000
3. Pallet.E.H.J., "Aircraft Instruments and Integrated Systems", Longman Scientific

## AVIONICS LABORATORY

### 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. MIL-Std – 1553 Data Buses Configuration with Message transfer.
9. Stability analysis using Root locus, Bode plot techniques.
10. Design of lead –lag compensator for aircraft dynamics.

**Contact Hours:15**

**Total Contact Hours:60**

### LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS

| S.No | Details of Equipment | Quantity | Experiment Nos. |
|---|---|---|---|
| 1. | Microprocessor 8085 Kit | 10 | 1,2,3,4 |
| 2. | Adder/Subtractor Binary bits Kit | 10 | 5 |
| 3. | Encoder Kit | 10 | 7 |
| 4. | Decoder Kit | 10 | 7 |
| 5. | Multiplexer Kit | 10 | 6 |
| 6. | Demultiplexer Kit | 10 | 6 |
| 7. | Computers | 10 | 8,9,10 |
| 8. | MATLAB software | - | 9,10 |
| 9. | MILSTD 1553 | 2 | 8 |

### SUGGESTED ACTIVITIES

- Flipped classroom
- Activity Based Learning
- Reinforced learning

### SUGGESTED EVALUATION METHODS

- Assignment problems
- Quizzes
- Class Presentation/Discussion

After successful completion of the course students will demonstrate the following outcomes:

**Course Outcomes:**

On completion of the course students will be able to

AE23731.1 Students will be able to explain the basic principles of avionics systems.
AE23731.2 Be able to learn the principle of digital avionics systems
AE23731.3 Able to know the practical and working of flight deck equipment
AE23731.4 Identify the different types of navigation systems and their applications
AE23731.5 Students will be able to analyze the performance of autopilot systems

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AE23731.1 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 2 | 2 |
| AE23731.2 | 2 | 2 | 2 | 1 | 3 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 2 | 3 |
| AE23731.3 | 2 | 2 | 3 | 1 | 3 | 2 | 1 | 1 | 2 | 3 | 2 | 2 | 2 | 3 | 3 |
| AE23731.4 | 2 | 2 | 2 | 2 | 3 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 2 | 3 |
| AE23731.5 | 2 | 2 | 2 | 2 | 3 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| **Average** | 2 | 2 | 2.2 | 1.4 | 2.8 | 1.2 | 1 | 1 | 2 | 2.2 | 2 | 2 | 2.8 | 2.4 | 2.8 |

| Subject Code | Subject Name (Lab Oriented Theory Course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| AE23711 | COMPOSITE MATERIALS AND STRUCTURES | PC | 3 | 0 | 0 | 3 |

**OBJECTIVES**

- Understand fundamentals of composites, focusing on reinforcements and hygrothermal effects.
- Study stress-strain behavior and properties using micromechanics.
- Derive equations for laminates and apply failure criteria.
- Learn composite fabrication and repair methods.
- Explore design and failure modes in sandwich constructions.

**UNIT I MICROMECHANICS 9**

Introduction - Advantages and application of composite materials - reinforcements and matrices – Classification of composite materials -Micro mechanics – Mechanics of materials approach, elasticity approach-Effect of voids - hygro thermal effects on a lamina.

**UNIT II MACROMECHANICS 9**

Macro mechanics - Generalized Hooke's Law - Elastic constants for anisotropic, orthotropic and isotropic materials - Macro Mechanics – Stress-strain relations with respect to natural axis, arbitrary axis – Determination of material properties - Experimental characterization of lamina.

**UNIT III LAMINATED PLATE 9**

Governing differential equation for a unidirectional lamina and general laminate, angle ply and cross ply laminate, Failure criteria for composites.

**UNIT IV FABRICATION PROCESS AND REPAIR METHODS 9**

Various open and closed mould processes, Manufacture of fibers, Types of resins, properties and applications, Netting analysis. importance of repair and different types of repair techniques in composites

**UNIT V SANDWICH CONSTRUCTIONS 9**

Basic design concepts - Materials used - Failure modes of sandwich panels - sandwich laminated plate theory.

**Total Contact Hours:45**

**OUTCOMES**

- Describe composite applications and analyze material behavior.
- Apply micromechanics for property determination and stress analysis.
- Formulate equations and assess laminate failure.
- Identify fabrication and repair techniques.
- Design and analyze sandwich constructions.

**TEXTBOOKS**

1. Jones, R.M., "Mechanics of Composite Materials," Taylor & Francis, II Edition, 2000.
2. Madhuji Mukhapadhyay, Mechanics of Composite Materials and Structures, University Press, 2004

**REFERENCES**

1. Agarwal, B.D., and Broutman, L.J., "Analysis and Performance of Fibre Composites," John Wiley and sons. Inc., New York, 1995.
2. Lubin, G., "Handbook on Advanced Plastics and Fibre Glass", Von Nostrand Reinhold Co., New York, 1989.
3. Calcote, L R. "The Analysis of laminated Composite Structures", Von – Nostrand Reinhold Company, New York 1998.

4. Allen Baker, "Composite Materials for Aircraft Structures", AIAA Series, II Edition, 1999.
5. Autar K Kaw, „Mechanics of Composite Materials", CRC Press, 1997.

**SUGGESTED EVALUATION METHODS (if Any)** (UNIT/ Module Wise) – could suggest topic

- Assignments
- Quizzes/MCQ
- Seminar Presentation/Discussion
- Assessment Tests

After successful completion of the course students will demonstrate the following outcomes:

AE23612.1 Students will able to illustrate the application and micromechanics approach of composites.

AE23612.2 Students will able to determine stress strain relations and elastic constants for different materials.

AE23612.3 Students will able to resolve the governing differential equation for different ply laminates.

AE23612.4 Students will be able to understand the manufacturing process and repair methods of composites.

AE23612.5 Students can design basic sandwich construction and calculate bending stress and shear flow in composite beams.

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23612.1 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | - | 1 | 3 | 1 | - |
| AE23612.2 | 3 | 3 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | - | 1 | 3 | 1 | - |
| AE23612.3 | 3 | 3 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | - | 1 | 3 | 2 | - |
| AE23612.4 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | - | 1 | 3 | 2 | - |
| AE23612.5 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | - | 1 | 3 | 2 | - |
| **Average** | 3 | 2.8 | 2.4 | 1.8 | 1 | 1 | 1 | 1 | 1 | 1 | - | 1 | 3 | 1.6 | - |

| GE23311 | FUNDAMENTALS OF MANAGEMENT FOR ENGINEERS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVES**

- To enable the students to study the evolution of Management, to study the functions and principles of management and to learn the application of the principles in an organization.

**UNIT I INTRODUCTION TO MANAGEMENT AND ORGANIZATIONS 9**

Definition of Management – Science or Art – Manager Vs Entrepreneur - types of managers -managerial roles and skills – Evolution of Management – Scientific, human relations, system and contingency approaches – Types of Business organization - Sole proprietorship, partnership, company-public and private sector enterprises - Organization culture and Environment – Current trends and issues in Management.

**UNIT II PLANNING 9**

Nature and purpose of planning – planning process – types of planning – objectives – setting objectives – policies – Planning premises – Strategic Management – Planning Tools and Techniques-Decision making steps and process.

**UNIT III ORGANISING 9**

Nature and purpose – Formal and informal organization – organization chart – organization structure types – Line and staff authority – departmentalization – delegation of authority – centralization and decentralization – Job Design - Human Resource Management – HR Planning, Recruitment, selection, Training and development, Performance Management, Career planning and management.

**UNIT IV DIRECTING 9**

Foundations of individual and group behaviour – motivation – motivation theories – motivational techniques – job satisfaction – job enrichment – leadership – types and theories of leadership – communication – process of communication – barrier in communication – effective communication – communication and IT.

**UNIT V CONTROLLING 9**

System and process of controlling – budgetary and non-budgetary control techniques – use of computers and IT in Management control – Productivity problems and management – control and performance – direct and preventive control – reporting.

**Total Contact Hours:45**

**TEXTBOOKS**

1. Stephen P. Robbins & Mary Coulter, “Management”, 10th Edition, Prentice Hall (India) Pvt. Ltd.,2009.
2. JAF Stoner, Freeman R.E and Daniel R Gilbert “Management”, 6th Edition, Pearson Education,2004.

**REFERENCES**

1. Stephen A. Robbins & David A. Decenzo & Mary Coulter, “Fundamentals of Management”7th Edition, Pearson Education, 2011.
2. Robert Kreitner & Mamata Mohapatra, “Management”, Biztantra, 2008.
3. Harold Koontz & Heinz Weihrich “Essentials of management” Tata Mc Graw Hill, 1998.
Tripathy PC & Reddy PN, “Principles of Management”, Tata McGraw Hill, 1999.

**OUTCOMES**

- GE23311.1 Understands the evolution of Management
- GE23311.2 Gains knowledge on the functions of management
- GE23311.3 knowledge on planning function in details
- GE23311.4 Knowledge on organizing, directing and controlling
- GE23311.5 Knowledge on application of the principles in an organization

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GE23311.1 | 3 | 1 | 1 | | 3 | - | - | 2 | - | - | - | - | 2 | 2 | - |
| GE23311.2 | 3 | 1 | 2 | - | 3 | - | - | - | - | - | - | 1 | 2 | 2 | - |
| GE23311.3 | 3 | 2 | 2 | - | 3 | - | - | - | - | - | - | 1 | 2 | 2 | - |
| GE23311.4 | 3 | 2 | 2 | - | 3 | - | - | - | - | - | - | 1 | 2 | 2 | - |
| GE23311.5 | 1 | 2 | 2 | | 1 | - | - | 2 | - | 2 | - | 2 | 1 | 1 | - |
| **Average** | 2.6 | 1.6 | 1.8 | - | 2.6 | - | - | 2 | - | 2 | - | 1.25 | 1.8 | 1.8 | - |

| AE23721 | PROJECT WORK PHASE I | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 4 | 2 |

**OBJECTIVES:**

- To develop the ability to solve a specific problem right from its identification and literature review.
- To train the students in preparing project reports and to face reviews and viva voce examination.

The students in a group of 2 to 3 works on a topic approved by the head of the department under the guidance of a faculty member and prepares a comprehensive phase 1 report after completing the work to the satisfaction of the supervisor. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A phase 1 project report is required to be submitted at the end of the semester. Evaluation is based on oral presentation and the phase 1 project report jointly by internal examiners constituted by the Head of the Department.

**Total Contact Hours:30**

**OUTCOMES:**

**Course Outcomes:**
On completion of the project students will be able to

AE23721.1 Demonstrate a sound technical knowledge of their selected project topic.
AE23721.2 Undertake problem identification, formulation, and solution.
AE23721.3 Design engineering solutions to complex problems utilizing a systematic approach.
AE23721.4 Conduct an engineering project.
AE23721.5 Communicate with engineers and the community at large in written an oral form.

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AE23721.1 | 2 | 3 | 3 | 2 | 1 | - | 2 | - | 3 | - | 1 | - | 3 | 3 | 2 |
| AE23721.2 | 2 | 3 | 3 | 2 | 1 | - | 2 | - | 3 | - | 1 | - | 3 | 3 | 2 |
| AE23721.3 | 2 | 3 | 3 | 2 | 3 | 1 | 2 | - | 3 | - | 1 | - | 3 | 3 | - |
| AE23721.4 | 1 | - | - | - | - | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 3 | - |
| AE23721.5 | 1 | 1 | - | - | - | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 3 | 3 |
| **Average** | 1.6 | 2.5 | 3 | 1.5 | 1.66 | 1.66 | 2 | 1.33 | 3 | 3 | 1.4 | 2 | 2.6 | 3 | 2.33 |

.

| AE23722 | ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING FOR AERONAUTICAL ENGINEERING | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 4 | 2 |

**OBJECTIVES**

To enable students to use the concepts of Artificial Intelligence and Machine Learning in the field of Aeronautical Engineering. Students have to choose **any one** of the problem statements from any of the following domain (the titles are not restricted to the sample exercises listed) and carry out a mini-project and submit a report.

**I. Aerodynamics**

1. Prediction of Airfoil Performance Using Neural Networks
   - Train a neural network to predict lift and drag coefficients from geometric and flow parameters.
   - Use datasets like NACA airfoils or create one from CFD simulations.
2. Flow Separation Detection Using Machine Learning
   - Use classification algorithms to detect flow separation patterns from CFD or experimental data.
   - Input: Pressure distribution, Output: Flow separation status.
3. Optimization of Wing Shape Using Genetic Algorithms
   - Implement a GA to optimize wing geometry for maximum lift-to-drag ratio under specific conditions.

**II. Aircraft Structures**

1. Crack Detection in Aircraft Panels Using Convolutional Neural Networks (CNNs)
   - Build and train a CNN model to classify images of aircraft panels as cracked or intact.
   - Dataset: Simulated or real-world crack images.
2. Material Property Prediction Using Regression Models
   - Predict properties like tensile strength or elasticity modulus from material composition data.
3. Structural Load Prediction Using Machine Learning
   - Use ML to predict structural loads based on flight data (e.g., altitude, speed, turbulence).

**III. Aircraft/Aerospace Propulsion**

1. Fault Diagnosis in Turbofan Engines Using One-Class SVM
   - Detect abnormal operating conditions in turbofan engines using vibration or temperature data.
2. Thrust Prediction of Jet Engines Using Gradient Boosting
   - Predict thrust based on input variables like fuel flow, altitude, and Mach number.
3. Combustion Efficiency Optimization Using AI
   - Apply reinforcement learning to optimize fuel-air mixture ratios for improved combustion efficiency.

**IV. Flight Dynamics**

1. Stability Analysis of Aircraft Using Reinforcement Learning
   - Develop a reinforcement learning model to maintain pitch and roll stability in dynamic conditions.
2. Control Surface Deflection Prediction Using ML
   - Predict required aileron, rudder, and elevator deflections based on flight conditions.
3. Dynamic System Modeling with Neural Networks
   - Use recurrent neural networks (RNNs) to model and predict aircraft response to control inputs.

**V. Aircraft Maintenance**

1. Predictive Maintenance for Aircraft Systems
   - Develop a machine learning model to predict failure probability of components based on usage data.
2. Health Monitoring of Landing Gear Using Vibration Analysis
   - Use AI to analyze vibration data and predict maintenance needs for landing gear systems.
3. Defect Categorization in Maintenance Logs Using NLP
   - Use natural language processing to classify maintenance logs into actionable categories.

**VI. UAVs and Avionics**

1. Path Planning for UAVs Using Reinforcement Learning
   - Create an RL model to plan obstacle-free paths for UAVs in a simulated environment.
2. Autonomous Navigation Using Vision-Based AI
   - Develop a system where UAVs navigate using computer vision (e.g., object recognition and tracking).
3. Battery Life Prediction for UAVs Using Regression Models
   - Predict remaining battery life for UAVs based on flight conditions and load.

**VII. Allied Fields**

1. Noise Prediction Around Airports Using AI
   - Predict and map noise levels in areas surrounding airports using machine learning algorithms.
2. Climate Impact Assessment of Aircraft Emissions
   - Use ML to correlate aircraft emissions data with environmental impact metrics like temperature rise.
3. AI-Driven Air Traffic Management
   - Optimize air traffic routing using reinforcement learning or optimization algorithms for congestion reduction.

**Total Contact Hours:30**

**OUTCOMES**

After completion of the course, students will be able to

- Apply the concepts of AI and ML in the field of Aerodynamics
- Apply the concepts of AI and ML in the field of Aircraft Structures
- Apply the concepts of AI and ML in the field of Propulsion
- Apply the concepts of AI and ML in the field of Flight Dynamics or Aircraft Maintenance
- Apply the concepts of AI and ML in the field of UAVs or other allied fields

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AE23722.1 | 2 | 3 | 3 | 2 | 1 | - | 2 | - | 3 | - | 1 | - | 3 | 3 | 2 |
| AE23722.2 | 2 | 3 | 3 | 2 | 1 | - | 2 | - | 3 | - | 1 | - | 3 | 3 | 2 |
| AE23722.3 | 2 | 3 | 3 | 2 | 3 | 1 | 2 | - | 3 | - | 1 | - | 3 | 3 | - |
| AE23722.4 | 1 | - | - | - | - | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 3 | - |
| AE23722.5 | 1 | 1 | - | - | - | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 3 | 3 |
| **Average** | 1.6 | 2.5 | 3 | 2 | 1.66 | 1.66 | 2 | 2 | 3 | 3 | 1.4 | 2 | 2.6 | 3 | 2.33 |

# SEMESTER VIII

| AE23821 | PROJECT WORK PHASE II | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 16 | 8 |

**OBJECTIVES:**

- To utilize the knowledge gained from literature survey and continue to solve the chosen problem (in phase 1) till the successful solution of the same.
- To train the students in preparing project reports and to face reviews and viva voce examination.

The students in a group of 2 to 3 works on a topic approved by the head of the department under the guidance of a faculty member and prepares a comprehensive project report after completing the work to the satisfaction of the supervisor. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department.

**Total Contact Hours:120**

**OUTCOMES:**

**Course Outcomes:**
On completion of the project students will be able to

AE23821.1 Demonstrate a sound technical knowledge of their selected project topic.
AE23821.2 Undertake problem identification, formulation, and solution.
AE23821.3 Design engineering solutions to complex problems utilizing a systematic approach.
AE23821.4 Conduct an engineering project.
AE23821.5 Communicate with engineers and the community at large in written an oral form.

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AE23821.1 | 2 | 3 | 3 | 2 | 1 | - | 2 | - | 3 | - | 1 | - | 3 | 3 | 2 |
| AE23821.2 | 2 | 3 | 3 | 2 | 1 | - | 2 | - | 3 | - | 1 | - | 3 | 3 | 2 |
| AE23821.3 | 2 | 3 | 3 | 2 | 3 | 1 | 2 | - | 3 | - | 1 | - | 3 | 3 | - |
| AE23821.4 | 1 | - | - | - | - | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 3 | - |
| AE23821.5 | 1 | 1 | - | - | - | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 3 | 3 |
| **Average** | 1.6 | 2.5 | 3 | 1.5 | 1.66 | 1.66 | 2 | 1.33 | 3 | 3 | 1.4 | 2 | 2.6 | 3 | 2.33 |

# PROFESSIONAL ELECTIVES

| AE23A11 | COMPUTATIONAL AERODYNAMICS | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| | | PE | 3 | 0 | 0 | 3 |

**OBJECTIVES**

- To provide students with a comprehensive understanding of the governing equations of fluid dynamics.
- To introduce structured and unstructured grid generation techniques.
- To teach discretization methods using Finite Difference Method (FDM) and Finite Volume Method (FVM).
- To explore flow field analysis and various turbulence models.
- To apply CFD techniques to solve problems in aerospace engineering.

**UNIT I GOVERING EQUATIONS AND ITS BEHAVIOUR 9**

Introduction - Governing equations of fluid dynamics. Classification of Partial Differential Equations (PDEs) - Elliptic, Parabolic and Hyperbolic equations - Boundary Conditions and Initial Conditions - Well posed problems.

**Case Study:** Investigation of shock wave formation and behavior in supersonic flow around a blunt body.

**UNIT II GRID GENERATION TECHNIQUES 9**

Structured and Unstructured Grids. Types and transformations. Generation of structured grids and unstructured grids – Adaptive Mesh refinement and Grid Independence Study – Grid Quality Metrics: Skewness, Aspect Ratio, and Orthogonality.

**Case study:** Boundary Layer Mesh Refinement in Turbulent Flow Simulations.

**UNIT III DISCRETIZATION TECHNIQUE 9**

FINITE DIFFERENCE SCHEME: Derivation of finite difference equations – Simple Methods –Explicit and Implicit time dependent methods. Stability properties of explicit and implicit methods

FINITE VOLUME TECHNIQUES: Finite Volume Techniques -Central, upwind differencing schemes properties of discretization schemes – Conservativeness, Boundedness, Transportiveness, Accuracy.

**Case study:** Apply discretization methods to simulate 2D incompressible flow

**UNIT IV FLOW FIELD ANALYSIS AND TURBULENCE 9**

Staggered grid, SIMPLE algorithm and its variants - Turbulence models, mixing length model, Two equation (k-Є) models – High and low Reynolds number models.

**Case study:** Implement SIMPLE Algorithm to simulate lid driven cavity flow

**UNIT V NUMERICAL METHODS FOR AERODYNAMICS 9**

Numerical solution for C-D nozzle isentropic flows, local similar solutions of boundary layer equations, Time dependent solutions of gas dynamic problems.

**Case study:** Develop a Computational Code to Simulate Supersonic Flow Through a Convergent-Divergent Nozzle

**TOTAL: 45 PERIODS**

**TEXTBOOKS**

1. Versteeg, H.K., and Malalasekera, W., "An Introduction to Computational Fluid Dynamics: The finite volume Method", Pearson Education Ltd. Second Edition – 2007
2. John D. Anderson, JR" Computational Fluid Dynamics", McGraw-Hill Book Co., Inc., New

**REFERENCES**

1. C.Y.Chow, "Introduction to Computational Fluid Dynamics", John Wiley, 1979.
2. A.A. Hirsch, 'Introduction to Computational Fluid Dynamics", McGraw-Hill, 1989.
3. T.J. Chung, Computational Fluid Dynamics, Cambridge University Press, 2002
4. C.A.J. Fletcher, "Computational Techniques for Fluid Dynamics 1" Springer Verlag,1995.

After successful completion of the course students will demonstrate the following outcomes:

**Course Outcomes:**

On completion of the course students will be able to

**AE23A13.1** Demonstrate a thorough understanding of the governing equations of fluid dynamics..
**AE23A13.2** Develop and implement structured and unstructured grids for CFD simulations.
**AE23A13.3** Apply discretization techniques using Finite Difference Method (FDM) and Finite Volume Method (FVM).
**AE23A13.4** Analyse flow fields and implement appropriate turbulence models
**AE23A13.5** Apply CFD techniques to solve aerospace engineering problems.

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **AE23A13.1** | 2 | - | - | 2 | 1 | - | - | - | - | - | - | 1 | 2 | 2 | 1 |
| **AE23A13.2** | 3 | 2 | 3 | - | 3 | - | - | - | - | - | - | 1 | 2 | 2 | 1 |
| **AE23A13.3** | 3 | 2 | 2 | - | 3 | - | - | - | - | - | - | 1 | 2 | 2 | 1 |
| **AE23A13.4** | - | - | 3 | 3 | - | - | 2 | - | - | - | - | - | - | - | - |
| **AE23A13.5** | - | - | 3 | 3 | - | - | 2 | - | - | - | - | - | - | - | - |
| **Average** | 2.6 | 2 | 2.5 | 2.6 | 2.3 | - | 2 | - | - | - | - | 1 | 2 | 2 | 1 |

| Subject Code | Subject Name | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| AE23A12 | APPLIED AERODYNAMICS | PE | 3 | 0 | 0 | 3 |

**OBJECTIVES**

- To familiarize the learner with non-aeronautical uses of aerodynamics such as road vehicle, building aerodynamics and problems of flow induced vibrations.

**UNIT I ATMOSPHERE** **9**

Types of winds, Causes of variation of winds, Atmospheric boundary layer, Effect of terrain on gradient height, Structure of turbulent flows

Case Study: Effect of urbanization on Atmospheric boundary layers and its impact on local climate

**UNIT II WIND ENERGY COLLECTORS** **9**

Horizontal axis and vertical axis machines, Power coefficient, Betz coefficient by momentum theory

Case Study: Challenges and benefits of deploying horizontal axis turbines in offshore environments – Hornsea wind farm

**UNIT III VEHICLE AERODYNAMICS** **9**

Power requirements and drag coefficients of automobiles, Effects of cut back angle, Aerodynamics of racing car, trains and Hovercraft

Case Study: Aerodynamics design innovations in Shinkansesn (Japan) / TGV (France)

**UNIT IV BUILDING AERODYNAMICS** **9**

Pressure distribution on low rise buildings, wind forces on buildings. Environmental winds in city blocks, Special problems of tall buildings, Building codes, Building ventilation and architectural aerodynamics

Case Study: Influence of wind speed and direction on low rise structures

**UNIT V FLOW INDUCED VIBRATIONS** **9**

Effects of Reynolds number on wake formation of bluff shapes, Vortex induced vibrations, Galloping and stall flutter.

Case Study: Influence of VIV on Tachoma bridge collapse

**Total Contact Hours:45**

**OUTCOMES**

- Use of aerodynamics for non- aerodynamics such as vehicle, building.
- Solve the problems and able to analyze vibrations during flow

**TEXT BOOKS**

1. M. Sovran (Ed), “Aerodynamics and drag mechanisms of bluff bodies and Road vehicles”, Plenum press, New York, 1978.
2. Sachs. P., “Winds forces in Engineering”, Pergamum Press, 1978.

**REFERENCES**

1. Blevins. R.D., “Flow Induced Vibrations”, Van Nostrand, 1990.
2. Calvent. N.G., “Wind Power Principles”, Charles Griffin & Co., London, 1979.

After successful completion of the course students will demonstrate the following outcomes:

| | |
|---|---|
| **AE23A12.1** | Understand the atmospheric winds and boundary layer |
| **AE23A12.2** | Understand working and solve problems related to wind energy collectors |
| **AE23A12.3** | Understand various aerodynamic aspects of ground vehicles |
| **AE23A12.4** | Understand various aerodynamic aspects of building structures |

**AE23A12.5** Understand the types of flow induced vibrations and effect of Reynolds number on them.

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| **AE23A12.1** | 3 | 2 | 2 | - | - | 3 | 3 | - | - | - | - | 1 | 2 | 2 | - |
| **AE23A12.2** | 3 | 2 | 2 | - | - | 3 | 3 | - | - | - | - | 1 | 2 | 2 | 1 |
| **AE23A12.3** | 3 | 2 | 2 | - | - | 3 | 3 | - | - | - | - | 1 | 2 | 2 | 1 |
| **AE23A12.4** | 3 | 2 | 2 | - | - | 3 | 3 | - | - | - | - | 1 | 2 | 2 | 1 |
| **AE23A12.5** | 3 | 2 | 2 | - | - | 3 | 3 | - | - | - | - | 1 | 2 | 2 | - |
| **Average** | 3 | 2 | 2 | - | - | 3 | 3 | - | - | - | - | 1 | 2 | 2 | 1 |

| AE23A13 | EXPERIMENTAL AERODYNAMICS | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| | | PE | 3 | 0 | 0 | 3 |

**Objectives:**

- To describe flow visualization techniques and to highlight in depth discussion of analog methods.
- To describe about calibration and instrumentation of various wind tunnels and force measurements.
- To provide details, operating principles and limitations of pressure, velocity, temperature, mass and volume flow measurements.
- To understand the concepts in data acquisition systems, error estimation and uncertainty analysis.

**UNIT-I MEASUREMENTS IN FLUIDS** 9

Fundamentals measurements in fluid mechanics:

Objectives of experimental studies – Fluid mechanics measurements: Measurement systems – Quantities associated with fluid flow measurements- Experiments on Taylor-Proudman theorem and Ekman layer – Measurements in boundary layers

Flow visualization and analogue methods:

Principles of Flow Visualization – Visualization techniques-Smoke tunnel-design and application – Compressible flows –Interferometer – Fringe-Displacement method – Schlieren system – Shadowgraph- Analogue methods-Heleshaw apparatus-Hydraulic analogy – Hydraulic jumps – Electrolytic tank.

**UNIT-II INSTRUMENTATION AND CALIBRATION OF WIND TUNNELS** 9

Power losses-subsonic and supersonic wind tunnels – Compressor tunnel matching-mass flow-Running time of blow down tunnels- Instrumentation and calibration of low speed wind tunnels - Wind tunnel balance – principles, types and classifications - balance calibration-boundary correction- Calibration of supersonic and hypersonic tunnels -Ludwieg tube-operating principle -Hypersonic simulation requirements.

**UNIT-III PRESSURE AND VELOCITYMEASUREMENTS** 9

Pressure measurement techniques:

Introduction-Barometers – Manometers – Dial type pressure gauge – Pressure transducers –Pitot, static and Pitot-Static tube - factors and characteristics –Pitot, static and Pitot-Static probes –Yaw effect-static pressure measurement in compressible Flows-Determination of flow direction –Low pressure measurements – Preston and Stanton Tubes - Sound measurements – Dynamic pressure gauges.

Velocity measurement:

Velocity and Mach number from pressure measurements– Laser Doppler Velocimetry (LDV) – Particle Image Velocimetry (PIV) – Hot-wire anemometry –Constant current and Constant temperature Hot-Wire anemometer – Hot-wire probes – Hot-wire bridge for classroom demonstration – effect of compressibility and limitations.

**UNIT-IV TEMPERATURE, MASS AND VOLUME FLOW MEASUREMENTS** 9

Temperature measurements Techniques:
Temperature scales – Temperature measurements – by thermal expansion and electrical effects – Practical Thermocouple measurements – The Resistance temperature detector – Pyrometer – Temperature measuring problems in fluid flow – Dynamic response of temperature sensors.
Mass and volume flow measurements:
Direct – indirect methods – Volume flow meter – Direct mass flow meter.

**UNIT-V DATA ACQUISITION SYSTEMS AND UNCERTAINTY ANALYSIS** 9

Data acquisition and processing – Signal conditioning - Estimation of measurement errors – External estimate of the error – Internal estimate of the error – Uncertainty analysis - Uncertainty calculation - Uses of uncertainty analysis.

**Total Contact Hours: 45**

**Course Outcomes:**

- Knowledge on measurement techniques in aerodynamic flow.
- Acquiring basics of wind tunnel measurement systems
- Specific instruments for flow parameter measurement like pressure, velocity, temperature etc

**Textbook(s):**

- Rathakrishnan, E., "Instrumentation, Measurements, and Experiments in Fluids," CRC Press –Taylor & Francis, 2007.
- Robert B Northrop, "Introduction to Instrumentation and Measurements", Second Edition, CRC Press, Taylor & Francis, 2006.

**Reference Books(s) / Web links:**

- Robert B Northrop, "Introduction to Instrumentation and Measurements", Second Edition, CRC Press, Taylor & Francis, 2006.
- NAL-UNI Lecture Series 12: Experimental Aerodynamics, NAL SP 98 01 April 1998

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| **AE23A13.1** | 3 | 2 | 2 | - | - | - | - | - | - | - | - | 1 | 2 | 2 | - |
| **AE23A13.2** | 3 | 2 | 2 | - | - | - | - | - | - | - | - | 1 | 2 | 2 | 1 |
| **AE23A13.3** | 3 | 2 | 2 | - | - | - | - | - | - | - | - | 1 | 2 | 2 | 1 |
| **AE23A13.4** | 3 | 2 | 2 | - | - | - | - | - | - | - | - | 1 | 2 | 2 | 1 |
| **AE23A13.5** | 3 | 2 | 2 | - | - | - | - | - | - | - | - | 1 | 2 | 2 | - |
| **Average** | 3 | 2 | 2 | - | - | - | - | - | - | - | - | 1 | 2 | 2 | 1 |

| AE23A14 | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| | MISSILE AERODYNAMICS | PE | 3 | 0 | 0 | 3 |

Objectives:

To introduce different classes of missiles and rockets to students.
To impart adequate knowledge on various airframe components of missiles and their functions to students.
To give exposure to analyse the various forms of drag and its estimations to students.
To make the students familiarize with the concepts of staging and stage separation methods.
To make students learn the stability and control aspects of missiles.

**UNIT-I** BASICS ASPECTS OF MISSILE AERODYNAMICS 9

Classification of missiles-Aerodynamics characteristics and requirements of air to air missiles, air to surface missiles and surface to air missiles-Missile trajectories-fundamental aspects of hypersonic aerodynamics.

**UNIT-II** MISSILE CONFIGURATIONS AND DRAG ESTIMATION 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-III** AERODYNAMICS OF SLENDER 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-IV** LAUNCH VEHICLE AERODYNAMICS 9

Forces and moments acting on missiles-Lateral, rolling and longitudinal moments-missile dispersion-stability aspects of missile configuration-Aerodynamic control methods-Jet control methods-Stability derivatives.

**UNIT-V** STABILITY AND CONTROL OF MISSILES 9

Forces and moments acting on missiles-Lateral, rolling and longitudinal moments-missile dispersion-stability aspects of missile configuration-Aerodynamic control methods-Jet control methods-Stability derivatives.

**Total Contact Hours:45**

**Course Outcomes:**

- Acquire enough knowledge on various configurations of missiles and rockets.
- Predict the aerodynamics characteristics of various airframes components.
- Acquire knowledge on unsteady flow characterizes of launch vehicles.
- Compare the aerodynamics performance of missiles determined form wind tunnel tests and CFD results.
- Determine the stability characteristics of missiles and necessary forces required to control.

**Textbook (s):**

1. Chin SS, Missile Configuration Design, McGraw Hill, New York, 1961.
2. Nielsen, Jack N, Stever, Gutford, "Missile Aerodynamics", McGraw Hill, New York, 1988.

**Reference Books(s) / Web links:**

1. Anderson, J.D., "Fundamentals of Aerodynamics", McGraw-Hill Book Co., New York, 2011.
2. John D. Anderson. Jr., "Hypersonic and High Temperature Gas Dynamics", AIAA; 2ndedition, 2006.
3. John D. Anderson. Jr., "Modern Compressible flow with historical Perspective", McGraw Hill Publishing Company, 3rd edition, 2002.

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| **AE23A14.1** | 3 | 2 | 2 | - | - | 3 | 3 | - | - | - | - | 1 | 2 | 2 | - |
| **AE23A14.2** | 3 | 2 | 2 | - | - | 3 | 3 | - | - | - | - | 1 | 2 | 2 | 1 |
| **AE23A14.3** | 3 | 2 | 2 | - | - | 3 | 3 | - | - | - | - | 1 | 2 | 2 | 1 |
| **AE23A14.4** | 3 | 2 | 2 | - | - | 3 | 3 | - | - | - | - | 1 | 2 | 2 | 1 |
| **AE23A14.5** | 3 | 2 | 2 | - | - | 3 | 3 | - | - | - | - | 1 | 2 | 2 | - |
| **Average** | 3 | 2 | 2 | - | - | 3 | 3 | - | - | - | - | 1 | 2 | 2 | 1 |

| AE23A15 | HYPERSONIC AERODYNAMICS | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| | | PE | 3 | 0 | 0 | 3 |

**UNIT I FUNDAMENTALS OF HYPERSONIC AERODYNAMICS 9**

Introduction to hypersonic aerodynamics-differences between hypersonic aerodynamics and supersonic aerodynamics-concept of thin shock layers-hypersonic flight paths, hypersonic similarity parameters-shock wave and expansion wave relations of in viscid hypersonic flows.

**UNIT II SIMPLE SOLUTION METHODS FOR HYPERSONIC IN VISCID FLOWS 9**

Local surface inclination Methods-Newtonian theory-modified Newtonian law-tangent wedge and tangent cone and shock expansion methods-approximate theory-thin shock layer theory.

**UNIT III VISCOUS HYPERSONIC FLOW THEORY 9**

Boundary layer equation for hypersonic flow-hypersonic boundary layers-self similar and non-self-similar boundary layers-solution methods for non-self-similar boundary layers, aerodynamic heating.

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

Introduction to the concept of viscous interaction in hypersonic flows-strong and weak viscous interactions-hypersonic viscous interaction similarity parameter-introduction to shock wave boundary layer interactions.

**UNIT V INTRODUCTION TO HIGH TEMPERATURE EFFECTS 9**

Nature of high temperature flows-chemical effects in air-real and perfect gases-Gibb's free energy and entropy-chemically reacting mixtures-recombination and dissociation.

**Total Contact Hours:45**

**TEXT BOOKS**

1. John. D. Anderson. Jr., "Hypersonic and High Temperature Gas Dyanmics", McGraw hill Series, New York, 1996.

**REFERENCES**

1. John. D. Anderson. Jr., "Modern compressible flow with historical perspective", McGraw Hill Publishing Company, New York, 1996.
2. John. T Bertin, "Hypersonic Aerothermodynamics", published by AIAA Inc., Washington. D.C., 1994.

After successful completion of the course students will demonstrate the following outcomes:

1.

**AE23A15.1** Understand the fundamental concepts of hypersonic flows
**AE23A15.2** Solve inviscid hypersonic flow properties using various methods
**AE23A15.3** Solve viscous hypersonic flow properties using various methods
**AE23A15.4** Understand the shock-boundary layer interactions in hypersonic flows
**AE23A15.5** Understand the high-temperature effects in hypersonic flows

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23A15.1 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | - | 1 | 3 | 1 | - |
| AE23A15.2 | 3 | 3 | 1 | - | - | - | 1 | - | - | - | - | 1 | 3 | 3 | - |
| AE23A15.3 | 3 | 3 | 1 | - | - | - | 1 | - | - | - | - | 1 | 3 | 3 | - |
| AE23A15.4 | 3 | 2 | 1 | - | - | - | 1 | - | - | - | - | 1 | 3 | 2 | - |
| AE23A15.5 | 3 | 2 | 1 | - | - | - | 1 | - | - | - | - | 1 | 3 | 2 | - |
| Average | 2.8 | 2.2 | 1 | - | - | - | 1 | - | - | - | - | 1 | 3 | 2.2 | - |

| AE23A16 | HELICOPTER THEOY | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| | | PE | 3 | 0 | 0 | 3 |

**OBJECTIVES**

- To make student familiarize with the evolution of Helicopters as a flying machine.
- To familiarize students with the aerodynamic theories of rotor.
- To teach students design calculation procedures involved in selection of engine and control systems.
- To familiarize students with the static and dynamic stability concepts of rotorcraft.
- To familiarize students with the problems associated with vibrations of the main rotor system.

**UNIT I INTRODUCTION 9**

A history of helicopter flight; Fundamentals of Rotor Aerodynamics; Momentum theory analysis in hovering flight. Disk loading, power loading, thrust & power coefficients. Figure of merit, rotor solidity and blade loading coefficient. Power required in flight. Axial climb, descent, and autorotation. Blade Element Analysis: Blade element analysis in hovering and forward flight. Rotating blade motion. Types of rotors. Concept of blade flapping, lagging and coning angle. Equilibrium about the flapping hinge, and lead/lag hinge.

**UNIT II BASIC HELICOPTER PERFORMANCE 9**

Hovering and axial climb performance. Forward flight performance; Induced power, blade profile power, parasite power, tail rotor power, climb power total power. Effects of gross weight, density and altitude. Speed for minimum power, maximum range. Factors affecting forward speed, and ground effect.

**UNIT III ROTOR AIRFOIL AERODYNAMICS 9**

Rotor airfoil requirements, effects of Reynolds number and Mach number. Airfoil shape definition, Airfoil pressure distribution. Pitching moment. Maximum lift and stall characteristics, high angle of attack range. Rotor Wakes and Blade Tip Vortices: Flow visualization, Characteristics of rotor wake in hover, and forward flight. Other characteristics of rotor wake. Structure of the tip vortices. Flow topology of dynamic stall.

**UNIT IV HELICOPTER FLIGHT DYNAMICS 9**

Forward speed disturbance, vertical speed disturbance, pitching angular velocity disturbance, side-slip disturbance, yawing disturbance. Static stability of helicopters: longitudinal, lateral-directional. Dynamic stability aspects. Main rotor and tail rotor control.

**UNIT V STANDARDS, SPECIFICATIONS AND TESTING ASPECTS 9**

Scope of requirements. General and operational requirements. Military derivatives of civil rotorcraft. Structural strength and design for operation on specified surfaces. Rotorcraft vibration classification. Flight and Ground Handling Qualities-General requirements and definitions. Control characteristics, beak forces. Levels of handling qualities. Flight Testing- General handing flight test requirements and, basis of limitations. Conceptual Design of Helicopters: Overall design requirements. Design of main rotors, Fuselage design, Empennage design, Design of tail rotors, High speed rotorcraft.

**Total Contact Hours:45**

**TEXTBOOKS**

1. Principles of Helicopter Aerodynamics - J. Gordon Leishman, Cambridge University Press, 2000.
2. Helicopter Performance Stability and Control by Prouty Raymond 2002

3. Antonio Filippone -Flight Performance of Fixed and Rotary Wing Aircraft, Elsevier Aerospace Engineering Services. (2006)

**REFERENCES**

1. Edward Seckel, Stability and Control of Airplanes and Helicopters, Elsevier, 1964
2. Helicopter Dynamics- ARS Bramwell, George Done, and David Balmford, 2nd Edition, Butterworth-Heinemann Publication, 2001.
3. Engineering Design Handbooks - Helicopter Engineering (Parts I, II & III), AMCP 706-203, 1974
4. Alastair K. Cooke, Eric W. H. Fitzpatrick, Helicopter Test and evaluation, , Blackwell Science, 2002.

After successful completion of the course students will demonstrate the following outcomes:

**AE23A16.1** Acknowledge the evolution of rotary wing flying machines.
**AE23A16.2** Understand and apply the ADT and BET in the aerodynamic design of helicopter rotors.
**AE23A16.3** Understand and apply the performance relations in the design/selection of engine for helicopters
**AE23A16.4** Understand the stability characteristics of simple helicopter configurations.
**AE23A16.5** Identify the areas of vehicle design to be taken care to avoid problems associated with rotor vibrations

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23A16.1 | 2 | - | - | 1 | - | - | 1 | - | 1 | - | - | 1 | 2 | - | - |
| AE23A16.2 | 3 | 2 | 1 | 1 | - | - | 1 | - | 1 | - | - | 1 | 3 | 3 | 1 |
| AE23A16.3 | 3 | 2 | 1 | 1 | - | - | 1 | - | 1 | - | - | 1 | 3 | 3 | 1 |
| AE23A16.4 | 3 | 2 | 1 | 1 | - | - | 1 | - | 1 | - | - | 1 | 3 | 3 | 1 |
| AE23A16.5 | 3 | 2 | 1 | 1 | - | - | 1 | - | 1 | - | - | 1 | 3 | 2 | - |
| Average | 2.8 | 2 | 1 | 1 | - | - | 1 | - | 1 | - | - | 1 | 2.8 | 2.75 | 1 |

L T P C

**AE23A17 INTRODUCTION TO AEROACOUSTICS** PE 3 0 0 3

Objectives:

To familiarize the student with the classical literature on aeroacoustics
To enumerate analytical, computational and experimental methods

**UNIT-I** REVIEW OF CLASSICAL ACOUSTICS 9

Linearized equations of motion; classical wave equation: plane and spherical waves, wave propagation in homogeneous and inhomogeneous media

Case Study: Analyze sound propagation in varying atmospheric conditions and its effect on aircraft noise perception on the ground.

**UNIT-II** MODELS FOR ACOUSTIC SOUND SOURCES 9

point sources, monopoles, dipoles and quadrupoles, Green's function solutions for wave equations, Kirchhoff–Helmholtz theorem for rigid boundaries.

Case Study: Application of monopole, dipole, and quadrupole models to predict noise from wind turbines and propellers.

**UNIT-III** AEROACOUSTIC SOURCES 9

Lighthill's acoustic analogy, integral solutions and far-field approximations; effect of solid surface: Curle's theory and Ffowcs Williams–Hawkings' equation.

Case Study: Analyze the noise generation mechanism in an airliner takeoff using Lighthill's analogy and Ffowcs Williams–Hawkings' equation.

**UNIT-IV** COMPUTATIONAL APPROACHES 9

Numerical aspects; direct methods: Reynolds-averaged Navier–Stokes equations (RANS), direct numerical simulations (DNS), application of large eddy simulations (LES); Hybrid methods: Flow-sound separation, numerical evaluation of Lighthill's integral.

Case Study: Computational simulation of the noise from a supersonic jet using LES and validation with experimental data.

**UNIT-V** JET ACOUSTICS 9

Noise sources from jet flows, mitigation methods. Experimental methods.

Case Study: Experimental analysis of noise mitigation using chevrons in jet engine exhausts.

**Total Contact Hours: 45**

**Course Outcomes:**

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

- Analyze classical acoustics principles and their relevance to aeroacoustics.

- Model various acoustic sound sources mathematically.
- Understand and apply aeroacoustic theories like Lighthill's analogy and Curle's theory.
- Implement computational approaches for simulating aeroacoustic phenomena.
- Evaluate jet noise and apply mitigation techniques using experimental and computational tools.

**Textbook (s):**

1. Pierce, A D: Acoustics, Acoustical Society of America, 1989.

**Reference Books(s) / Web links:**

1. Blackstock, D T: Fundamentals of physical acoustics, Wiley, 2000.
2. Howe, M S: Hydrodynamics and sound, Cambridge, 2007.
3. Howe, M S: Theory of vortex sound, Cambridge, 2003.
4. Tam, C K W: Computational aeroacoustics, Cambridge, 2012.
5. Rienstra, S W and Hirschberg A: An introduction to acoustics, 2011.
6. Crighton, D G: Basic principles of aerodynamic noise generation, Prog. Aerospace Sci., 16 (1), 1975, pp. 31-96.
7. Crighton, D G, Dowling A P, Ffowcs Williams J E, Heckl M and Leppington F G:

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23A17.1 | 3 | 1 | 1 | - | - | 1 | 1 | - | - | - | - | 1 | 2 | 1 | 1 |
| AE23A17.1 | 3 | 3 | 2 | - | - | 2 | 2 | - | - | - | - | 1 | 3 | 2 | 1 |
| AE23A17.1 | 3 | 3 | 2 | - | - | 2 | 2 | - | - | - | - | 1 | 3 | 2 | 1 |
| AE23A17.1 | 3 | 3 | 2 | - | - | 1 | 1 | - | - | - | - | 1 | 2 | 1 | 1 |
| AE23A17.1 | 3 | 3 | 2 | - | - | 2 | 2 | - | - | - | - | 1 | 2 | 2 | 1 |
| Average | 3 | 2.6 | 2 | - | - | 1.6 | 1.6 | - | - | - | - | 1 | 2.4 | 1.6 | 1 |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **AE23A18** | **TURBULENCE MODELING IN FLUID FLOWS** | PE | 3 | 0 | 0 | 3 |

Objectives:
To familiarize the student with the concept of turbulence
To prepare the student to choose and mathematically model turbulent flows

**UNIT-I Introduction to turbulence** 9

Definition of turbulence in fluid flows. Physical turbulence, brief history of turbulence modeling. The closure problem: Reynolds averaging, correlations, RANS, Reynolds-Stress equation

**UNIT-II Algebraic Models** 9

Molecular Transport of Momentum. The Mixing-Length Hypothesis. Application to Free Shear Flows - The Far Wake, The Mixing Layer, The Jet. Modern Variants of the Mixing-Length Model - Cebeci-Srnith Model, Baldwin-Lomax Model, Application to Wall-Bounded Flows - Channel and Pipe Flow, Boundary Layers, Separated Flows. The ½ equation model. Range of applicability.

**UNIT-III Turbulence Energy Equation Models** 9

One-Equation Models, Two-Equation Models, Other Two-Equation Models, Closure Coefficients, Application to Free Shear Flows, Perturbation Analysis of the Boundary Layer, The Defect Layer, The Viscous Sublayer, Surface Boundary Conditions, Application to Wall-Bounded Flows, Low-Reynolds-Number Effects, Separated Flows, Range of Applicability

**UNIT-IV Effects of Compressibility** 9

Physical Considerations, Favre Averaging, Favre-Averaged Equations, Compressible-Flow Closure, approximations, Dilatation Dissipation, Compressible Law of the Wall, Compressible Boundary Layers, Shock-Induced Boundary-Layer Separation

**UNIT-V Numerical Considerations and High-fidelity schemes** 9

Multiple Time Scales and Stiffness, Numerical Accuracy Near Boundaries, Solid Surfaces, Turbulent/Nonturbulent Interfaces, Parabolic Marching Methods, Elementary Time-Marching Methods, Block-Implicit Methods, Solution Convergence and Grid Sensitivity. Introduction to LES and DNS.

**Total Contact Hours: 45**

**Course Outcomes:**

- To understand the background of turbulence modeling
- To be able to use algebraic models for turbulence models
- To understand the industry accepted k models in CFD
- To be aware of the effects of compressibility on the turbulence level
- To understand various numerical considerations during turbulent flow simulations

**Textbook (s):**

1. "Turbulence modeling for CFD" by David C Wilcox, DCW Industries, Canada, 1998

**Reference Books(s) / Web links:**

1. Turbulence: An Introduction for Scientists and Engineers, by Peter Davidson, OUP Oxford Press

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| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23A18.1 | 3 | 1 | 1 | - | - | 1 | 1 | - | - | - | - | 1 | 2 | 1 | 1 |
| AE23A18.2 | 3 | 3 | 2 | - | - | 2 | 2 | - | - | - | - | 1 | 3 | 2 | 1 |
| AE23A18.3 | 3 | 3 | 2 | - | - | 2 | 2 | - | - | - | - | 1 | 3 | 2 | 1 |
| AE23A18.4 | 3 | 3 | 2 | - | - | 1 | 1 | - | - | - | - | 1 | 2 | 1 | 1 |
| AE23A18.5 | 3 | 3 | 2 | - | - | 2 | 2 | - | - | - | - | 1 | 2 | 2 | 1 |
| Average | 3 | 2.6 | 2 | - | - | 1.6 | 1.6 | - | - | - | - | 1 | 2.4 | 1.6 | 1 |

| AE23A19 | BOUNDARY LAYER THEORY | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| | | PE | 3 | 0 | 0 | 3 |

**UNIT I VISCOUS FLOW EQUATIONS 9**

Navier-Stokes Equations, Creeping motion, Couette flow, Poiseuille flow through ducts, Ekman drift, shear layer growth in jet flows.

**UNIT II LAMINAR BOUNDARY LAYER 9**

Development of boundary layer – Estimation of boundary layer thickness, Displacement thickness-Momentum and energy thicknesses for two-dimensional flow – Two-dimensional boundary layer equations – Similarity solutions - Blasius solution. Effect of pressure gradient on boundary layer.

**UNIT III TURBULENT BOUNDARY LAYER 9**

Physical and mathematical description of turbulence, two-dimensional turbulent boundary layer equations, Velocity profiles – Inner, outer and overlap layers, Transition from laminar to turbulent boundary layers, turbulent boundary layer on a flat plate, mixing length hypothesis.

**UNIT IV APPROXIMATE SOLUTION TO BOUNDARY LAYER EQUATIONS 9**

Approximate integral methods, digital computer solutions – Von Karman – Polhausen method.

**UNIT V THERMAL BOUNDARY LAYER 9**

Introduction to thermal boundary layer – Heat transfer in boundary layer - Convective heat transfer, importance of non-dimensional numbers – Prandtl number, Nusselt number, Lewis number etc.

**Total Contact Hours: 45**

**TEXTBOOKS**

1. Frank White – Viscous Fluid flow – McGraw Hill, 1998

**REFERENCES**


1. H. Schlichting, “Boundary Layer Theory”, McGraw-Hill, New York, 1979.
2. A. J. Reynolds, “Turbulent flows in Engineering”, John Wiley & Sons, 1980.
3. Ronald L., Panton, “Incompressible fluid flow”, John Wiley & Sons, 1984.
4. Tuncer Cebeci and Peter Bradshaw, “Momentum transfer in boundary layers”, Hemisphere Publishing Corporation, 1977.


After successful completion of the course students will demonstrate the following outcomes:

| | |
|---|---|
| **AE23A19.1** | Apply Navier-Stokes equations to various types of viscous flows |
| **AE23A19.2** | Estimate properties of laminar flow over a flat plate |
| **AE23A19.3** | Estimate properties of turbulent flow over a flat plate |
| **AE23A19.4** | Understand various solution methods for boundary layer equations |
| **AE23A19.5** | Understand the concept of thermal boundary layer and relevant non-dimensional numbers |

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| AE23A19.1 | 3 | 1 | 1 | - | - | 1 | 1 | - | - | - | - | 1 | 2 | 1 | 1 |
| AE23A19.2 | 3 | 3 | 2 | - | - | 2 | 2 | - | - | - | - | 1 | 3 | 2 | 1 |
| AE23A19.3 | 3 | 3 | 2 | - | - | 2 | 2 | - | - | - | - | 1 | 3 | 2 | 1 |
| AE23A19.4 | 3 | 3 | 2 | - | - | 1 | 1 | - | - | - | - | 1 | 2 | 1 | 1 |
| AE23A19.5 | 3 | 3 | 2 | - | - | 2 | 2 | - | - | - | - | 1 | 2 | 2 | 1 |
| Average | 3 | 2.6 | 2 | - | - | 1.6 | 1.6 | - | - | - | - | 1 | 2.4 | 1.6 | 1 |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **AE23B11** | **HEAT TRANSFER FOR AEROSPACE** | PE | 3 | 0 | 0 | 3 |

**Objectives:**

- To understand the steady and unsteady heat transfer problems
- To analyse laminar and turbulent heat flow over vertical and parallel plates
- To understand the radiative heat transfer between black body and gray body
- To analyze heat exchanger performance by using the LMTD and E-NTU methods.
- To understand the heat transfer problems involved in various types of aerospace vehicles

**UNIT-I CONDUCTIVE HEATA TRANSFER** 9

Basic Modes of Heat Transfer – One dimensional steady state heat conduction: Composite Medium – Critical thickness – Effect of variation of thermal Conductivity – Extended Surfaces – Unsteady state. Heat Conduction: Lumped System Analysis – Heat Transfer in Semi-infinite and infinite solids – Use of Transient – Temperature charts – Application of numerical techniques.

**UNIT-II CONVECTIVE HEAT TRANSFER** 10

Free Convection: Introduction – Free convection in atmosphere free convection on a vertical flat plate – Empirical relation in free convection.
Forced convection: Introduction – Laminar and turbulent convective heat transfer analysis in flows between parallel plates, over a flat plate and in a circular pipe. Empirical relations, application of numerical techniques in problem solving.

**UNIT-III RADIATIVE HEAT TRANSFER** 9

Introduction to Physical mechanism – Radiation properties – Radiation shape factors – Heat exchange between non – black bodies – Radiation shields.

**UNIT-IV HEAT EXCHANGERS** 9

Classification – Temperature Distribution – Overall heat transfer coefficient, Heat Exchange Analysis – LMTD Method and E-NTU Method.

**UNIT-V HEAT TRANSFER PROBLEMS IN AEROSPACE ENGINEERING** 8

Heat Transfer problems in gas turbine combustion chambers – Rocket thrust chambers – Aerodynamic heating – Ablative heat transfer.
Case studies: Space shuttle disasters – Challenger (1986) and Columbia (2003)

**Total Contact Hours: 45**

**Course Outcomes:**

- Perform calculations of steady and unsteady conductive heat transfer problems and to find the amount of insulation required for minimum heat loss.
- Evaluate heat transfer coefficients for natural and forced convection inside ducts and over external surfaces.
- Calculate radiation shape factors and thus heat transfer between black body surfaces and between gray body surfaces.
- Analyze heat exchanger performance by using the LMTD and E-NTU methods.
- Understand the heat transfer problems/limitations involved in various types of aerospace vehicles.

**SUGGESTED ACTIVITIES (if any)** (UNIT/ Module Wise) – Could suggest topic

- Problem solving sessions
- Flipped classroom - Comparing SOA with Client-Server and Distributed architectures
- Survey on various storage technologies
- Activity Based Learning
- Implementation of small module

**SUGGESTED EVALUATION METHODS (if Any)**

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

**Textbook(s):**

1. Sachdeva, S.C., "Fundamentals of Engineering Heat & Mass Transfer", Wiley Eastern Ltd., New Delhi, Fifth Ed, 2017.
2. Holman, J.P. "Heat Transfer", McGraw-Hill Book Co., Inc., New York, 10th Ed., 2017.

**Reference Books(s) / Web links:**

- David P. Dewitt, Theodore L. Bergman, Adrienne S. Lavine Frank P. Incropera, "Principals of Heat and Mass Transfer" Wiley; Seventh edition (2013)– 2002.
- Nag P., "Heat and Mass Transfer", Tata-McGraw Hill, 2011.
- Lienhard, J.H., "A Heat Transfer Text Book", Prentice Hall Inc., 1981.
- Yunus A. Cengel., "Heat Transfer – A practical approach", Second Edition, Tata McGraw-Hill, 2002.

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| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23B11.1 | 3 | 1 | 1 | - | - | 1 | 1 | - | - | - | - | 1 | 2 | 1 | 1 |
| AE23B11.2 | 3 | 3 | 2 | - | - | 2 | 2 | - | - | - | - | 1 | 3 | 2 | 1 |
| AE23B11.3 | 3 | 3 | 2 | - | - | 2 | 2 | - | - | - | - | 1 | 3 | 2 | 1 |
| AE23B11.4 | 3 | 3 | 2 | - | - | 1 | 1 | - | - | - | - | 1 | 2 | 1 | 1 |
| AE23B11.5 | 3 | 3 | 2 | - | - | 2 | 2 | - | - | - | - | 1 | 2 | 2 | 1 |
| Average | 3 | 2.6 | 2 | - | - | 1.6 | 1.6 | - | - | - | - | 1 | 2.4 | 1.6 | 1 |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **AE23B12** | **FUNDAMENTALS OF REFRIGERATION AND CRYOGENICS** | **PE** | **3** | **0** | **0** | **3** |

**Objectives:**

- To provide the students with a foundation of refrigeration.
- To provide the students details of the refrigerants
- To make the students aware of the capabilities and limitations of cryogenics.
- To study advanced features of the cryogenic engineering.
- To study the industrial practices in cryogenic engineering.

**UNIT-I BASICS OF REFEREGIRATION** 9

Brief history of refrigeration, refrigerants and environmental issues. Reverse Carnot cycle and standard vapor compression refrigeration cycle - analysis, comparison and Ewing's construction. Compressors - reciprocating, centrifugal and screw type, volumetric efficiency and performance. Performance of single stage refrigeration cycle and its limitations. Multistage, multi evaporator and cascade systems.

**UNIT-II PROPERTIES OF REFRIGERANTS** 9

Properties of refrigerants -primary, secondary and mixtures. Ozone friendly refrigerants, ozone depletion and global warming. lubricants. Absorption refrigeration system - LiBr- water and aqua-ammonia systems, calculations by h-x diagrams, Platen-Munter's system and solar energy applications. Steam jet refrigeration, vortex tube, Pulse tube, thermoelectric refrigeration and gas cycle refrigeration.

**UNIT-III BASICS OF CRYOGENICS** 9

Air liquefaction cycles. Condensers and evaporators: classifications, condensation and boiling heat transfer correlations, design and performance. Expansion values - capillary tube, AEV, TEV and float value. Refrigeration system simulation: balancing of condensing unit and evaporator

**UNIT-IV THERMODYNAMICS OF CRYOGENIC ENGINEERING** 9

Thermodynamics of gas liquefaction- liquefaction cycles- cryogenic refrigeration systems down to milli Kelvin range. Properties of cryogenic liquids, superfluidity, properties of solids at cryogenic temperatures: mechanical, thermal, electrical and magnetic properties, superconductivity. Storage and transfer of cryogenic liquids, liquid level.

**UNIT-V INDUSTRIAL APPLICATIONS OF CRYOGENIC ENGINEERING** 9

Thermocouples, platinum resistance and semiconductor thermometry. Cool down of cryogenic transfer lines, frost phenomena, cryogenic insulation. Applications of cryogenics in engineering, space technology, liquid fuel rockets, space simulation chambers.

**Total Contact Hours: 45**

**Course Outcomes:**

- Able to understand the details of the working principle of refrigeration cycle
- Able to analyse the properties of different types of refrigerants
- Able to understand different types of cryogenic processes
- Able to understand different types of cryogenic engineering
- Able to understand the application of cryogenic engineering in the industries

**SUGGESTED ACTIVITIES (if any)** (UNIT/ Module Wise) – Could suggest topic

- Problem solving sessions
- Flipped classroom - Comparing SOA with Client-Server and Distributed architectures
- Survey on various storage technologies
- Activity Based Learning
- Implementation of small module

**SUGGESTED EVALUATION METHODS (if Any)** (UNIT/ Module Wise) – could suggest topic

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

**Textbook(s):**

4. Gosney W.B. "Principles of refrigeration" Cambridge University Press( 1982)
5. Dossat R. J., Principles of Refrigeration" 4th Edition 2002.-Pearson Education, India.
6. Haselden C.J. (Ed) Cryogenic Fundamentals, Academic Press (1975)

**Reference Books(s) / Web links:**

- ASHRAE guide and Data Books Fundamentals (1977), Transactions (1978), Equipment, (1979), Systems (1980)
- Transactions of ASHRAE. 2008
- Baily C.A. Advanced cryogenics. Plenum Press (1971)

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23B12.1 | 3 | 1 | 1 | - | - | 1 | 1 | - | - | - | - | 1 | 2 | 1 | 1 |
| AE23B12.2 | 3 | 3 | 2 | - | - | 2 | 2 | - | - | - | - | 1 | 3 | 2 | 1 |
| AE23B12.3 | 3 | 3 | 2 | - | - | 2 | 2 | - | - | - | - | 1 | 3 | 2 | 1 |
| AE23B12.4 | 3 | 3 | 2 | - | - | 1 | 1 | - | - | - | - | 1 | 2 | 1 | 1 |
| AE23B12.5 | 3 | 3 | 2 | - | - | 2 | 2 | - | - | - | - | 1 | 2 | 2 | 1 |
| Average | 3 | 2.6 | 2 | - | - | 1.6 | 1.6 | - | - | - | - | 1 | 2.4 | 1.6 | 1 |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **AE23B13** | **COMPUTATIONAL HEAT TRANSFER** | **PE** | **3** | **0** | **0** | **3** |

**Objectives:**

- To impart knowledge to students in the fundamental principles of various numerical methods which are useful to obtain numerical solutions to heat transfer problems
- To make the students learn numerical methods to obtain solution to 1-D, 2-D and 3-D conductive heat transfer problems.
- To introduce both implicit and explicit methods for numerical solution of transient heat conduction problems to students
- To make the students familiarize with the numerical treatment of convective heat transfer problems to compute velocity and temperature profiles in boundary problems.
- To acquaint students with the use of finite volume method in radiative heat transfer problems

**UNIT-I NTRODUCTION** **9**

Finite Difference Method-Introduction-Taylor's series expansion - Discretization Methods Forward, backward and central differencing scheme for first 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 generationwithout Heat generation- 2D-heat conduction problem with different boundary conditionsNumerical 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 convectiondiffusion 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 – Montacalro 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 Contact Hours: 45**

**Course Outcomes:** Upon completion of this course, Students will be able to

- Acquire knowledge on the basic concepts on the applications of numerical methods for the heat transfer problem solutions
- Appreciate the role of boundary conditions in defining the complexities and the methodology for numerical solutions of heat transfer problems
- Use both implicit and explicit schemes for transient heat conduction problems
- Compute the temperature profiles in thermal boundary layer.

- Apply finite volume methods for radiative heat transfer problems and the role of Montecarlo methods in radiative heat transfer.

**SUGGESTED ACTIVITIES (if any**

- Problem solving sessions
- Flipped classroom - Comparing SOA with Client-Server and Distributed architectures
- Survey on various storage technologies
- Activity Based Learning
- Implementation of small module

**SUGGESTED EVALUATION METHODS (if Any)**

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

**Textbook(s):**

1. Sachdeva, S.C., Fundamentals of Engineering Heat and Mass Transfer, NEW AGE publishers,2010
2. Yunus A. Cengel, Heat Transfer – A Practical Approach Tata McGraw Hill 4thEdition, 2009

**Reference Books(s) / Web links:**

- Necati Ozisik, Finite Difference Method in Heat Transfer, CRC Press, 2nd edition, 2017.
- Pradip Majumdar, Computational Methods for Heat & Mass Transfer, CRC Press, 2005.
- Yogesh Jaluria, Kenneth E Torrence, Computational Heat transfer, CRC Press, 3rd Edition, 2017

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| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| **AE23B13.1** | 3 | 2 | 2 | - | - | 3 | 3 | - | - | - | - | 1 | 2 | 2 | - |
| **AE23B13.2** | 3 | 2 | 2 | - | - | 3 | 3 | - | - | - | - | 1 | 2 | 2 | 1 |
| **AE23B13.3** | 3 | 2 | 2 | - | - | 3 | 3 | - | - | - | - | 1 | 2 | 2 | 1 |
| **AE23B13.4** | 3 | 2 | 2 | - | - | 3 | 3 | - | - | - | - | 1 | 2 | 2 | 1 |
| **AE23B13.5** | 3 | 2 | 2 | - | - | 3 | 3 | - | - | - | - | 1 | 2 | 2 | - |
| **Average** | 3 | 2 | 2 | - | - | 3 | 3 | - | - | - | - | 1 | 2 | 2 | 1 |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **AE23B14** | **TURBO MACHINES** | **PE** | **3** | **0** | **0** | **3** |

**Objectives:**

- To classify the turbomachines based on energy interactions
- To study the performance characteristics of turbomachines under different operating conditions
- To inculcate knowledge in the thermal design of turbomachines
- To study the features and working of various turbomachines
- To Apply the concepts of energy transformation in turbo machines

**UNIT-I INTRODUCTION** 9

Definition of turbo machine, parts of turbo machines, Comparison with positive displacement machines, Classification, Dimensionless parameters and their significance, Unit and specific quantities, model studies and its numerical. (Note: Since dimensional analysis is covered in Fluid Mechanics subject, questions on dimensional analysis may not be given. However, dimensional parameters and model studies may be given more weightage.)

**UNIT-II ENERGY EXCHANGE IN TURBO MACHINES** 9

Euler's turbine equation, Alternate form of Euler's turbine equation, Velocity triangles for different values of degree of reaction, Components of energy transfer, Degree of Reaction, utilization factor, Relation between degree of reaction and Utilization factor, Problems.

**UNIT-III STEAM TURBINES** 9

**Steam Turbines:** Classification, Single stage impulse turbine, condition for maximum blade efficiency, stage efficiency, Need and methods of compounding, Multi-stage impulse turbine, expression for maximum utilization factor, Numerical Problems.

**Reaction turbine** – Parsons's turbine, condition for maximum utilization factor, reaction staging. Numerical Problems

**UNIT-IV HYDRAULIC TURBINES** 9

**Hydraulic Turbines:** Classification, various efficiencies.

**Pelton Wheel** – Principle of working, velocity triangles, design parameters, maximum efficiency, and numerical problems.

**Francis turbine** – Principle of working, velocity triangles, design parameters, and numerical problems

**Kaplan and Propeller turbines** - Principle of working, velocity triangles, design parameters and Numerical Problems. Theory and types of Draft tubes.

**UNIT-V CENTRIFUGAL PUMPS** 9

Centrifugal Pumps: Classification and parts of centrifugal pump, different heads and efficiencies of centrifugal pump, Theoretical head – capacity relationship, Minimum speed for starting the flow, Maximum suction lift, Net positive suction head, Cavitation, Need for priming, Pumps in series and parallel. Problems.

Centrifugal Compressors: Stage velocity triangles, slip factor, power input factor, Stage work, Pressure developed, stage efficiency and surging and problems.

**Total Contact Hours: 45**

**Course Outcomes:** At the end of the course students can able to

- Compare the features and working of various turbomachines
- Apply the concepts of energy transformation in turbo machines
- Analyse the performance of Hydraulic pumps and turbines
- Design and evaluate the critical parameters involved in power generation
- Evaluate the performance of axial and centrifugal compressors

**SUGGESTED ACTIVITIES (if any)** (UNIT/ Module Wise) – Could suggest topic

- Problem solving sessions
- Flipped classroom - Comparing SOA with Client-Server and Distributed architectures
- Survey on various storage technologies
- Activity Based Learning
- Implementation of small module

**SUGGESTED EVALUATION METHODS (if Any)**

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

**Textbook(s):**

1. Yahya S. M. "Turbines, Fans and Compressors",4/e,Tata McGraw Hill Publishing Company Limited ,2011
2. Turbo Machines B.U.Pai Wiley India Pvt, Ltd 1st Edition
3. Fundamentals of Turbo Machinery B.K Venkanna PHI Publishers

**Reference Books(s) / Web links:**

- Turbines, Compressors & Fans S. M. Yahya Tata McGraw Hill Co. Ltd 2nd edition, 2002
- Principals of Turbo machines D. G. Shepherd The Macmillan Company 1964
- Fluid Mechanics & Thermodynamics of Turbo machines S. L. Dixon Elsevier 2005

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| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23B14.1 | 3 | 1 | 1 | - | - | - | - | - | - | - | - | 1 | 2 | 1 | 1 |
| AE23B14.2 | 3 | 3 | 2 | - | - | - | - | - | - | - | - | 1 | 3 | 2 | 1 |
| AE23B14.3 | 3 | 3 | 2 | - | - | - | - | - | - | - | - | 1 | 3 | 2 | 1 |
| AE23B14.4 | 3 | 3 | 2 | - | - | - | - | - | - | - | - | 1 | 2 | 1 | 1 |
| AE23B14.5 | 3 | 3 | 2 | - | - | - | - | - | - | - | - | 1 | 2 | 2 | 1 |
| Average | 3 | 2.6 | 2 | - | - | - | - | - | - | - | - | 1 | 2.4 | 1.6 | 1 |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
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| **AE23B15** | **DESIGN OF GAS TURBINE ENGINE COMPONENTS** | **PE** | **3** | **0** | **0** | **3** |

**Objectives:**

- To introduce basic design concepts of jet engine and estimation of required thrust to students.
- To make students familiarize with the design parameter and off design calculations
- To give the students adequate exposure to design procedure to the rotating components of engine such as compressor and turbine along with staging.
- To make the students learn the aspects of combustion processes, flame stabilization issue, igniters design and NOx controls.
- To make students familiarize with the concept of design inlet and nozzle for various on - off design conditions.

**UNIT-I** GAS TURBINE ENGINE DESIGN FUNDAMENTALS 9

Design Process- compressible flow relationship; Constraint Analysis - Concept-Design toolspreliminary estimates; Mission analysis - Aircraft weight and fuel consumption data-Example problems on Constrain analysis, Mission analysis.

**UNIT-II** ON DESIGN AND OFF-DESING PARAMETRIC ANALYSIS 9

Total and static properties-corrected mass flow rate-Engine Cycle Design- One-Dimensional Through flow Area-Flow path force on components- aircraft constraint analysis, aircraft mission analysis, engine parametric (design point) analysis, engine performance (off-design) analysis, engine installation drag and sizing.

**UNIT-III** DESIGN OF ROTATING COMPONENTS 9

Fan and Compressor Aerodynamics-Diffusion factor-Aerofoil geometry-Flow path dimensionRadial variation-Turbine Aerodynamics- Constant axial velocity-adiabatic-selected Mach number-Mean line stage Design-stage pressure ratio-Airfoil geometry-radial variation-turbine cooling-range of turbine parameters-Engine life-Design Example –for fan-compressor-turbine.

**UNIT-IV** COMBUSTION CHAMBER DESIGN 9

Design: Combustion system components- Combustion- Chemical reactor theory. Combustor Stability map-Stirring and mixing-Total pressure loss-Fuels-Ignition-Combustion Systems of Main Burner Design: Air partitioning- Main burner component Design: Diffuser-types of burnerinner and outer casing design-Fuel nozzle-Dome and liner-Primary zone- swirler-Secondary holes-Dilution holes-Transition duct-Design of Afterburners-Design parameters-Diffuser-Fuel injection-Ignition-Flame stabilization – Flame spread and after burner length – Examples design calculation.

**UNIT-V** INLET AND NOZZLE DESIGN 9

Inlets and Exhaust Nozzles Design: Elements of a Successful Inlet-Engine Integration Program-Definition of Subsonic Inlet-Engine Operational Requirements- Definition of Supersonic Inlet-Engine Operational Requirements- Engine Impact on Inlet Design- Inlet Impact on Engine Design-Validation of Inlet-Engine System-Exhaust nozzle design-Nozzle types and their design -Jet control methods for reduction of infrared signature

**Total Contact Hours: 45**

**Course Outcomes:** Upon completion of this course, Students will be able to

- Do preliminary weight and fuel estimation for an aircraft mission.
- Identify variation in parametric analysis of ON and OFF design calculations
- Identify variation in parametric analysis of ON and OFF design calculations
- Estimate the total pressure losses and able to predict ignition delay.
- Determine the basic design factors affects ON and OFF design operation of inlets and nozzle on engine performance.

**SUGGESTED ACTIVITIES (if any)** (UNIT/ Module Wise) – Could suggest topic

- Problem solving sessions
- Flipped classroom - Comparing SOA with Client-Server and Distributed architectures
- Survey on various storage technologies
- Activity Based Learning
- Implementation of small module

**SUGGESTED EVALUATION METHODS (if Any)** (UNIT/ Module Wise) – could suggest topic

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

**Text Book(s):**


7. Mattingly J.D., Heiser, W.H. and Pratt D.T, 'Aircraft Engine Design', 2nd Edition, AIAA Education Series, AIAA, 2002.
8. Oates G.C.,' Aircraft Propulsion Systems Technology and Design',1989, AIAA Education Series.
9. Saravanamuttoo H.I.H and Rogers, G.F.C. “Gas Turbine Technology”, Pearson Education Canada; 6th edition, 2008.


**Reference Books(s) / Web links:**


- Cumpsty N., “Jet Propulsion: A Simple Guide to the Aerodynamics and Thermodynamics Design and Performance of Jet Engines” , Cambridge University Press; 2nd edition, 2003
- Murthy S.N. and Curran E.T.,' High-Speed Flight Propulsion Systems', Volume 137, Progress in Astronautics and Aeronautics, AIAA,1991.
- Rathakrishnan E, 'Applied Gas Dynamics, John Wiley & Sons (Asia) Pvt Ltd, 2010.
- Treage I.E, Aircraft Gas Turbine Engine Technology, 3 rd edition, Glencoe McGraw-Hill, Inc. 1995


| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23B15.1 | 3 | 1 | 1 | - | - | - | - | - | - | - | - | 1 | 2 | 1 | 1 |
| AE23B152 | 3 | 3 | 2 | - | - | - | - | - | - | - | - | 1 | 3 | 2 | 1 |
| AE23B15.3 | 3 | 3 | 2 | - | - | - | - | - | - | - | - | 1 | 3 | 2 | 1 |
| AE23B15.4 | 3 | 3 | 2 | - | - | - | - | - | - | - | - | 1 | 2 | 1 | 1 |
| AE23B15.5 | 3 | 3 | 2 | - | - | - | - | - | - | - | - | 1 | 2 | 2 | 1 |
| Average | 3 | 2.6 | 2 | - | - | - | - | - | - | - | - | 1 | 2.4 | 1.6 | 1 |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **AE23B16** | **ADVANCED PROPULSION SYSTEMS** | PE | 3 | 0 | 0 | 3 |

**Objectives:**

- To impart knowledge on the basic concepts of detonation engine.
- To learn about the physics of electric and electromagnetic propulsion.
- To get familiarize with the types of nuclear rockets and the basic concepts of nuclear propulsion systems.
- To study about the radioisotope propulsion.
- To realise the importance of advanced space propulsion concepts.

UNIT I **DETONATION ENGINE** 9

Introduction to detonation -– Hugoniot curve – Properties of Hugoniot curve - Chapman–Jouguet detonation- detonation wave structure – the mechanism of deflagration to detonation transition - pulse detonation and rotating detonation engine.

UNIT II **FUNDAMENTALS OF ELECTRIC PROPULSION** 9

Classifications of Electrical Rockets- Electrostatic and Electromagnetic Forces- Electrothermal Thrusters- Electrostatic Thrusters – Electromagnetic Thruster - Types of Plasma Thruster – thruster efficiency - Characteristic Velocity - Advanced Electric Propulsion Systems for Space Vehicles.

UNIT III **NUCLEAR PROPULSION** 9

Types Of Nuclear Reaction - Nuclear Fission - Fusion Propulsion- Essential Components of a Reactor– Fuel Rod -– Reactor Core Materials – Solid Core Reactors- Liquid Core Reactors- Gas Core Reactor – Shielding - Nuclear Rocket Nozzles – Nuclear Rocket Engine Control- Nuclear Rocket Performance – NERVA.

UNIT IV **RADIOISOTOPE PROPULSION** 9

Alternative Approaches, Direct Recoil Method, Thermal Heating Method, Basic Thruster Configurations, Propulsion System and Upper Stage, Primary Propulsion, Auxiliary Propulsion, Thruster Technology, Design Criteria, Performance, Radioisotope Fuel, Capsule Technology, General Considerations, Thermal Design, Fabrication and Non-Destructive Testing Techniques, Pressure Containment, Nozzle Performance.

UNIT V **ADVANCED SPACE PROPULSION CONCEPT AND TECHNIQUES** 9

Free radical propulsion - Sputtering Phenomena – Micropropulsion - Micropropulsion Requirements – Cold gas micro propulsion - Field Emission Electric Propulsion – Laser ablation thrusters – Vacuum arc thruster - Pulsed Plasma Thruster - Colloid Thruster - Photon Rocket – Gelled Propellants and processing methods – Atomization of Gelled propellants - Green Propellants.

**TOTAL: 45 PERIODS**

**TEXT BOOKS**

1. Kuo K.K. “Principles of Combustion” John Wiley and Sons, 2nd Edition, 2012.
2. Sutton, G.P., “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 9th Edition, 2017.
3. Loh, W.H.T., “Jet, Rocket, Nuclear, Ion and Electric Propulsion: Theory and Design (Applied Physics and Engineering)”, Springer Verlag, New York, 2012.

**REFERENCE BOOK**

1. Martin Tajmar, "Advanced Space Propulsion Systems" Springer Verlag GmbH, 1st Edition, 2003.
2. Robert G. Jahn, "Physics of Electric Propulsion", McGraw-Hill Series, New York, 2006.
3. William J. Emrich Jr., "Principles of Nuclear Rocket Propulsion" Elsevier Science, 2nd Edition, 2023.

**SUGGESTED EVALUATION METHODS (if Any)** (UNIT/ Module Wise) – could suggest topic

- Assignments
- Quizzes/MCQ
- Seminar Presentation/Discussion
- Assessment Tests

**Course Outcomes:**

- Able to analyse in detail the thermodynamics cycles of detonation engine.
- Able to gain idea on the concepts of electric and electromagnetic propulsion.
- Able to demonstrate the working principle of nuclear rocket engine.
- Able to demonstrate the concept of radioisotope propulsion
- Able to acquire knowledge on the concepts of advanced space propulsion systems.

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23B16.1 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 3 |
| AE23B16.2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 3 |
| AE23B16.3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 3 |
| AE23B16.4 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 3 |
| AE23B16.5 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 3 |
| Average | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 3 |

| AE23B17 | COMBUSTION AND FLAMES | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| | | PE | 3 | 0 | 0 | 3 |

**OBJECTIVE**

- To familiarize the learner chemical kinetics of different types of combustions.

**UNIT I REVIEW OF THERMODYNAMICS RELATIONS 9**

Review of Thermodynamics, Chemical kinetics, Mass transfer definitions: Fick's law.

**UNIT II CONSERVATION OF MASS AND ENERGY 9**

Equations of conservation of species mass, momentum and energy, Schvab-Zel'dovich formulation, Rankine-Hugoniot relations.

**UNIT III LAMINAR PREMIXED FLAMES 9**

Flame speed, Flammability limits, Flame stabilization, Ignition and quenching. Burke-Schumann problem, Droplet Burning, Partially premixed flames,

**UNIT IV PROPELLANT COMBUSTION 9**

Solid propellant combustion, Spray combustion, Detonation: ZND model, Combustion instabilities.

**UNIT V SUPERSONIC COMBUSTION 9**

Introduction to turbulent premixed and diffusion flames, governing equation for chemically reacting viscous flow, Dissociation, Boundary layer equation for chemically reacting gas, Boundary- layer solutions.

**Total Contact Hours: 45**

**TEXT BOOK**

1. K. K. Kuo, Principles of Combustion, Second Edition.

**REFERENCES**

1. W. C. Strahle, Introduction to Combustion.
2. S. Mukunda, Understanding Combustion
3. J. D. Anderson, Hypersonic and High Temperature Gas Dynamics, Second Edition

After successful completion of the course students will demonstrate the following outcomes:

| | |
|---|---|
| **AE23B17.1** | Understand the different types of thermodynamics relations applicable to combustion |
| **AE23B17.2** | Understand the different types of conservation laws |
| **AE23B17.3** | Understand the laminar premixed flames |
| **AE23B17.4** | Analyze the laminar diffusion flames |
| **AE23B17.5** | Understand the supersonic combustion |

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23B17.1 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | - | - | - | - | - | 1 | 1 | 1 |
| AE23B17.2 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | - | - | - | - | - | 1 | 1 | 1 |
| AE23B17.3 | 3 | 2 | 1 | 1 | 3 | 1 | 1 | - | - | - | - | - | 1 | 1 | 1 |
| AE23B17.4 | 3 | 3 | 2 | 1 | 3 | 1 | 1 | - | - | 1 | - | 1 | 2 | 2 | 3 |
| AE23B17.5 | 3 | 3 | 2 | 1 | 2 | 1 | 1 | - | - | 1 | - | 1 | 2 | 2 | 3 |
| Average | 3 | 2.4 | 1.4 | 1 | 2 | 1 | 1 | - | - | 1 | - | 1 | 1.4 | 1.4 | 1.8 |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **AE23B18** | **HIGH-TEMPERATURE GAS DYNAMICS** | PE | 3 | 0 | 0 | 3 |

**Objectives:**

- To gain basic knowledge of thermo-physical properties of gases
- To give conceptual understanding of equilibrium and non-equilibrium processes in a gas
- To understand behaviour of gases in equilibrium
- To know the basic gas dynamics like isentropic flow and shocks
- To know the basics of frictional flow and the flow with heating

**UNIT-I INTRODUCTION** 9

Review of equilibrium gas properties, non-equilibrium and non-equilibrium kinetic theory.

**UNIT-II EQUILLIBRIUM OF GASES** 9

Equilibrium flow (Steady shocks, nozzle flow, Prandtl-Meyer flow, Frozen flow), Vibrational and Chemical rate processes (Vibrational rate equation, chemical rate equation, local relaxation times, small departures from equilibrium)

**UNIT-III PROPERTIES OF GASES** 9

Flow with Vibrational and chemical non-equilibrium (Equilibrium and frozen flow, non- linear equations, acoustic equations, speed of sound, sound propagation, small departures from uniform flow, linearised normal shock wave, dispersed shock wave, nozzle flow, MOC)

**UNIT-IV GAS FLOWS** 9

Flow with translational non-equilibrium (transport properties, Bulk viscosity, structure of shock wave, linearised Couette flow)

**UNIT-V RADIATION CHARACTERISTICS** 9

Radiative transfer in gases (Equation of radiative transfer, radiative equilibrium, radiation-solid surface interaction, Emission and absorption of radiation), Flow with radiative non-equilibrium (Basic non-linear equations, grey-gas, 1D equations, normal shock wave) .

**Total Contact Hours: 45**

**Course Outcomes:**

- Abel to analyse the thermo-physical properties of gases
- Able to understand the equilibrium and non-equilibrium processes in a gas
- Able to understand behaviour of gases in equilibrium
- Able to understand the basic gas dynamics like isentropic flow and shocks
- Able to understand the basics of frictional flow and the flow with heating

**SUGGESTED ACTIVITIES (if any)** (UNIT/ Module Wise) – Could suggest topic

- Problem solving sessions
- Flipped classroom - Comparing SOA with Client-Server and Distributed architectures
- Survey on various storage technologies
- Activity Based Learning
- Implementation of small module

**SUGGESTED EVALUATION METHODS (if Any)** (UNIT/ Module Wise) – could suggest topic

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

**Textbook(s):**

1. W G Vincenti and C H Kruger,Jr., Introduction to Physical Gas Dynamics, Kreiger Publishing Co., Malabar, Florida, USA (1986).
2. J.D. Anderson Jr., Hypersonic and High Temperature gas dynamics, McGraw Hill (1989)
3. T.K. Bose, High Temperature Gas Dynamics: an Introduction for Physicists and Engineers, Springer (2004).

**Reference Books(s) / Web links:**

- J.O. Hirschfelder, C.F. Curtiss, and R.B. Bird, Molecular theory of gases and liquids, Wiley-Inter science; Rev Ed edition (1964)

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23B18.1 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | - | 1 | 3 | 1 | - |
| AE23B18.2 | 3 | 3 | 1 | - | - | - | 1 | - | - | - | - | 1 | 3 | 3 | - |
| AE23B18.3 | 3 | 3 | 1 | - | - | - | 1 | - | - | - | - | 1 | 3 | 3 | - |
| AE23B18.4 | 3 | 2 | 1 | - | - | - | 1 | - | - | - | - | 1 | 3 | 2 | - |
| AE23B18.5 | 3 | 2 | 1 | - | - | - | 1 | - | - | - | - | 1 | 3 | 2 | - |
| Average | 2.8 | 2.2 | 1 | - | - | - | 1 | - | - | - | - | 1 | 3 | 2.2 | - |

| AE23B19 | SPRAY THEORY | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| | | PE | 3 | 0 | 0 | 3 |

**OBJECTIVES**

- This course covers the theory necessary to understand spray formation and evolution, as well as a host of spray applications.

**UNIT I INTRODUCTION TO SPRAYS AND ATOMIZATION 9**

Basic spray processes, Factors controlling spray formation. Number distributions, Mass/volume distributions, Empirical distributions, Theoretical distributions.

**UNIT II ATOMIZERS AND THEIR DESIGNS 9**

**Sheet and ligament breakup:** Instability analyses for ligaments and sheets, Design models based on instability analyses.

**Drop formation:** Static and dynamic force balances, Continuity considerations, Secondary atomization, Collisions and coalescence.

**UNIT III ATOMIZATION AND SPRAY THEORY 9**

**Drop motion and spray-surroundings interactions:** Steady trajectories (gas turbines, spray cooling, paint sprays), Entrainment.

**Drop evaporation:** Steady evaporation, Unsteady evaporation, Convective effects.

**UNIT IV INTERNAL AND EXTERNAL SPRAYS 9**

**Internal fluid mechanics:** Swirl atomizers, Impinging jet atomizers. **External spray characteristics:** Cone angle, Radial circumferential mass flux distributions.

**UNIT V ATOMIZER PERFORMANCE AND MEASUREMENT TECHNIQUES 9**

**Atomizer performance:** Modern design models for pressure-swirl atomizers, impinging jet atomizers, transient pressure (Diesel) atomizers.

**Measurement techniques:** Drop sizing by Malvern and P/DPA, Drop velocity by P/DPA, Mass flux distribution via patternators and P/DPA.

**Total Contact Hours: 45**

**TEXTBOOKS**

1. Atomization and Sprays, by A.H. Lefebvre (Hemisphere: New York, 1989. ISBN 0-89116-603-3) and
2. Liquid Atomization, by L. Bayvel and Z. Orzechowski (Taylor and Francis: Washington DC, 1993. ISBN 0-89116-959-8).

After successful completion of the course students will demonstrate the following outcomes:

**AE23B19.1** Understand the factors controlling spray formation and spray distribution
**AE23B19.2** Analyze the drop formation
**AE23B19.3** Understand the different types of spray patterns
**AE23B19.4** Distinguish between internal and external spray patterns
**AE23B19.5** Analyze atomizer performance by using different model measuring techniques

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23B19.1 | 3 | 3 | 2 | 3 | 2 | 2 | 1 | - | - | 1 | - | - | 2 | 2 | 2 |
| AE23B19.2 | 3 | 3 | 2 | 3 | 2 | 2 | 1 | - | - | 1 | - | - | 2 | 2 | 3 |
| AE23B19.3 | 3 | 3 | 2 | 3 | 2 | 2 | 1 | - | - | 1 | - | - | 2 | 2 | 3 |
| AE23B19.4 | 3 | 3 | 2 | 3 | 2 | 2 | 1 | - | - | 1 | - | - | 1 | 1 | 1 |
| AE23B19.5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | - | - | 1 | - | 2 | 3 | 3 | 3 |
| Average | 3 | 3 | 2.2 | 3 | 2.2 | 2.2 | 1.4 | - | - | 1 | - | 2 | 2 | 2 | 2.4 |

| Subject Code | Subject Name | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| AE23C11 | THEORY OF ELASTICITY | PE | 3 | 0 | 0 | 3 |

**OBJECTIVES**

- To make the student understand the elastic behavior of different structural components under various loadings and boundary conditions.

**UNIT I BASIC EQUATIONS OF ELASTICITY 9**

Definition of Stress and Strain: Stress - Strain relationships - Equations of Equilibrium, Compatibility equations, Boundary Conditions, Saint Venant‟s principle - Principal Stresses, Stress Ellipsoid - Stress invariants.

**UNIT II PLANE STRESS AND PLANE STRAIN PROBLEMS 9**

Airy‟s stress function, Bi-harmonic equations, Polynomial solutions, Simple two-dimensional problems in Cartesian coordinates like bending of cantilever and simply supported beams.

**UNIT III POLAR COORDINATES 9**

Equations of equilibrium, Strain - displacement relations, Stress – strain relations, Airy‟s stress function, Axi – symmetric problems, Introduction to Dunder‟s table, Curved beam analysis, Lame‟s, Kirsch, Michell‟s and Boussinesque problems – Rotating discs.

**UNIT IV TORSION 9**

Navier‟s theory, St. Venant‟s theory, Prandtl‟s theory on torsion, semi- inverse method and applications to shafts of circular, elliptical, equilateral triangular and rectangular sections. Membrane Analogy.

**UNIT V INTRODUCTION TO THEORY OF PLATES AND SHELLS 9**

Classical plate theory – Assumptions – Governing equations – Boundary conditions – Navier‟s method of solution for simply supported rectangular plates – Levy‟s method of solution for rectangular plates under different boundary conditions.

**Total Contact Hours: 45**

**OUTCOMES**

- Ability to use mathematical knowledge to solve problem related to structural elasticity.

**TEXTBOOKS**

1. Timoshenko, S., and Goodier, T.N., "Theory of Elasticity", McGraw – Hill Ltd., Tokyo, 1990.
2. Ansel C Ugural and Saul K Fenster, "Advanced Strength and Applied Elasticity", 4th Edition, Prentice Hall, New Jersey, 2003.
3. Bhaskar, K., and Varadan, T. K., "Theory of Isotropic/Orthotropic Elasticity", CRC Press USA, 2009.

**REFERENCES**

1. Wang, C. T., "Applied Elasticity", McGraw – Hill Co., New York, 1993.
2. Sokolnikoff, I. S., "Mathematical Theory of Elasticity", McGraw – Hill, New York, 1978.
3. Volterra & J.H. Caines, "Advanced Strength of Materials", Prentice Hall, New Jersey, 1991
4. Barber, J. R., "Elasticity", Kluwer Academic Publishers, 2004

After successful completion of the course students will demonstrate the following outcomes:

**AE23C11.1** Students will able to solve problems on equations of elasticity with different boundary conditions.

**AE23C11.2** Students will able able to determine bi harmonic equations and its application to two dimensional problems like bending of cantilever and simply supported beams

**AE23C11.3** Students will resolve the stress strain and displacements problems in polar coordinates for axi-symmetric sections.

**AE23C11.4** Students will able to determine Navier's theory, St. Venant's theory, Prandtl's theory on torsion and its application to various shafts.

**AE23C11.5** Students can interprete the results obtained from governing equation and give solutions for different plates and shells using Navier's and Levy's method.

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23C11.1 | 3 | 3 | 2 | 1 | - | - | - | - | 1 | 1 | - | 1 | 3 | 1 | - |
| AE23C11.2 | 3 | 3 | 2 | 2 | - | - | - | - | 1 | 1 | - | 1 | 3 | 1 | - |
| AE23C11.3 | 3 | 3 | 2 | 2 | - | - | - | - | 1 | 1 | - | 1 | 3 | 1 | - |
| AE23C11.4 | 3 | 2 | 2 | 1 | - | - | - | - | 1 | 1 | - | 1 | 3 | 1 | - |
| AE23C11.5 | 3 | 3 | 3 | 2 | - | - | - | - | 1 | 1 | - | 1 | 3 | 1 | - |
| Average | 3 | 2.8 | 2.2 | 1.6 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 3 | 1 | 0 |

| Subject Code | Subject Name | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| AE23C12 | FINITE ELEMENT METHOD | PE | 2 | 1 | 0 | 3 |

**OBJECTIVES**

- To give exposure various methods of solution and in particular the finite element method. Gives exposure to the formulation and the procedure of the finite element method and its application to varieties of problems.

**UNIT I INTRODUCTION 8**

Review of various approximate methods – variational approach and weighted residual approach–application to structural mechanics problems. Finite difference methods–governing equation and convergence criteria of finite element method.

**UNIT II DISCRETE ELEMENTS 10**

Bar elements, uniform section, mechanical and thermal loading, varying section, 2D and 3D truss element. Beam element - problems for various loadings and boundary conditions – 2D and 3D Frame elements.

**UNIT III CONTINUUM ELEMENTS 8**

Plane stress, plane strain and axisymmetric problems. Derivation of element matrices for constant and linear strain triangular elements and axisymmetric elements.

**UNIT IV ISOPARAMETRIC ELEMENTS 9**

Definitions, Shape function for 4, 8 and 9 nodal quadrilateral elements, stiffness matrix and consistent load vector, evaluation of element matrices using numerical integration.

**UNIT V FIELD PROBLEM AND METHODS OF SOLUTIONS 10**

Heat transfer problems, steady state fin problems, derivation of element matrices for two dimensional problems, torsion problems. Bandwidth – elimination method and method of factorization for solving simultaneous algebraic equations – Features of software packages, sources of error.

**Total Contact Hours: 45**

**TEXT BOOKS**

1. Tirupathi.R. Chandrapatha and Ashok D. Belegundu, "Introduction to Finite Elements in Engineering", Printice Hall India, Third Edition, 2003.
2. Rao. S.S., "Finite Element Methods in Engineering," Butterworth and Heinemann, 2001
3. Reddy J.N., "An Introduction to Finite Element Method", McGraw Hill, 2000.

**REFERENCES**

1. Krishnamurthy, C.S., "Finite Element Analysis", Tata McGraw Hill, 2000.
2. Bathe, K.J. and Wilson, E.L., "Numerical Methods in Finite Elements Analysis", Prentice Hall of India, 1985.
3. Robert D Cook, David S Malkus, Michael E Plesha, "Concepts and Applications of Finite Element Analysis", 4th edition, John Wiley and Sons, Inc., 2003.
4. Larry J Segerlind, "Applied Finite Element Analysis", 2nd Edition, John Wiley and Sons, 1984.

**Course Outcomes:**

On completion of the course students will be able to

| | |
|---|---|
| **AE23C12.1** | Will obtain an overall understanding of Finite Element analysis |
| **AE23C12.2** | Will be able to perform discrete element analysis |
| **AE23C12.3** | Will be able to perform continuum element analysis |
| **AE23C12.4** | Will be able to perform isoparametric element analysis |
| **AE23C12.5** | Will be able to apply FEM methods to typical engineering situations |

| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **AE23C12.1** | 3 | 2 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **AE23C12.2** | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **AE23C12.3** | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **AE23C12.4** | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **AE23C12.5** | 3 | 2 | 2 | - | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **Average** | 3 | 2 | 2 | 1 | 1.8 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **AE23C13** | **INTRODUCTION TO VIBRATIONS** | **PE** | **3** | **0** | **0** | **3** |

**Objectives:**

- To study the effect of time dependent forces on mechanical systems and to get the natural characteristics of system with single degree of freedom systems.
- Determine the natural frequencies of the system subjected to forced excitation with single degrees of freedom
- Understand the modal analysis for the multi-degree of freedom systems
- Obtain the natural frequencies for all the continuous systems through wave equations
- Use of approximate and numerical methods to solve for the natural frequencies in multi-degrees of freedom

**UNIT-I SINGLE DEGREE OF FREEDOM SYSTEMS – FREE VIBRATIONS** 9

Introduction to simple harmonic motion, Single degree of freedom systems – free vibrations – damped vibrations.

**UNIT-II SINGLE DEGREE OF FREEDOM SYSTEMS - FORCED VIBRATIONS** 9

Forced vibrations, with and without damping – Logarithmic decrement - Support excitation – Transmissibility.

**UNIT-III DYNAMICS OF MULTI DEGREES OF FREEDOM SYSTEMS** 9

Two degrees of freedom systems - Eigen value problems – Modal Analysis - Static and dynamic couplings – Hamilton's principle - Lagrangian equations and application.

**UNIT-IV DYNAMICS OF CONTINUOUS SYSTEMS** 9

Vibration of string – Longitudinal, Lateral and Torsional vibrations

**UNIT-V APPROXIMATE METHODS** 9

Influence Co-efficient method – Rayleigh's method – Rayleigh-Ritz method - Dunkerley's method – Matrix iteration method.

**Total Contact Hours: 45**

**Course Outcomes:**

- Apply knowledge of mathematics, science, and engineering by developing the equations of motion for vibratory systems and solving for the free response
- Formulate and analyse the forced vibration
- Construct the governing differential equation and solve vibration problems that contain multiple degrees of freedom
- Calculate the modes of simple structural elements and explain the utility of modal analysis in structural dynamics
- Demonstrate a basic understanding of modern numerical methods in structural dynamics

**SUGGESTED ACTIVITIES (if any)** (UNIT/ Module Wise) – Could suggest topic

- Problem solving sessions
- Flipped classroom - Comparing SOA with Client-Server and Distributed architectures
- Survey on various storage technologies
- Activity Based Learning
- Implementation of small module

**SUGGESTED EVALUATION METHODS (if Any)** (UNIT/ Module Wise) – could suggest topic

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

**Textbook(s):**

1. Singiresu S. Rao, 'Mechanical Vibrations', Fifth Edition, Prentice Hall, 2011.
2. Thomson W T, „Theory of Vibration with Application" - CBS Publishers, 1990.

**Reference Books(s) / Web links:**

- Grover. G.K., "Mechanical Vibrations", 7th Edition, Nem Chand Brothers, Roorkee, India, 2003
- TSE. F.S., Morse, I.F., Hinkle, R.T., "Mechanical Vibrations" – Prentice Hall, New York, 1984.
- V. P. Singh, 'Mechanical Vibrations', Fourth Edition, Dhanpat Rai and Co., 2014.

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23C13.1 | 3 | 2 | 2 | 2 | - | - | - | - | - | - | - | 2 | 3 | - | 2 |
| AE23C13.2 | 3 | 3 | 2 | 3 | - | - | - | - | - | - | - | 2 | 3 | - | 2 |
| AE23C13.3 | 3 | 3 | 3 | 3 | - | - | - | - | - | - | - | 2 | 3 | - | 2 |
| AE23C13.4 | 3 | 3 | 3 | 2 | - | - | - | - | - | - | - | 2 | 3 | 3 | 3 |
| AE23C13.5 | 3 | 2 | 3 | 2 | - | - | - | - | - | - | - | 2 | 3 | - | 3 |
| Average | 3 | 2.6 | 2.6 | 2.4 | - | - | - | - | - | - | - | 2 | 3 | 3 | 2.4 |

| AE23C14 | FATIGUE AND FRACTURE | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| | | PE | 3 | 0 | 0 | 3 |

**OBJECTIVE**

- To understand the basic concepts involved in fatigue analysis and to study the importance of fracture mechanics in aerospace applications.

**UNIT I FATIGUE OF STRUCTURES** **7**

Kinds of Failure - S.N. curves - Endurance limits - 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** **7**

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

**UNIT IV FRACTURE MECHANICS** **13**

Strength of cracked bodies - Potential energy and surface energy - Griffith's theory – Energy Release Rate - Importance of R-curve in fracture mechanics – Critical Energy Release Rate – Stress Intensity Factor – Westergaard Approach – Relation between $G_I$ and $K_I$ - Irwin - Orwin extension of Griffith's theory to ductile materials -– Effective Crack Length - Effect of thickness on fracture toughness. Elastic – Plastic analysis through J-integral – CTOD.

**UNIT V FATIGUE DESIGN, TESTING AND NUMERICAL ANALYSIS OF FRACTURE** **10**

Safe life and Fail-safe design philosophies –Test Methods-FEM- Direct and indirect method to determine fracture parameters-Importance of Fracture Mechanics in aerospace structures.

**Total Contact Hours: 45**

**TEXTBOOKS**

1. Prasanth Kumar, "Elements of fracture mechanics", Wheeter publication, 1999.
2. Barrois W, Ripely, E.L., "Fatigue of aircraft structure," Pergamon press. Oxford, 1983.

**REFERENCES:**

1. Sih C.G., "Mechanics of fracture." Vol - I, Sijthoff and w Noordhoff International Publishing Co., Netherlands, 1989.
2. Knott, J.F., "Fundamentals of Fracture Mechanics," - Buterworth & Co., Ltd., London, 1983.
3. Kare Hellan ,'Introduction to Fracture Mechanics', McGraw Hill, Singapore,1985
4. D.Brock, "Elementary Engineering Fracture Mechanics", Noordhoff International PublishingCo., London, 1994.

After successful completion of the course students will demonstrate the following outcomes:

1.

| | |
|---|---|
| **AE23C14.1** | Apply mathematical knowledge to define fatigue behaviour |
| **AE23C14.2** | Apply concept of various theories to define fatigue behavior. |
| **AE23C14.3** | Compute the physical aspects of fatigue. |
| **AE23C14.4** | Analyze fracture due to fatigue |
| **AE23C14.5** | Perform fatigue design and testing |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| **AE23C14.1** | 3 | 2 | 2 | 2 | - | - | - | - | - | - | - | 2 | 3 | - | 2 |
| **AE23C14.2** | 3 | 3 | 2 | 3 | - | - | - | - | - | - | - | 2 | 3 | - | 2 |
| **AE23C14.3** | 3 | 3 | 3 | 3 | - | - | - | - | - | - | - | 2 | 3 | - | 2 |
| **AE23C14.4** | 3 | 3 | 3 | 2 | - | - | - | - | - | - | - | 2 | 3 | 3 | 3 |
| **AE19C14.5** | 3 | 2 | 3 | 2 | - | - | - | - | - | - | - | 2 | 3 | - | 3 |
| **Average** | 3 | 2.6 | 2.6 | 2.4 | - | - | - | - | - | - | - | 2 | 3 | 3 | 2.4 |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **AE23C15** | **THEORY OF PLATES AND SHELLS** | **PE** | **3** | **0** | **0** | **3** |

**Objectives:**

- Achieve fundamental understanding of the classical theory of elastic plates and shells
- Use analytical methods for the solution of thin plates
- Understand the dynamic behaviour of the plates
- Apply the numerical techniques for the complex problems in thin plates
- Use analytical methods for the solution of thin shells

**UNIT-I INTRODUCTION TO PLATE THEORY** 9

Classical Plate Theory – Assumptions – Differential Equation – Boundary Conditions – Kirchoff's Plate Theory

**UNIT-II PLATES OF VARIOUS SHADES** 9

Navier's Method of Solution for Simply Supported Rectangular Plates – Leavy's Method of Solution for Rectangular Plates under Different Boundary Conditions. Governing Equation – Solution for Axi-symmetric loading – Annular Plates – Plates of other shapes.

**UNIT-III EIGEN VALUE ANALYSIS** 9

Stability and free Vibration Analysis of Rectangular Plates.

**UNIT-IV APPROXIMATE METHODS** 9

Rayleigh – Ritz, Galerkin Methods– Finite Difference Method – Application to Rectangular Plates for Static, Free Vibration and Stability Analysis.

**UNIT-V SHELLS** 9

Basic Concepts of Shell Type of Structures – Membrane and Bending theories for Circular Cylindrical Shells.

**Total Contact Hours: 45**

**Course Outcomes:**

- Describe the governing equation for a rectangular plate
- Analyze under axi-symmetric loading, governing differential equation in polar co-ordinates.
- Demonstrate the vibrations of the plates and analyze the behaviour.
- Approximate methods of analysis- Rayleigh-Ritz approach for simple cases in rectangular plates.
- Understand the membrane theory of cylindrical shells

**SUGGESTED ACTIVITIES (if any)** (UNIT/ Module Wise) – Could suggest topic

- Problem solving sessions
- Flipped classroom - Comparing SOA with Client-Server and Distributed architectures
- Survey on various storage technologies
- Activity Based Learning
- Implementation of small module

**SUGGESTED EVALUATION METHODS (if Any)** (UNIT/ Module Wise) – could suggest topic

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

**Textbook(s):**

1. Timoshenko, S.P. Winowsky. S., and Kreger, "Theory of Plates and Shells", McGraw-Hill Book Co. 1990.
2. Varadan. T. K. and Bhaskar. K., "Theory of Plates and Shells", 1999, Narosa.

**Reference Books(s) / Web links:**

- Timoshenko, S.P. and Gere, J.M., "Theory of Elastic Stability", McGraw-Hill Book Co. 1986
- Ugural, A. C. Stresses in Plates and Shells. 2nd ed. New York, NY: McGraw-Hill, 1998.
- J. N. Reddy, "Theory and Analysis of Elastic Plates and Shells", CRC Press, 2006.

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23C15.1 | 1 | 1 | 1 | 1 | - | 1 | - | 1 | 1 | 1 | - | 1 | 2 | 3 | - |
| AE23C15.2 | 2 | 2 | 1 | 1 | - | 1 | - | 1 | 1 | 1 | - | 1 | 2 | 3 | - |
| AE23C15.3 | 2 | 1 | 1 | 1 | - | 1 | - | 1 | 1 | 1 | - | 1 | 2 | 2 | - |
| AE23C15.4 | 1 | 1 | 1 | 1 | - | 1 | - | 1 | 1 | 1 | - | 1 | 2 | 3 | - |
| AE23C15.5 | 1 | 1 | 1 | 1 | - | 1 | - | 1 | 1 | 1 | - | 2 | 1 | 3 | - |
| Average | 1.4 | 1.2 | 1 | 1 | - | 1 | - | 1 | 1 | 1 | - | 1.2 | 1.8 | 2.8 | - |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **AE23C16** | **AEROELASTICITY** | **PE** | **3** | **0** | **0** | **3** |

**Objectives:**

- Explain structural concepts such as elastic stiffness, inertia, influence coefficients, elastic axis, and shear center.
- Describe structural dynamics of wings, including bending and torsion modes of vibration and theirassociated natural frequencies.
- Apply aeroelastic concepts of divergence, flutter, lift and roll effectiveness, aileron reversal,and mode coalescence.
- Knowledge to formulate and derive static and dynamic aeroelastic equations of motion.
- To Apply Rayleigh-Ritz Method for Approximate continuous aeroelastic systems able to Interpret velocity-damping and velocity-frequency flutter diagrams.

**UNIT-I AERO ELASTICITY PHENOMENA 9**

Vibration of beams due to coupling between bending and torsion - The aero-elastic triangle of forces -Stability versus response problems — Aeroelasticity in Aircraft Design — Vortex induced vibration — Introduction to aero servo elasticity.

**UNIT-II DIVERGENCE OF A LIFTING SURFACE 9**

Simple two dimensional idealizations – Strip theory – Fredholm integral equation of the second kind – Exact solutions for simple rectangular wings – Semi rigid assumption and approximate solutions –Generalized coordinates – Successive approximations – Numerical approximations using matrix equations.

**UNIT-III STEADY STATE AEROELASTIC PROBLEMS 9**

Loss and reversal of aileron control – Critical aileron reversal speed – Aileron efficiency – Semi rigidtheory and successive approximations – Lift distributions – Rigid and elastic wings.

**UNIT-IV FLUTTER ANALYSIS 9**

Non-dimensional parameters – Stiffness criteria Dynamic mass balancing – Model experiments – Dimensional similarity – Flutter analysis – Two dimensional thin airfoils in steady incompressible flow Quasi steady aerodynamic derivatives – Galerkin's method for critical speed – Stability of distributedmotion – Torsion flexure flutter – Solution of the flutter determinant – Methods of determining the critical flutter speeds – Flutter prevention and control.

**UNIT-V EXAMPLES OF AEROELASTIC PROBLEMS 9**

Galloping of transmission lines and flow induced vibrations of tall slender structures and suspension bridges – Aircraft wing flutter- Vibrational problems in Helicopters.

**Total Contact Hours: 45**

**Course Outcomes:**

- Formulate and perform classical solutions of aeroelastic problems.
- Calculate divergence of a lifting surface in the aerospace vehicles.
- Formulate aeroelastic equations of motion and use them to derive fundamental relations foraeroelastic analysis.
- Analyze the static aeroelastic instabilities such as divergence, control surface reversal and flutter
- Analyze the aeroelastic problems in civil and mechanical engineering.

**SUGGESTED ACTIVITIES (if any)** (UNIT/ Module Wise) – Could suggest topic

- Problem solving sessions
- Flipped classroom - Comparing SOA with Client-Server and Distributed architectures
- Survey on various storage technologies
- Activity Based Learning
- Implementation of small module

**SUGGESTED EVALUATION METHODS (if Any)** (UNIT/ Module Wise) – could suggest topic

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

**Textbook(s):**

1. Fung, Y.C. An Introduction to the theory of Aeroelasticity, Dover Publications Inc., 2008.

2. Bisplinghoff., R.L. Ashley, H., and Halfman, R.L, "Aeroelasticity" Addison Wesley Publishing Co., Inc. II ed. 1996.

**Reference Books(s) / Web links:**

- Broadbent, E.G., Elementary Theory of Aeroelasticity, Bunhill Publications Ltd, 1986.
- Blevins R.D, "Flow induced vibrations", Krieger Pub Co; 2 Reprint editions, 2001.
- Scanlan, R.H. and Rosenbaum, R., Introduction to the Study of Aircraft Vibration and Flutter, Macmillan Co., N.Y., 1991.

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23C16,1 | 3 | 2 | 2 | 2 | - | - | - | - | - | - | - | 2 | 3 | - | 2 |
| AE23C16.2 | 3 | 3 | 2 | 3 | - | - | - | - | - | - | - | 2 | 3 | - | 2 |
| AE23C16.3 | 3 | 3 | 3 | 3 | - | - | - | - | - | - | - | 2 | 3 | - | 2 |
| AE23C16.4 | 3 | 3 | 3 | 2 | - | - | - | - | - | - | - | 2 | 3 | 3 | 3 |
| AE23C16.5 | 3 | 2 | 3 | 2 | - | - | - | - | - | - | - | 2 | 3 | - | 3 |
| Average | 3 | 2.6 | 2.6 | 2.4 | - | - | - | - | - | - | - | 2 | 3 | 3 | 2.4 |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **AE23C17** | **NON-DESTRUCTIVE EVALUATION** | **PE** | **3** | **0** | **0** | **3** |

**Objectives:**

- To impart knowledge on the fundamentals of nondestructive testing methods and techniques, aircraft inspection methodology using NDT methods
- To get insights into the basic aspects of electron microscopy
- To learn modern NDT techniques like acoustic emission, ultrasonic and thermographic testing methods.
- To inspect the aircraft structures using NDT techniques
- To get basic knowledge on the structural health monitoring of aerospace structures.

**UNIT-I INTRODUCTION** 9

Need for non-destructive evaluation (NDT) – NDT Versus Mechanical testing, Overview of the Non-Destructive Testing Methods for the detection of manufacturing defects as well as material characterisation – Structural deterioration due to corrosion and fatigue –Relative merits and limitations, Various physical characteristics of materials and their applications in NDT - Visual inspection – Unaided and aided - Aircraft wing and fuselage inspection using various NDT techniques

**UNIT-II ELECTRON MICROSCOPY** 9

Fundamentals of optics – Optical microscope and its instrumental details – Variants in the optical microscopes and image formation – Polarization light effect – Sample preparation and applications of optical microscopes – Introduction to Scanning electron microscopy (SEM) – Instrumental details and image formation of SEM – Introduction to transmission electron microscopy (TEM) – Imaging techniques and spectroscopy – Sample preparation for SEM and TEM

**UNIT-III ACOUSTIC EMISSION AND ULTRASONICS** 9

Sources of acoustic emission – Physical principals involving acoustic emission and ultrasonics – Configuration of ultrasonic sensors – Phased array ultrasonics – Instrument parts and features for acoustic emission and ultrasonics – Defect characterization – Inspection of cracks and other flaws in metals and composites – Interpretation of data – Image processing – Concepts and application

**UNIT-IV AIRCRAFT INSPECTION** 9

Inspection Levels – General Visual Inspection – During pre, or post flight – Detailed Visual Inspection (DET) – Periodic inspection – Special Detailed Inspection (SDET) – Uses of NDT Methods - Comparison of different methods of NDT – Visual – Radiography – Eddy Current Testing – Liquid Penetrant Testing – Remote Testing - Landing Gear Inspection

**UNIT-V STRUCTURAL HEALTH MONITORING** 9

An Overview of Structural Health Monitoring – Structural Health Monitoring and Role of Smart Materials – Structural Health Monitoring versus Non-Destructive Evaluation – A Broad Overview of Smart Materials Applications – Notable Applications of SHM in Aerospace Engineering – Structural health monitoring of composites – Repair investigation using SHM – Current limits and future trends.

**Total Contact Hours: 45**

**Course Outcomes:**

- To realize the importance of various NDT techniques
- To identify suitable NDT technique for a particular application.
- To demonstrate the physical principles involved in acoustic emission and ultrasonics.
- To have knowledge on the physical principles involved in the various other techniques of NDT.
- To realise the state-of-the-art in NDT testing and structural health monitoring.

**SUGGESTED ACTIVITIES (if any)**

- Flipped classroom
- Activity Based Learning

**SUGGESTED EVALUATION METHODS (if Any)**

- Class Presentation/Discussion

**Textbook(s):**

1. J Prasad, C G K Nair, "Non-Destructive Testing and Evaluation of Materials", Tata McGraw Hill Education Private Limited
2. Baldev Raj, T.Jayakumar, M.Thavasimuthu Practical Non-Destructive Testing, Narosa Publishing House, 2014.
3. Douglas B. Murphy, "Fundamentals of light microscopy and electronic imaging", Wiley-Liss, Inc. USA, 2001.

**Reference Books(s) / Web links:**

- ASM Metals Handbook, "Non-Destructive Evaluation and Quality Control", Volume-17 American Society of Metals, Metals Park, Ohio, USA, 2000
- Handbook of Non-Destructive evaluation Charles, J. Hellier McGraw Hill, New York 2001
- Douglas E Adams, "Health Monitoring of Structural Materials and Components-Methods with Applications", John Wiley and Sons, 2007.

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23C17.1 | 3 | 3 | 2 | 1 | - | - | - | - | 1 | 1 | - | 1 | 3 | 1 | - |
| AE23C17.2 | 3 | 3 | 2 | 2 | - | - | - | - | 1 | 1 | - | 1 | 3 | 1 | - |
| AE23C17.3 | 3 | 3 | 2 | 2 | - | - | - | - | 1 | 1 | - | 1 | 3 | 1 | - |
| AE23C17.4 | 3 | 2 | 2 | 1 | - | - | - | - | 1 | 1 | - | 1 | 3 | 1 | - |
| AE23C17.5 | 3 | 3 | 3 | 2 | - | - | - | - | 1 | 1 | - | 1 | 3 | 1 | - |
| Average | 3 | 2.8 | 2.2 | 1.6 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 3 | 1 | 0 |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **AE23C18** | **EXPERIMENTAL STRESS ANALYSIS** | **PE** | **3** | **0** | **0** | **3** |

**OBJECTIVES**

- To study the various experimental techniques involved for measuring displacements, stresses, strains in structural components.

**UNIT I EXTENSOMETERS AND DISPLACEMENT SENSORS 8**

Principles of measurements, Accuracy, Sensitivity and range of measurements, Mechanical, Optical, Acoustical and Electrical extensometers and their uses, Advantages and disadvantages**,** Capacitance gauges, Laser displacement sensors.

**UNIT II ELECTRICAL RESISTANCE STRAIN GAUGES 12**

Principle of operation and requirements, Types and their uses, Materials for strain gauges, Calibration and temperature compensation, cross sensitivity, Wheatstone bridge and potentiometer circuits for static and dynamic strain measurements, strain indicators, Rosette analysis, stress gauges, load cells, Data acquisition, six component balance.

**UNIT III PHOTOELASTICITY 11**

Two dimensional photo elasticity, Photo elastic materials, Concept of light - photoelastic effects, stress optic law, Transmission photoelasticity, Jones calculus, plane and circular polariscopes, Interpretation of fringe pattern, Calibration of photoelastic materials, Compensation and separation techniques, Introduction to three dimensional photo elasticity.

**UNIT IV BRITTLE COATING AND MOIRE TECHNIQUES 7**

Introduction to Brittle Coating - Relation between stresses in coating and specimen, use of failure theories in brittle coating, Moire method of strain analysis.

**UNIT V NON – DESTRUCTIVE TESTING 7**

Fundamentals of NDT, Acoustic Emission Technique, Radiography, Thermography, Ultrasonics, Eddy Current testing, Fluorescent Penetrant Testing,

**Total Contact Hours:45**

**TEXTBOOKS**

1. Dally, J.W., and Riley, W.F., "Experimental Stress Analysis", McGraw Hill Inc., New York 1998.
2. Srinath, L.S., Raghava, M.R., Lingaiah, K., Garagesha, G., Pant B., and Ramachandra, K., "Experimental Stress Analysis", Tata McGraw Hill, New Delhi, 1984.
3. Sadhu Singh, "Experimental Stress Analysis", Khanna Publishers, New Delhi, 1996.

**REFERENCES**

1. Hetenyi, M., "Hand book of Experimental Stress Analysis", John Wiley and Sons Inc., New York, 1972.
2. Pollock A.A., Acoustic Emission in Acoustics and Vibration Progress, Ed. Stephens R.W.B., Chapman and Hall,1993.
3. Max Mark Frocht, "Photo Elasticity", John Wiley and Sons Inc., New York, 1968
4. Durelli. A.J., "Applied Stress Analysis", Prentice Hall of India Pvt Ltd., New Delhi, 1970
5. Ramesh, K., Digital Photoelasticity, Springer, New York, 2000.

After successful completion of the course students will demonstrate the following outcomes:

**AE23C18.1** Able to distinguish various types of principles in strain and stress measurement.
**AE23C18.2** Able to analyze various electrical resistance strain gauges and its applications
**AE23C18.3** Able to acquire knowledge on photoelastic techniques
**AE23C18.4** Able to use brittle coating and moire fringe methods
**AE23C18.5** Familiarized to various techniques on non-destructive testing

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23C18.1 | 1 | 1 | 1 | 1 | - | 1 | - | 1 | 1 | 1 | - | 1 | 2 | 3 | - |
| AE23C18.2 | 2 | 2 | 1 | 1 | - | 1 | - | 1 | 1 | 1 | - | 1 | 2 | 3 | - |
| AE23C18.3 | 2 | 1 | 1 | 1 | - | 1 | - | 1 | 1 | 1 | - | 1 | 2 | 2 | - |
| AE23C18.4 | 1 | 1 | 1 | 1 | - | 1 | - | 1 | 1 | 1 | - | 1 | 2 | 3 | - |
| AE23C18.5 | 1 | 1 | 1 | 1 | - | 1 | - | 1 | 1 | 1 | - | 2 | 1 | 3 | - |
| Average | 1.4 | 1.2 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1.2 | 1.8 | 2.8 | 0 |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **AE23C19** | **MATERIALS TESTING AND CHARACTERIZATION TECHNIQUES** | **PE** | **3** | **0** | **0** | **3** |

## OBJECTIVE:

(1) Make them acquainted with microscopic techniques to analyse crystal structures
(2) Acquire an understanding on the electron microscopic techniques for characterization
(3) Gain a fundamental on chemical and thermal analysis
(4) Provide the knowledge on various static methods to characterize materials
(5) Study the failure of materials under stress

## UNIT I MICRO AND CRYSTAL STRUCTURE ANALYSIS 9

Principles of Optical Microscopy – Specimen Preparation Techniques – Polishing and Etching – Polarization Techniques – Quantitative Metallography – Estimation of grain size – ASTM grain size numbers – Microstructure of Engineering Materials - Elements of Crystallography – X- ray Diffraction – Bragg's law – Techniques of X-ray Crystallography – Debye – Scherer camera – Geiger Diffractometer – analysis of Diffraction patterns – Inter planer spacing – Identification of Crystal Structure, Elements of Electron Diffraction.

## UNIT II ELECTRON MICROSCOPY 9

Interaction of Electron Beam with Materials – Transmission Electron Microscopy – Specimen Preparation – Imaging Techniques – BF & DF – SAD – Electron Probe Microanalysis – Scanning Electron Microscopy – Construction & working of SEM – various Imaging Techniques – Applications. Atomic Force Microscopy- Construction & working of AFM - Applications.

## UNIT III CHEMICAL AND THERMAL ANALYSIS 9

Basic Principles, Practice and Applications of X-Ray Spectrometry, Wave Dispersive X-Ray Spectrometry, Auger Spectroscopy, Secondary Ion Mass Spectroscopy, Fourier Transform Infra-Red Spectroscopy (FTIR)- Proton Induced X-Ray Emission Spectroscopy, Differential Thermal Analysis, Differential Scanning Calorimetry (DSC) And Thermo-Gravitymetric Analysis (TGA)

## UNIT IV MECHANICAL TESTING – STATIC TESTS 9

Hardness – Brinell, Vickers, Rockwell and Micro Hardness Test – Tensile Test – Stress – Strain plot – Proof Stress – Torsion Test - Ductility Measurement – Impact Test – Charpy & Izod – DWTT - Fracture Toughness Test, Codes and standards for testing metallic and composite materials.

## UNIT V MECHANICAL TESTING – DYNAMIC TESTS 9

Creep Tests – LM parameters – AE Tests-modal analysis - Applications of Dynamic Tests.

**Total Contact Hours: 45**

## OUTCOMES:

1) At the end of this course the students are expected
2) to be knowledgeable in microstructure evaluation, crystal structure analysis,
3) to take images in electron microscopy and process those images,
4) to do Chemical Thermal Analysis,
5) Analyse the results of static and dynamic mechanical testing.

**TEXTBOOK(S)**

1. ASM Handbook-Materials characterization, Vol – 10, 2004.
2. Culity B.D., Stock S.R& Stock S., Elements of X ray Diffraction, (3rd Edition). Prentice Hall, 2001.

**REFERENCES:**

1. Davis J. R., Tensile Testing, 2nd Edition, ASM International, 2004.
2. Davis, H.E., Hauck G. & Troxell G.E., The Testing of engineering Materials, (4th Edition), McGraw Hill, College Divn., 1982.
3. Dieter G.E., Mechanical Metallurgy, (3rd Edition), ISBN: 0070168938, McGraw Hill, 1988.
4. Goldsten,I.J., Dale.E., Echin.N.P.& Joy D.C., Scanning Electron Microscopy & X ray-Micro Analysis, (2nd Edition), ISBN – 0306441756, Plenum Publishing Corp., 2000.
5. Grundy P.J. and Jones G.A., Electron Microscopy in the Study of Materials, Edward Arnold Limited, 1976.
6. Morita.S, Wiesendanger.R, and Meyer.E, "Non-contact Atomic Force Microscopy" Springer, 2002
7. Newby J., Metals Hand Book- Metallography & Micro Structures, (9th Edition), ASM International, 1989.
8. Suryanarayana A. V. K., Testing of metallic materials, (2nd Edition), BS publications, 2007

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23C19.1 | 1 | 1 | 1 | 1 | - | 1 | - | 1 | 1 | 1 | - | 1 | 2 | 3 | - |
| AE23C19.2 | 2 | 2 | 1 | 1 | - | 1 | - | 1 | 1 | 1 | - | 1 | 2 | 3 | - |
| AE23C19.3 | 2 | 1 | 1 | 1 | - | 1 | - | 1 | 1 | 1 | - | 1 | 2 | 2 | - |
| AE23C19.4 | 1 | 1 | 1 | 1 | - | 1 | - | 1 | 1 | 1 | - | 1 | 2 | 3 | - |
| AE23C19.5 | 1 | 1 | 1 | 1 | - | 1 | - | 1 | 1 | 1 | - | 2 | 1 | 3 | - |
| Average | 1.4 | 1.2 | 1 | 1 | - | 1 | - | 1 | 1 | 1 | - | 1.2 | 1.8 | 2.8 | - |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| AE23D11 | **FUNDAMENTALS OF UAV SYSTEMS AND DESIGN** | PE | 3 | 0 | 0 | 3 |

**Objectives:** To make the students to understand the basic concepts of UAV systems and design

- To create awareness on classification and application of UAV
- To study the process of UAV sizing.
- To analyse the principles of UAV system design
- To study about the payloads and communication systems in UAV
- To understand the importance of ground control station

**UNIT-I UAV CONFIGURATIONS** **9**

History of UAV - Overview of UAS - UAV categories & Classification - Military and Civilian Unmanned Aircraft – Applications- naval - army- air force – civilian & commercial role.

**UNIT-II UAV SIZING** **9**

UAV Geometry & configuration- Aerodynamics- structures- propulsion system – flight performance – Case Study.

**UNIT-III UAV SYSTEM DESIGN** **9**

Fundamental of autopilot – control system design – navigation system design- Guidance system design – microcontroller.

**UNIT-IV UAV COMMUNICATION AND PAYLOAD** **9**

Launch and recovery system - payload selection - Surveillance Payloads - Weapon Payloads - Other Payloads - Communication Systems -case study.

**UNIT-V MISSION PLANNING AND CONTROL** **9**

Ground control station – Mission system integration - Command, Control, Tasking, Processing, Exploitation, and Dissemination - UAS future & challenges.

**Total Contact Hours:45**

**Course Outcomes:** Students will be able to

- Distinguish the various types of UAV and its applications
- Design the preliminary geometry sizing of UAV
- Understand the concept of UAV system Design
- Familiarize the various types of launch and recovery techniques
- Understand the function of and task of ground control station

**SUGGESTED ACTIVITIES**

- Flipped classroom
- Activity Based Learning

**SUGGESTED EVALUATION METHODS**

- Quizzes
- Class Presentation/Discussion

**Textbook(s):**


10. Jay Gundlach “Designing Unmanned Aircraft Systems: A comprehensive approach”, second edition, AIAA education series July 2014
11. Mohammed Sadraey “Unmanned Aircraft Design, a review of fundamentals” Morgan & Claypool, First edition, publications July 2017
12. Paul Gerin Fahlstrom and Thomas James Gleason “Introduction to UAV systems”, Fourth edition, A john Wiley & sons’ ltd publications, 2012


**Reference Books(s) / Web links:**


- Kimon P. Valavanis and George J. Vachtsevano “Handbook of Unmanned Aerial Vehicles”, first edition, Springer reference, 2015
- Reg Austin “Unmanned Aircraft Systems UAV design, development and deployment”, First edition, A john Wiley & sons’ ltd publications, 2010
- Dr. Mohammed Sadraey “Design of Unmanned Aerial Systems”, First edition, A john Wiley & sons’ ltd publications,2020


| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23D11.1 | 3 | 1 | 1 | 2 | | | 3 | 2 | 2 | 1 | | | 1 | | 2 |
| AE23D11.2 | 2 | - | - | | 1 | 1 | 1 | 2 | | | 1 | | 3 | | 1 |
| AE23D11.3 | 2 | 3 | 1 | | | 1 | | 1 | 2 | | 1 | 2 | 2 | | 1 |
| AE23D11.4 | 3 | 2 | - | - | | 1 | 2 | 2 | 1 | 1 | 2 | | | 1 | |
| AE23D11.5 | 2 | - | 1 | 1 | 1 | | | | 1 | | 1 | 2 | | 2 | |
| Average | 2.4 | 1.2 | 0.6 | 0.6 | 0.4 | 0.6 | 1.2 | 1.4 | 1.2 | 0.4 | 1 | 0.8 | 1.2 | 0.6 | 0.8 |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **AE23D12** | **DRONE COMPUTING SYSTEMS** | PE | 3 | 0 | 0 | 3 |

**Objectives:** To make the students to understand the integration of flight control boards in drone

- To create awareness about the function of autonomous UAV
- To study the process of UAV Path planning.
- To analyse the principles of collision avoidance and mission planning
- To study about the different types of drone control components
- To understand the importance of drone computing boards

**UNIT-I AUTONOMOUS UAV** 9

Introduction- Autonomous UAVs in civil application - Fundamental Modelling of Small and Miniature Helicopters- Control System Design of Small Unmanned Helicopter -Experimental setup- Autonomous Control of a Mini Quadrotor Vehicle - Experimental setup- Modelling and Controller Design - Development of Autonomous Quad-Tilt-Wing- Linearization and Identification of Helicopter Model.

**UNIT-II UAV PATH PLANNING** 9

Path Planning Formulation- Path Planning Constraints- Cooperative Path Planning and Mission Planning- The Road Map Method - Path Planning in Two Dimensions - Path Planning in Three Dimensions

**UNIT-III UAV COLLISION AVIODANCE** 9

Collision Avoidance - Obstacle Avoidance for Mapped Obstacles - Obstacle Avoidance of Unmapped Static Obstacles - Algorithmic Implementation – Path Following Guidance - Path Planning for Multiple UAVs

**UNIT-IV DRONE CONTROL COMPONENTS** 9

Flight controller- GPS- Gyro and compass- Receiver and transmitter- telemetry – PCB- propulsion components - servos- actuators- cameras- payloads-case studies

**UNIT-V DRONE COMPUTING BOARDS** 9

Overview, specifications and connector block diagrams of Flight control boards: Arduino board - Ardupilot board- Pixhawk board- DJI Flight Controllers - Navio2– raspberry pi- case study.

**Total Contact Hours:45**

**Course Outcomes:** Students will be able to

- Distinguish the various types of function of autonomous UAV
- Understand the process of UAV Path planning.
- Understand the principles of collision avoidance and mission planning
- Familiarize about the different types drone control components
- Understand the importance of drone computing boards

**SUGGESTED ACTIVITIES**

- Flipped classroom
- Activity Based Learning

**SUGGESTED EVALUATION METHODS**

- Quizzes
- Class Presentation/Discussion

**Textbook(s):**

1. Kenzo Nonami , Farid Kendoul and Satoshi Suzuki "Autonomous Flying Robots, Unmanned Aerial Vehicles and Micro Aerial Vehicles" springer publications, first edition 2010

2. Antonios Tsourdos, Brian White and Madhavan Shanmugavel "Cooperative Path Planning of Unmanned Aerial Vehicles", John Wiley & Sons, Ltd, 2011

3. Gareth Halfacree ,"the official raspberry pi beginner's guide", second edition Raspberry Pi Trading Ltd, 2019

**Reference Books(s) / Web links:**

- John Baichtal "Building Your Own Drones: A Beginners' Guide to Drones, UAVs, and ROVs" Que Publishing, second edition 2016.
- David McGriffy "Make: Drones", first edition, Make: Drones, 2017.
- Quan quan, Xunhua Dai, Shuai Wang "Multicopter design and control practice, A series experiments based on MATLAB and Pixhawk", first edition springer publication, 2020

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23D12.1 | 3 | 1 | 1 | 2 | | | 3 | 2 | 2 | 1 | | | 1 | | 2 |
| AE23D12.2 | 2 | - | - | | 1 | 1 | 1 | 2 | | | 1 | | 3 | | 1 |
| AE23D12.3 | 2 | 3 | 1 | | | 1 | | 1 | 2 | | 1 | 2 | 2 | | 1 |
| AE23D12.4 | 3 | 2 | - | - | | 1 | 2 | 2 | 1 | 1 | 2 | | | 1 | |
| AE23D12.5 | 2 | - | 1 | 1 | 1 | | | | 1 | | 1 | 2 | | 2 | |
| Average | 2.4 | 1.2 | 0.6 | 0.6 | 0.4 | 0.6 | 1.2 | 1.4 | 1.2 | 0.4 | 1 | 0.8 | 1.2 | 0.6 | 0.8 |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| AE23D13 | ELECTRONIC WARFARE | PE | 3 | 0 | 0 | 3 |

OBJECTIVES:

- To introduce principles of electronic warfare, electronic support measure and Electronic counter measures
- To study the Radar Warning Receivers trends in display technology
- To identify the Radar detection performance low RCS aircraft
- To know EM sensor subsystem, Mile parameter tracking
- To study electronic counter - counter measures (ECCM)

**UNIT I ELECTRONIC WARFARE PRINCIPLES AND RADAR** **9**

Electronic Warfare taxonomy-EW Mission and scenarios – Basic principles of Radar – Radar Equations – Types

**UNIT II ELECTRONIC SUPPORT MEASURE RECEIVERS - ELECTRONIC COUNTER MEASURES** **9**

Radar Warning Receivers (RWR) - Passive direction finding and emitter - location - noise jamming Deception Electronic Counter Measures (DECM) - Modern ECM systems.

**UNIT III RADAR AND ECM PERFORMANCE ANALYSIS** **9**

Radar detection performance low RCS aircraft - ECM - Jamming equations - EW receiver Sensitivity

**UNIT IV EW SIGNAL PROCESSING** **9**

Signal environment - EM sensor subsystem - The receiver subsystem - The pre-processor the data servo loop - Mile parameter tracking - Advanced pulley power - Managed Jamming.

**UNIT V ELECTRONIC COUNTER - COUNTER MEASURES (ECCM)** **9**

Radar applications in weapon systems - Radar types and characteristics, EW Technology and Future Trends - Antenna Technology - ECM transmitter power source technology - EW receiver technology - EW at millimeter Wavelength - Low Observability EW technology.

**Total Contact Hours: 45**

**OUTCOMES:**

Students will be able to:

CO1: Explain the importance and advantages of electronic warfare
CO2: Explain the electronic support measure and electronic counter measures
CO3: Do the performance analysis of Radar detection
CO4: Demonstrate the receiver subsystem, the pre-processor and the data servo loop - Mile parameter tracking
CO5: Explain system assessment, counter measures (ECCM)

**SUGGESTED ACTIVITIES**

- Flipped classroom
- Activity Based Learning
- Reinforced learning

**SUGGESTED EVALUATION METHODS**

- Assignment problems
- Quizzes
- Class Presentation/Discussion

TEXTBOOKS:

1. Curtis Schleher. D. — 'Introduction to Electronic Warfare', Artech House Inc., U.S.A., 1986

2. Mario De Archnaelis, —Electronic War from Battle of Osushima to the Falklands and Lebanon Conflicts, Ritana Books, New Delhi, 1990.

REFERENCES:

1. Sen, A.K. Bhattacharya, A.B. —Radar Systems & Radar Aids to Navigation, Khanna Publishers,1988

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| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23D13.1 | 3 | 1 | 1 | 2 | | | 3 | 2 | 2 | 1 | | | 1 | | 2 |
| AE23D13.2 | 2 | - | - | | 1 | 1 | 1 | 2 | | | 1 | | 3 | | 1 |
| AE23D13.3 | 2 | 3 | 1 | | | 1 | | 1 | 2 | | 1 | 2 | 2 | | 1 |
| AE23D13.4 | 3 | 2 | - | - | | 1 | 2 | 2 | 1 | 1 | 2 | | | 1 | |
| AE23D13.5 | 2 | - | 1 | 1 | 1 | | | | 1 | | 1 | 2 | | 2 | |
| Average | 2.4 | 1.2 | 0.6 | 0.6 | 0.4 | 0.6 | 1.2 | 1.4 | 1.2 | 0.4 | 1 | 0.8 | 1.2 | 0.6 | 0.8 |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| AE23D14 | EMBEDDED SYSTEMS IN UAV | PE | 3 | 0 | 0 | 3 |

**Objectives:** To understand the basic of embedded system and its software and hardware implementation

- Introduce the basic of embedded system
- Provide knowledge about the types of hardware used in embedded system
- Impart knowledge about real time operating system
- Provide knowledge about Integration and Testing of Embedded Hardware and Firmware
- Educate about the Embedded application in UAV

**UNIT-I INTRODUCTION TO EMBEDDED SYSTEMS** 9

Introduction to computer and electronics – Introduction to embedded system – embedded system architecture – process of embedded system development – typical embedded system – Characteristics and Quality Attributes of Embedded Systems

**UNIT-II EMBEDDED HARDWARE** 9

Terminology – Gates – board Memory – board buses - microcontroller – direct memory access- interrupts- basic hardware material – analog electronic components- digital electronic components - semiconductors- building block of processor and memory – integrated circuits – PCB layout design

**UNIT-III REAL TIME OPERATING SYSTEM** 9

Embedded firmware design and development - Introduction to RTOS - Operating systems concepts – types – multiprocessing and multi-tasking – task scheduling - Task Communication- task Synchronisation - Choose an RTOS- case study

**UNIT-IV INTEGRATION AND TESTING OF EMBEDDED SYSTEM** 9

Integration and Testing of Embedded Hardware and Firmware – Embedded software development tools – debugging techniques - The Embedded System Development Environment - Integrated Development Environment - Types of Files Generated on Cross-Compilation - Simulators, Emulators and Debugging- target Hardware Debugging - product Enclosure Design and Development - Implementing the Design

**UNIT-V EMBEDDED APPLICATION IN UAV** 9

Drones in delivering mail, parcels and other cargo- Drones in agriculture- Drones in inspection of transmission lines and power distribution -Drones in filming and panoramic picturing- SWARM UAV- Case studies

**Total Contact Hours:45**

**Course Outcomes:** The students are able to

- Understand the basic of embedded system
- Differentiate the types of hardware used in embedded system
- Understand about real time operating system
- Analysis the Integration and Testing of Embedded Hardware and Firmware
- Apply Embedded application in UAV

**SUGGESTED ACTIVITIES**

- Flipped classroom
- Activity Based Learning

**SUGGESTED EVALUATION METHODS**

- Quizzes
- Class Presentation/Discussion

**Textbook(s):**

1. Tommy Noergaard “Embedded system Architecture A comprehensive guide for Engineers and programmers” Elsevier publication, 2005
2. David E Simon “An Embedded software primer” Addison Wesley, 14th edition 2005
3. Shibu kizhakke vallathai “Introduction to embedded systems”, McGraw Hill Education (India) Private Limited, 1st edition 2017

**Reference Books(s) / Web links:**

- J. W. Valvano, “Embedded Systems: Real-Time Interfacing to ARM ® Cortex TM-M Microcontrollers” , ARM Limited,4th edition 2014
- E. A. Lee and S. A. Seshia, Introduction to Embedded Systems - A Cyber-Physical Systems Approach, Second Edition, MIT Press, 2017
- Michael Barr and Anthony Massa, “Programming Embedded Systems: With C and GNU Development Tools” 2nd edition, O'Reilly Media, Inc.", 2006

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| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23D14.1 | 3 | 1 | 1 | 2 | | | 3 | 2 | 2 | 1 | | | 1 | | 2 |
| AE23D14.2 | 2 | - | - | | 1 | 1 | 1 | 2 | | | 1 | | 3 | | 1 |
| AE23D14.3 | 2 | 3 | 1 | | | 1 | | 1 | 2 | | 1 | 2 | 2 | | 1 |
| AE23D14.4 | 3 | 2 | - | - | | 1 | 2 | 2 | 1 | 1 | 2 | | | 1 | |
| AE23D14.5 | 2 | - | 1 | 1 | 1 | | | | 1 | | 1 | 2 | | 2 | |
| Average | 2.4 | 1.2 | 0.6 | 0.6 | 0.4 | 0.6 | 1.2 | 1.4 | 1.2 | 0.4 | 1 | 0.8 | 1.2 | 0.6 | 0.8 |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
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| AE23D15 | **IMAGE PROCESSING TECHNIQUES FOR UAV** | PE | 3 | 0 | 0 | 3 |

**Objectives:** To understand the basic of Image processing techniques and its application using UAV

- To introduce fundamentals of image processing
- Provide knowledge about the different image processing segments
- To introduce the detail concept about the image enhancement and filtration
- To introduce fundamentals of drone imagery and data
- To expose students about to application of drone imagery and data

**UNIT-I FUNDAMENTALS OF IMAGE PROCESSING** 9

Introduction – fundamental steps in digital image processing- components - Digital image fundamentals – element of visual perception - light and electromagnetic spectrum - image sensing and acquisition – image sampling and quantization – pixels - Introduction to mathematical tools- Machine Vision Inspection.

**UNIT-II IMAGE PROCESSING SEGMENTS** 9

Image perception – light, luminance- MTF of visual system – visibility function – monochrome – colour representation - matching – coordinate system – measures- vision model- properties – image sampling and quantization – 2D sample theory – Extension – partial limitations in sampling – optimum mean square – compandor design - image transform.

**UNIT-III IMAGE ENHANCEMENT AND FILTERATION** 9

Point operations – histogram modelling – spatial operations – transform operations- multispectral image enhancement – image filtering and restoration – image observation models – types of filtering- Digital Processing of Speckle Images - Extrapolation of Bandlimited Signals -

**UNIT-IV DRONE IMAGERY AND DATA** 9

Introduction to Capturing and Processing Drone Imagery and Data - Drone Remote Sensing and Photogrammetry - Choosing a Sensor for UAS Imagery Collection - Mission Planning for Capturing UAS Imagery - Structure from Motion Workflow for Processing Drone Imagery- Aerial Cinematography with UAS - Planning Unoccupied Aircraft Systems Missions - Aligning and Stitching Drone-Captured Images.

**UNIT-V APPLICATIONS USING DRONE IMAGERY AND DATA** 9

Counting Wildlife from Drone-Captured Imagery- Terrain and Surface Modelling - Assessing the Accuracy of Digital Surface Models - Estimating Forage Mass from UAS- Applications of UAS-Derived Terrain Data- Comparing UAS and Terrestrial Laser Scanning Methods - Identifying Burial Mounds and Enclosures - Detecting Scales of Drone - Assessing the Greenhouse Gas.

**Total Contact Hours:45**

**Course Outcomes:** The students are able to

- Understand the fundamentals of image processing
- Differentiate the different types of image processing segments and 2D sampling theory
- Understand the concept about the image enhancement and filtration
- Study about the drone imagery and date concepts using image processing
- Apply image processing application in UAV

**SUGGESTED ACTIVITIES**

- Flipped classroom
- Activity Based Learning

**SUGGESTED EVALUATION METHODS**

- Quizzes
- Class Presentation/Discussion

**Textbook(s):**

1. Anil k Jain ‘Fundamentals of Digital Image Processing” Pearson publication, 1989
2. Amy E. Frazier and Kunwar K. Singh “Fundamentals of Capturing and Processing Drone Imagery and Data” CRC press, first edition 2021

**Reference Books(s) / Web links:**

- Rafael C. Gonzalez and Richard E. Woods “Digital image processing” , Pearson publications,2018
- Alexander Hornberg “Handbook of Machine and Computer Vision, the Guide for Developers and Users” second edition, Wiley publication,2017
- Rafael C Gonzalez and Richard E Woods “Digital image processing using MATLAB”, Second edition, Gatesmark publication, 2009

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23D15.1 | 3 | 1 | 1 | 2 | | | 3 | 2 | 2 | 1 | | | 1 | | 2 |
| AE23D15.2 | 2 | - | - | | 1 | 1 | 1 | 2 | | | 1 | | 3 | | 1 |
| AE23D15.3 | 2 | 3 | 1 | | | 1 | | 1 | 2 | | 1 | 2 | 2 | | 1 |
| AE23D15.4 | 3 | 2 | - | - | | 1 | 2 | 2 | 1 | 1 | 2 | | | 1 | |
| AE23D15.5 | 2 | - | 1 | 1 | 1 | | | | 1 | | 1 | 2 | | 2 | |
| Average | 2.4 | 1.2 | 0.6 | 0.6 | 0.4 | 0.6 | 1.2 | 1.4 | 1.2 | 0.4 | 1 | 0.8 | 1.2 | 0.6 | 0.8 |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **AE23D16** | **DRONE SAFETY RULES AND REGULATIONS** | **PE** | 3 | 0 | 0 | 3 |

**Objectives:** To make the students to understand the national and international drone safety rules and regulations

- To create awareness on drone safety rules and regulations in India
- To study the process of RPAS certifications
- To analyse the drone safety regulation and traffic management
- To study about the Drone rules in DGCA, India
- To understand the importance of international drone safety and regulations

**UNIT-I REMOTELY PILOTED AIRCRAFT SYSTEM RULES** 9

DGCA- Digital sky – DGCA RPAS- Acquisition of RPAS - Unique Identification Number - Unmanned Aircraft Operator Permit - RPAS Operation - Remote Pilot & Training - Manufacturing of RPAS - NPNT Specifications - Procedure for acceptance of RPAS model for Digital Sky - Authorisation procedures for operations of RPAS- SOP Approval Procedure for RPAS.

**UNIT-II REMOTELY PILOTED AIRCRAFT SYSTEM CERTIFICATION** 9

Certification criteria for RPAS – objective and scope- competence requirement – General – Performance – Powerplant – Structure- Material and Construction - Data Link - Digital Sky NPNT- instruments - Qualification Testing - Documentation

**UNIT-III DGCA SAFTY REGULATION & TRAFFIC MANAGEMENT** 9

Establishment of a Safety Management System – APPLICABILITY- ALoSP - SMS framework - safety policy and objectives - Safety Accountabilities and Responsibilities - Appointment of Key Safety Personnel - Coordination of Emergency Response Planning – Documentation- UAS TRAFFIC Management - UTM services - UTM participation - real-time identification and tracking - UTM data communication, security and privacy - Integration of UTM - UTM deployment plan.

**UNIT-IV DRONE RULES DGCA** 9

Drone rules 2021- Possible Modes of Impact Damage on Failure- Limits - guidelines for flight testing - flight test schedule and checklist – stages -flight module compliance levels - certification process - requirements for certification bodies - resource requirements – process requirement – document requirements - rules for use of certification mark- provisional approval system for certification bodies

**UNIT-V INTERNATIONAL DRONE REGULATIONS** 9

Remote Identification of Unmanned Aircraft - Moored Balloons, Kites, Amateur Rockets, and Unmanned Free Balloons - Ultralight Vehicles - Parachute Operations- Small Unmanned Aircraft Systems.

**Total Contact Hours:45**

**Course Outcomes:** Students will be able to

- Understand the drone safety rules and regulations in India
- Familiarise the process of RPAS certifications
- Understand the drone safety regulation and traffic management
- Study about the Drone rules in DGCA, India
- Understand the importance of international drone safety and regulations

**SUGGESTED ACTIVITIES**

- Flipped classroom

**SUGGESTED EVALUATION METHODS**

- Quizzes
- Class Presentation/Discussion

**Textbook(s):**

13. "DGCA RPAS Guidance manual", DGCA, CAR Section 3 SERIES X, PART 1, 2020. & CAR Section 1 , Series C Part 1, 2017
14. DGCA "Drone rule 2021", Part II , Section 3, 2021
15. Code of federal regulation title 14 chapter 1, subchapter F, part 89,91,101,103,105,107

**Reference Books(s) / Web links:**

- "Unmanned Aircraft Systems (UAS)", cir 328, AN/190International Civil Aviation Organization, Canada, 2021
- John Baichtal "Building Your Own Drones: A Beginners' Guide to Drones, UAVs, and ROVs" Que Publishing, second edition 2016

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| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23D16.1 | 3 | 2 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23D16.2 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23D163 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23D16.4 | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| AE23D16.5 | 3 | 2 | 2 | - | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| Average | 3 | 2 | 2 | 1 | 1.8 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
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| AE23D17 | **FAULT TOLERANT CONTROL** | PE | 3 | 0 | 0 | 3 |

## OBJECTIVES:

- Study the fundamental concepts of fault tolerance and its significance in engineering systems.
- Identify common types of errors that can occur in engineering systems.
- Apply analytical redundancy techniques to design fault-tolerant systems.
- Classify different types of faults, such as hardware faults, software faults, and environmental faults.
- Apply fault diagnosis procedures to isolate faulty components or subsystems.

**UNIT I INTRODUCTION TO FAULT TOLERANCE** 9

Principles of fault tolerance – redundancy – quantitative reliability – evaluation – exception

handling. Application of fault tolerant systems in aircraft – reliability strategies – software fault tolerance-recovery block – Acceptance – tests – run-time Overheads -Fault Tolerant Processor –Hardware and software

**UNIT II ERROR DETECTION AND ERROR RECOVERY** 9

Measure for error detection – Mechanisms for error detection – Measures for damage confinement and damage assessment – Protection mechanisms – Protection in multi-level systems. Measures for error recovery – mechanisms for error recovery – check points and audit trials – the recovery cache – Concurrent processes – recovery for competing process – recovery for cooperating process – distributed systems – fault treatment – location and repair.

**UNIT III ANALYTICAL REDUNDANCY CONCEPT** 9

Additive faults and disturbance-Multiplicative faults and disturbance Residual generation-Detection property-Isolation property-Computational property-Design of Residual generation-Specification and implementation

**UNIT IV DESIGN FOR DIRECTIONAL RESIDUAL** 9

Parametric faults-Representation of parametric fault-Design for parametric fault and model errors-Robustness in residual generation-Perfect decoupling from disturbance.

**UNIT V FAULT DIAGNOSIS** 9

Fault diagnosis using Kalman filtering-Fault diagnosis using principle component analysis –Fault diagnosis using ANN and Fuzzy clustering, Case study: Aircraft fault detection.

**Total Contact Hours: 45**

**COURSE OUTCOMES:**

Upon completion of the course, Students will be able to
CO1 Study the importance of fault tolerance principles and procedures
CO2 Explain error detection and error recovery methods
CO3 Explain Analytical redundancy concepts.
CO4 Study types of faults and detection procedures
CO5 Apply fault diagnosis procedures

**TEXTBOOKS**:

1. Janos.J.Gertler, “Fault detection and diagnosis in engineering systems”, second edition,

Marcel Dekker, 1998.

2. Rami S.Mangoubi, “Robust Estimation and Failure detection”, Springer-Verlag London,

1998.

**REFERENCES**:

1. Anderson and Lee, Fault tolerant principles and practice, Prentice – Hall, 1981

2. John. D. Musa, Anthony Jannino, Kzuhira, Okunito, Software reliability measurement,

prediction and application, McGraw – Hill, 1989

**SUGGESTED ACTIVITIES**

- Flipped classroom
- Activity Based Learning
- Reinforced learning

**SUGGESTED EVALUATION METHODS**

- Assignment problems
- Quizzes
- Class Presentation/Discussion

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| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| **AE23D17.1** | 3 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| **AE23D17.2** | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| **AE23D17.3** | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 |
| **AE23D17.4** | 3 | 3 | 2 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| **AE23D17.5** | 2 | 3 | 2 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| **Average** | 2.8 | 2.8 | 1.8 | 2.2 | 2.2 | 1 | 1.2 | 1 | 1 | 1 | 1 | 1 | 2 | 1.8 | 1.6 |

## AE23D18 AIR TRAFFIC CONTROL AND PLANNING

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

**OBJECTIVES**

- To study the procedure of the formation of aerodrome and its design and air traffic control.

**UNIT I BASIC CONCEPTS 9**

Objectives of air traffic control systems - Parts of ATC services – Scope and Provision of ATCs – VFR& IFR operations – Classification of ATS air spaces – Various kinds of separation – Altimeter setting procedures – Establishment, designation and identification of units providing ATS – Division of responsibility of control.

**UNIT II AIR TRAFFIC SYSTEMS 9**

Area control service, assignment of cruising levels - minimum flight altitude - ATS routes and significant points – RNAV and RNP – Vertical, lateral and longitudinal separations based on time /distance –ATC clearances – Flight plans – position report. Automatic Dependent Surveillance Broadcast (ADS-B).

**UNIT III FLIGHT INFORMATION SYSTEMS 10**

Radar service, Basic radar terminology – Identification procedures using primary / secondary radar –performance checks – use of radar in area and approach control services – assurance control and coordination between radar / non radar control – emergencies – Flight information and advisory service – Alerting service – Co-ordination and emergency procedures – Rules of the air.

**UNIT IV AERODROME DATA 9**

Aerodrome data - Basic terminology – Aerodrome reference code – Aerodrome reference point –Aerodrome elevation – Aerodrome reference temperature – Instrument runway, physical Characteristics; length of primary / secondary runway – Width of runways – Minimum distance between parallel runways etc. – obstacles restriction.

**UNIT V NAVIGATION AND OTHER SERVICES 8**

Visual aids for navigation Wind direction indicator – Landing direction indicator – Location and characteristics of signal area – Markings, general requirements – Various markings – Lights, general requirements – Aerodrome beacon, identification beacon – Simple approach lighting system and various lighting systems – VASI & PAPI - Visual aids for denoting obstacles; object to be marked and lighter – Emergency and other services.

**Total Contact Hours: 45**

**TEXTBOOK**

1. AIP (India) Vol. I & II, “The English Book Store”, 17-1, Connaught Circus, New Delhi.

After successful completion of the course students will demonstrate the following outcomes:

**AE23D18.1** Understanding the Objective and requirement of air traffic control systems
**AE23D18.2** Knowledge about types of air traffic control system.
**AE23D18.3** Knowledge in flight information systems and rules of air traffic systems.
**AE23D18.4** Knowledge about aerodrome related data’s
**AE23D18.5** Knowledge indirection indicator systems for air navigation.

**SUGGESTED ACTIVITIES (if any)** (UNIT/ Module Wise) – Could suggest topic

- Flipped classroom
- Activity Based Learning

**SUGGESTED EVALUATION METHODS (if Any)** (UNIT/ Module Wise) – could suggest topic

- Quizzes
- Class Presentation/Discussion

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| **AE23D18.1** | 3 | 2 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **AE23D18.2** | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **AE23D18.3** | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **AE23D18.4** | 3 | 2 | 2 | 1 | 2 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **AE23D18.5** | 3 | 2 | 2 | - | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| **Average** | 3 | 2 | 2 | 1 | 1.8 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **AE23D19** | **MISSILE SYSTEMS** | PE | 3 | 0 | 0 | 3 |

**Objectives:**

- Introduces students to missile systems, covering history, classification, system elements, and basics of trajectory dynamics.
- Focuses on the principles of tactical missile guidance, including motion equations and proportional navigation techniques.
- Examines weapon delivery systems, addressing factors affecting accuracy and the integration of flight control with guided weapons.
- Explores the dynamics of strategic missiles, emphasizing ballistic trajectories, re-entry, and missile interception
- Provides insights into cruise missile systems, with a focus on navigation errors, TERCOM, and GPS-based guidance.

**UNIT-I MISSILE SYSTEMS** 9

Introduction - history - classification - missile system elements, missile ground systems - radars – launchers, coordinate frames- basics of trajectory dynamics.

**UNIT-II TACTICAL MISSILE GUIDANCE** 9

Introduction- Tactical Guidance Intercept Technique - Missile Equations of Motion- Fundamental Guidance Equations- Proportional Navigation- Augmented Proportional Navigation-3D Proportional Navigation- Application of Optimal Control of Linear Feedback Systems.

**UNIT-III MISSILE WEAPON DELIVERY SYSTEMS** 9

Weapon Delivery Requirements- Factors Influencing Weapon Delivery Accuracy-Unguided Weapons-The Bombing Problem - Guided Weapons - Missile Launch Envelope Integrated Flight Control in Weapon Delivery.

**UNIT-IV STRATEGIC MISSILES** 9

The Two-Body Problem - Lambert's Theorem - First-Order Motion of a Ballistic Missiles- The Correlated Velocity and Velocity-to-Be-Gained Concepts- Atmospheric Re-entry- Missile Flight Model-Ballistic Missile Intercept.

**UNIT-V CRUISE MISSILES** 9

Introduction - System Description- Cruise Missile Navigation System Error Analysis- Terrain Contour Matching (TERCOM)- The NAVSTAR/GPS Navigation System.

**Total Contact Hours: 45**

Course Outcomes:

- Students will grasp the foundational concepts of missile systems and trajectory dynamics.
- Students will apply guidance techniques and analyze missile motion equations effectively.
- Students will evaluate weapon delivery accuracy and differentiate between guided and unguided systems.
- Students will analyse ballistic missile behaviour and understand the challenges of atmospheric re-entry.
- Students will comprehend cruise missile navigation methods and the application of GPS and TERCOM in operations.

**SUGGESTED ACTIVITIES (if any)** (UNIT/ Module Wise) – Could suggest topic

- Flipped classroom
- Activity Based Learning

**SUGGESTED EVALUATION METHODS (if Any)** (UNIT/ Module Wise) – could suggest topic

- Quizzes
- Class Presentation/Discussion

**Textbook(s):**

1. Siouris, George M. "Missile guidance and control systems" , springer publications Frist edition 2004

**Reference Books(s) / Web links:**

9. Paul Zarchan "Tactical and Strategic Missile Guidance: Volumes 1 & 2" , American Institute of Aeronautics & Astronautics; 7th edition, 2019

10. S S Chin "Missile Configuration Design" MCGRAW HILL PUBLISHING COMPANY; First Edition 1960

11. JH Blakelock "Automatic Control of Aircraft and Missiles" John Wiley & Sons Inc; 2nd edition, 1991

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| **AE23D19.1** | 3 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| **AE23D19.2** | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| **AE23D19.3** | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 |
| **AE23D19.4** | 3 | 3 | 2 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| **AE23D19.5** | 2 | 3 | 2 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| **Average** | 2.8 | 2.8 | 1.8 | 2.2 | 2.2 | 1 | 1.2 | 1 | 1 | 1 | 1 | 1 | 2 | 1.8 | 1.6 |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **AE23E11** | **MECHNAICS OF MACHOINES** | **PE** | **3** | **0** | **0** | **3** |

**Objectives:**

To understand the principles in the formation of mechanisms and their kinematics.
To understand the importance of cams and gear mechanism
To understand the effect of friction in different machine elements.
To understand the static and dynamic forces and toques acting on simple mechanical systems
To understand the importance of balancing of revolving and reciprocating masses in machine elements

**UNIT-I KINEMATIC OF MECHANICS 8**

Mechanisms – Terminology and definitions – kinematics inversions of 4 bar and slide crank chain – Displacement, velocity and acceleration analysis of simple mechanisms – Graphical method– Velocity and acceleration polygons, **develop a prototype of different mechanisms**

**UNIT-II CAMS AND GEARS 11**

Cams – classifications – displacement diagrams - layout of plate cam profiles– derivatives of followers motion - Spur gear – law of toothed gearing – involute gearing – Interchangeable gears – Gear tooth action interference and undercutting – nonstandard teeth – gear trains – parallel axis gears trains – epicyclic gear trains – automotive transmission gear trains.

**UNIT-III FRICTION 8**

Sliding and Rolling Friction angle – friction in threads – Friction Drives – Friction clutches – Belt and rope drives - Ratio of tensions – Effect of centrifugal and initial tension– Condition for maximum power transmission – Open and crossed belt drive.

**UNIT-IV FORCE ANALYSIS 9**

Applied and Constrained Forces – Free body diagrams – static Equilibrium conditions – Two, Three and four members – Static Force analysis in simple machine members – Dynamic Force Analysis – Inertia Forces and Inertia Torque – D'Alembert's principle – superposition principle – dynamic Force Analysis in simple machine members.

**UNIT-V BALANCING AND MECHANISM FOR CONTROL 9**

Static and Dynamic balancing – Single and several masses in different planes –Balancing of reciprocating masses- primary balancing and concepts of secondary balancing Gyroscopes –Gyroscopic forces and torques – Gyroscopic stabilization – Gyroscopic effects in Automobiles, ships and airplanes.

**Total Contact Hours : 45**

**Course Outcomes:**

On completion of course students will be able to

| | |
|---|---|
| AE23E11.1 | Assess different mechanisms with their working methods |
| AE23E11.2 | Apply the concepts of cams and gear mechanism |
| AE23E11.3 | Apply the concepts of friction in different machine elements |
| AE23E11.4 | Analyze the static and dynamic forces and toques acting on simple mechanical systems |
| AE23E11.5 | Analyze the unbalanced forces in revolving and reciprocating masses in machine elements |

**Textbooks:**

1. Rattan S. S. - 'Theory of Machines' - McGraw Hill India Pvt. Ltd. - 2014 - 4th Edition
2. Ghosh A. and Mallick A. K. - 'Theory of Mechanisms and Machines' - Affiliated East West Press Pvt. Ltd., New Delhi - 2008

**Reference Books / Web links:**


1. Thomas Bevan, “Theory of Machines”, CBS Publishers and Distributors, 1984.
2. Ambekar A.G., “Mechanism and Machine Theory” Prentice Hall of India, New Delhi, 2007
3. Shigley J.E., Pennock G.R and Uicker J.J., “Theory of Machines and Mechanisms”, Oxford University Press, 2003
4. Ramamurthi. V, "Mechanisms of Machine", Narosa Publishing House, 2002.
5. Robert L. Norton, "Design of Machinery", McGraw-Hill, 2004.


| CO/PO-PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AE23E11.1 | 3 | 2 | 2 | 2 | 3 | - | - | - | 1 | 1 | 1 | 3 | 3 | 2 | - |
| AE23E11.2 | 3 | 2 | 2 | 2 | 3 | - | - | - | 1 | 1 | - | 3 | 3 | 2 | - |
| AE23E11.3 | 3 | 2 | 2 | 2 | 3 | - | - | - | 1 | 1 | - | 3 | 3 | 2 | - |
| AE23E11.4 | 3 | 2 | 2 | 2 | 3 | - | - | - | 1 | 1 | - | 3 | 3 | 2 | - |
| AE23E11.5 | 3 | 2 | 2 | 2 | 3 | - | - | - | 1 | 1 | - | 3 | 3 | 2 | - |
| **Average** | 3 | 2 | 2 | 2 | 3 | - | - | - | 1 | 1 | 1 | 3 | 3 | 2 | - |

| AE23E12 | AIRCRAFT GENERAL ENGINEERING AND MAINTENANCE PRACTICES | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVES**

- To study ground handling and support equipment
- To understand aircraft logbooks and documentation
- To acquire knowledge of different agencies and documents
- To understand aircraft inspection
- To understand aircraft hardware materials

**UNIT I AIRCRAFT GROUND HANDLING AND SUPPORT EQUIPMENTS 10**

Mooring, jacking, levelling and towing operations – Preparation – Equipment – precautions – engine starting procedures – Piston engine, turboprops and turbojets – Ground power units.

**UNIT II AIRCRAFT MATERIALS TESTING 7**

Knowledge of various types of corrosion, its cause and protection- detailed knowledge of the hot oil and chalk, dye penetrant and fluorescent and magnetic particle techniques and the subsequent inspection of the parts, knowledge of the X-ray, ultrasonic and eddy current inspections.

**UNIT III AIRCRAFT DOCUMENTATION 8**

Roll of DGCA in Indian aviation-Categories of AME Licenses'-civil airworthiness requirements-various aircraft-logbooks- logbook maintenance and making entry-Advisory circulars-certificate of registration and certificate of airworthiness- modification, concession

**UNIT IV INSPECTION 10**

Process – Purpose – Types – Inspection intervals – Techniques – Checklist – Special inspection – Publications, bulletins, various manuals – FAR Air worthiness directives – Type certificate Data sheets– ATA Specifications

**UNIT V AIRCRAFT HARDWARE, MATERIALS, SYSTEM PROCESSES 10**

Precision instruments – special tools and equipment in an airplane maintenance shop– specification and correct use of various aircraft hardware (i.e., nuts, bolts, rivets) – threads, gears, bearings-Identification of all types of fluid line fittings, materials, metallic and non-metallic plumbing connectors – cables – swaging procedures, tests, advantages of swaging over splicing.

**Total Contact Hours: 45**

**TEXTBOOK**

1. Airframe &Plant Mechanics," General Hand Book", Shroff publishers, 2007

**REFERENCES**

1. Kroes, Watkins and Delp, "Aircraft Maintenance and Repair", Tata McGraw Hill, 2010

OUTCOMES:

After successful completion of the course students will demonstrate the following outcomes:

| | |
|---|---|
| AE23E12.1 | Knowledge gaining on ground handling equipment and starting procedure of aircraft |
| AE23E12.2 | Evaluate different methods of non-destructive test methods |
| AE23E12.3 | Understand role of DGCA and its structure |
| AE23E12.4 | Understand inspection procedures and documentation |
| AE23E12.5 | Understand hardware and repair of swaging in aircraft maintenance |

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23E12.1 | 3 | 1 | 1 | | 3 | - | - | 2 | - | - | - | - | 2 | 2 | - |
| AE23E12.2 | 3 | 2 | 2 | - | 3 | - | - | - | - | - | - | 1 | 2 | 2 | - |
| AE23E12.3 | 3 | 2 | 2 | - | 3 | - | - | - | - | - | - | 1 | 2 | 2 | - |
| AE23E12.4 | 3 | 2 | 2 | - | 3 | - | - | - | - | - | - | 1 | 2 | 2 | - |
| AE23E12.5 | 1 | 2 | 2 | | 1 | - | - | 2 | - | 2 | - | 2 | 1 | 1 | - |
| **Average** | 2.6 | 1,8 | 1.8 | - | 2.6 | - | - | 2 | - | 2 | - | 1.25 | 1.8 | 1.8 | - |

| Subject Code | Subject Name (Theory course) | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| AE23E13 | **MODERN MANUFACTURING PROCESSES** | PE | 3 | 0 | 0 | 3 |

**Objectives:**

- To create awareness on Abrasive aided machining
- To understand electrical and electrochemical machining processes.
- To analyse the principles of high energy aided machining.
- To study the surface and bulk machining processes of silicon wafer.
- To introduce students to the major manufacture steps in electronic circuit boards.

**UNIT-I ABRASIVE AIDED MACHINING PROCESSES** 9

Abrasive machining – water jet machining - ultrasonic machining –Abrasive flow machining- Magnetorheological Abrasive flow machining- construction working principle – steps - types – process parameters – derivations – problems, merits, demerits and applications.

**UNIT-II ELECTRICAL AND CHEMICAL AIDED MACHINING PROCESSES** 9

Wire cut EDM - Electric discharge machining – Electrochemical machining – chemical machining – Maskants - Electrochemical grinding - construction – principle – types – control - circuits – tool design – merits, demerits and applications. Hybrid Machining.

**UNIT-III HIGH ENERGY AIDED MACHINING PROCESSES** 9

Laser beam machining – Electron beam machining – Plasma arc machining – Ion beam machining – construction working principle types – process parameter – derivations – problems, merits, demerits and applications.

**UNIT-IV FABRICATION OF MICRO DEVICES** 9

Semiconductors – Si wafer - planarization – Oxidation - diffusion – ion implantation – etching – metallization – bonding – surface and bulk machining – LIGA Process

**UNIT-V MICROFABRICATION TECHNOLOGY** 9

Moulding – PCB board hybrid and MCM technology – programmable devices and ASIC – electronic material and processing– stereolithography – Solid free form fabrication -SAW devices, Surface Mount Technology

**Total Contact Hours: 45**

**Course Outcomes:** Students will be able to

- Understand and grasp the significance of modern machining process and its applications.
- Identify the selection of machining process and its parameters.
- Express and appreciate the cutting edge technologies and apply the same for research purposes.
- Measure the stages involved in fabrication of micro devices.
- Create new devices involved in micro fabrication and recent technology

**SUGGESTED ACTIVITIES (if any)** (UNIT/ Module Wise) – Could suggest topic

- Flipped classroom - Comparing SOA with Client-Server and Distributed architectures
- Activity Based Learning

**SUGGESTED EVALUATION METHODS (if Any)** (UNIT/ Module Wise) – could suggest topic

- Quizzes
- Class Presentation/Discussion

**Textbook(s):**

1. Pandey P.C. and Shan HS Modern Machining Processes, Standard Publishing Co., 1stEdition,1980.
2. Serope Kalpakjian and Steven R. Schmid- Manufacturing Process for Engineering Material – Pearson Education, 6thEdition, 2018
3. Jain V K, Micromanufacturing Processes, CRC Press, 2012.

**Reference Books(s) / Web links:**

- Brahem T. Smith, Advanced Machining I.F.S. UK 2016.
- Jaeger R.C., Introduction to Microelectronic Fabrication Addison Wesley, 2ndEdition, 1998.
- Julian W. Gardner, Vijay K Varadan and Osama O Awadelkarim, Microsensors MEMS and Smart devices, John Willey, 2013.

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23E13.1 | 3 | 1 | 1 | | 3 | - | - | 2 | - | - | - | - | 2 | 2 | - |
| AE23E13.2 | 3 | 2 | 2 | - | 3 | - | - | - | - | - | - | 1 | 2 | 2 | - |
| AE23E13.3 | 3 | 2 | 2 | - | 3 | - | - | - | - | - | - | 1 | 2 | 2 | - |
| AE23E13.4 | 3 | 2 | 2 | - | 3 | - | - | - | - | - | - | 1 | 2 | 2 | - |
| AE23E13.5 | 1 | 2 | 2 | | 1 | - | - | 2 | - | 2 | - | 2 | 1 | 1 | - |
| **Average** | 2.6 | 1,8 | 1.8 | - | 2.6 | - | - | 2 | - | 2 | - | 1.25 | 1.8 | 1.8 | - |

| Subject Code | | L | T | P | C |
|---|---|---|---|---|---|
| **AE23E14** | **AIRFRAME MAINTENANCE AND REPAIR** | **3** | **0** | **0** | **3** |

**OBJECTIVES**

- To impart knowledge of the aircraft control systems
- To gain knowledge on hydraulic and pneumatic systems of aircraft
- Basic knowledge of piston and jet engine fuel and lubrication systems
- To impart knowledge on aircraft environment systems
- To gain knowledge on flight and engine instruments.

**UNIT I AIRPLANE CONTROL SYSTEMS 8**

Conventional Systems – power assisted and fully powered flight controls – push pull rod and cable system – perating principles – modern control systems – FBW and FBL systems – auto pilot system.

**UNIT II AIRCRAFT SYSTEMS 12**

Hydraulic systems – Study of typical hydraulic systems Boeing 727 components – hydraulic systems operation – selector valves-accumulators-Control valves – pneumatic systems – Schematic diagram and operation – brake system- typical brake system Boeing 757 – landing gear systems – components – shock strut operation-retraction systems.

**UNIT III ENGINE SYSTEMS 8**

Typical fuel systems – piston and jet engines – components – typical fuel lubricating systems - piston and jet engines – starting and ignition systems – piston and jet engines

**UNIT IV AIRCONDITIONING AND PRESSURIZING SYSTEM 8**

Basic air cycle systems – vapor cycle systems - air cycle machine cooling system – cooling pack-oxygen systems –Typical oxygen system Cessna– fire protection systems-fire extinguishing agents-deicing and anti-icing system-pneumatic deicing of large aircraft-thermal anti-icing. -probe anti-icing.

**UNIT V AIRCRAFT INSTRUMENTS 9**

Flight and engine instruments – accelerometers, air speed indicators – mach meters – altimeters – typical Boeing system with air data computer- gyroscopic instruments– principles and operation – study of various types of engine instruments – tachometers – oil temperature gauges-EGT-EPR- fuel quantity indicators-operation and principles.

**Total Contact Hours: 45**

OUTCOME:

After successful completion of the course students will demonstrate the following outcomes:

- Knowledge gaining sheet metal repair
- Evaluate different methods plastic repair
- Understand jacking and rigging procedure
- Analysis of trouble shooting in aircraft
- Understand safety procedures in aircraft

**TEXTBOOKS**

1. Kroes, Watkins and Delp, "Aircraft Maintenance and Repair", Tata McGraw Hill, 2010

**REFERENCES**

1. Pallet, E.H.J, "Aircraft Instruments & Principles", Pitman & Co 1993.

2. Kroes and Wild, “Aircraft Power plants”, Tata McGraw Hill 2010

3. Instrument Flying Handbook: FAA-H-8083-15B, Sky Pony Press; Clr Csm edition, 2017.

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23E14.1 | 3 | 1 | 1 | | 3 | - | - | 2 | - | - | - | - | 2 | 2 | - |
| AE23E14.2 | 3 | 2 | 2 | - | 3 | - | - | - | - | - | - | 1 | 2 | 2 | - |
| AE23E14.3 | 3 | 2 | 2 | - | 3 | - | - | - | - | - | - | 1 | 2 | 2 | - |
| AE23E14.4 | 3 | 2 | 2 | - | 3 | - | - | - | - | - | - | 1 | 2 | 2 | - |
| AE23E14.5 | 1 | 2 | 2 | | 1 | - | - | 2 | - | 2 | - | 2 | 1 | 1 | - |
| **Average** | 2.6 | 1,8 | 1.8 | - | 2.6 | - | - | 2 | - | 2 | - | 1.25 | 1.8 | 1.8 | - |

| Subject Code | Subject Name | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| AE23E15 | CIVIL AVIATION REQUIREMENTS | PE | 3 | 0 | 0 | 3 |

**Objectives**

1. Enhance the knowledge of aircraft act1934, and aircraft rules.
2. Understand the responsibility of owner/operator of a/c.
3. Understand the procedure for the preparation.
4. Enhance the knowledge on the different types of maintenance programme their approval.
5. Understand the procedure for getting the approvals of organizations in different categories.

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**UNIT I INDIAN AIRCRAFT RULES 1937 AND RELATED PUBLICATIONS 9**

Knowledge of aircraft act, 1934, aircraft rules, 1937 as far as they related to airworthiness and safety of aircraft. Knowledge of civil airworthiness requirements, aeronautical information circulars, aeronautical information publications- (relating to airworthiness), advisory circulars & A.M.E. notices (NOTAMS) by DGCA.

**UNIT II C.A.R. SERIES "A" &"B " 9**

C.A.R. series A - procedure for issue of civil airworthiness requirements and responsibility of operators vis-à-vis air worthiness directorate:

Responsibilities of operators/owners; procedure of CAR issue, amendments etc; objectives and targets of airworthiness directorate; airworthiness regulations and safety oversight of engineering activities of operations

C.A.R. series "B" - issue approval of cockpit check list, MEL, CDL:

Deficiency list (MEL & CDL); preparation and use of cockpit check list and emergency check list.

**UNIT III C.A.R. SERIES "C" 9**

C.A.R. series 'C' - defect recording, monitoring, investigation and reporting: Defect recording, reporting, investigation, rectification and analysis; flight report, recording of in-flight instrument, reading and reporting of flight defects and rectification of defects observed on aircraft.

**UNIT IV C.A.R. SERIES "E" 9**

C.A.R. Series E - approval of organizations:

Approval of organizations in categories A, B, C, D, E, F, & G; requirements of infrastructure at stations other than parent base.

**UNIT V C.A.R. SERIES "F " 9**

C.A.R. Series "F" airworthiness and continued airworthiness:

Procedure relating to registration of aircraft; procedure for issue / revalidation of type certification of aircraft and its engines / propellers; issue /revalidation and renewal of certificate of airworthiness; require for renewal of certificate of airworthiness. Suspensions of certificate of airworthiness and its subsequent revalidation; rebuilding of aircraft, continuous airworthiness maintenance programme; airworthiness of ageing aircraft; control system-duplicate inspection, Inspection of wooden aircraft; airworthiness requirements of gliders, requirements of manufacture , registration & airworthiness control of hot air balloons; approval of flight manuals and their amendments ; pooling of aircraft parts by national airlines of India with foreign airlines construction, certification and operation of experimental / amateur built aircraft; manufacture of aircraft and accessories and airworthiness certification thereof; age of aircraft to be imported for charter hire " air taxi and other operations", import/export of aircraft, item of equipment etc . For use on

aircraft; load and trim sheet - requirements thereof.

**Total Contact Hours: 45**

**References**


1. Aircraft manual (India) volume - latest edition, the English bookstore, 17-l, Connaught circus, New Delhi.
2. Civil aviation requirements with latest amendment (section 2 airworthiness) - published by DGCA, the English bookstore, 17-l, Connaught circus, New Delhi.
3. Aeronautical information circulars (relating to airworthiness) from DGCA. Advisory circulars from DGCA.


**Course Outcomes**

1. Describe the Indian aircraft rules and the related publications.
2. Know the procedure for keeping the aircraft in airworthiness conditions.
3. Describe the use of MEL, and the procedure for releasing the a/c under MEL.
4. Describe the different types of maintenance programme.
5. Understand the procedure for getting the approvals of organizations in different categories

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23E15.1 | 3 | 1 | 1 | | 3 | - | - | 2 | - | - | - | - | 2 | 2 | - |
| AE23E15.2 | 3 | 2 | 2 | - | 3 | - | - | - | - | - | - | 1 | 2 | 2 | - |
| AE23E15.3 | 3 | 2 | 2 | - | 3 | - | - | - | - | - | - | 1 | 2 | 2 | - |
| AE23E15.4 | 2 | 2 | 2 | - | 3 | - | - | - | - | - | - | 1 | 2 | 2 | - |
| AE23E15.5 | 1 | 2 | 2 | | 1 | - | - | 2 | - | 2 | - | 2 | 1 | 1 | - |
| Average | 2.4 | 1,8 | 1.8 | - | 2.6 | - | - | 2 | - | 2 | - | 1.25 | 1.8 | 1.8 | - |

| | | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| **ME23712** | **TOTAL QUALITY MANAGEMENT** | **PE** | **3** | **0** | **0** | **3** |

## OBJECTIVES

To facilitate the understanding of basic quality management in engineering.

- To summarize the various principles of TQM.
- To be acquainted with management tools, Six Sigma and benchmarking.
- To demonstrate the quality functions and TPM concepts.
- To implement various quality systems and TQM in the manufacturing and service sectors.

### UNIT I INTRODUCTION TO TOTAL QUALITY MANAGEMENT 9

Introduction - Need for quality - Evolution of quality - Definitions of quality - Dimensions of product and service quality - Basic concepts of TQM - TQM Framework - Contributions of Deming, Juran and Crosby - Barriers to TQM - Quality statements - Customer focus - Customer satisfaction, Customer complaints, Customer retention.

### UNIT II TQM PRINCIPLES 9

Leadership, Quality Councils - Employee involvement - Motivation, Empowerment, Team and Teamwork, Recognition and Reward, Performance appraisal - Continuous process improvement – Juran Trilogy, PDCA cycle, 5S, Kaizen, 8D methodology - Supplier partnership - Partnering, Supplier selection and certification, Supplier rating.

### UNIT III TQM TOOLS AND TECHNIQUE I 9

The seven traditional quality tools - New management tools - Six Sigma, Lean Six Sigma: Concepts, Methodology, applications to manufacturing, service sector including IT - Bench marking – Types, Reason to Bench mark, Bench marking process, Benefits - FMEA - Stages, Procedure, Types.

### UNIT IV TQM TOOLS AND TECHNIQUES II 9

Quality Circles – Cost of Quality – Quality Function Deployment (QFD) – House of Quality – QFD Process - Taguchi quality loss function – Total Productive Maintenance (TPM) – Concepts, development program, fundamental activities, benefits, POKA-YOKE, JIT Concepts.

### UNIT V QUALITY MANAGEMENT SYSTEM 9

Introduction—Benefits of ISO Registration—ISO 9000 Series of Standards—Sector-Specific Standards—AS 9100, TS16949 and TL 9000– ISO 9001 Requirements—Implementation—Documentation—Internal Audits—Registration - Environmental Management System: Introduction—ISO 14000 Series Standards—Concepts of ISO 14001—Requirements of ISO 14001— EMS implementation - Benefits of EMS.

**Total Contact Hours: 45**

## TEXTBOOK


1. Dale H.Besterfield, Carol B.Michna, Glen H. Besterfield, Mary B. Sacre, Hemant Urdhwareshe and Rashmi Urdhwareshe ―Total Quality Management, Pearson Education Asia, Revised Third Edition, Indian Reprint, Sixth Impression, 2013.
2. James R. Evans and William M. Lindsay, "The Management and Control of Quality", 8th Edition, First Indian Edition, Cengage Learning, 2012.


## REFERENCES


1. Suganthi.L and Anand Samuel, "Total Quality Management", Prentice Hall (India) Pvt. Ltd., 2011.
2. Janakiraman. B and Gopal .R.K., "Total Quality Management - Text and Cases", Prentice Hall (India) Pvt. Ltd., 2006.
3. H. Lal, ―Organizational Excellence through TQM‖, New Age Publications, 2008.
4. ISO 9001-2015 standards.

After successful completion of the course students will demonstrate the following outcomes:

ME23712.1 Understand the importance of quality in engineering.
ME23712.2 Conceptualize various principles in TQM and continuous process improvement.
ME23712.3 Explore the knowledge of implementing various TQM tools.
ME23712.4 Demonstrate the applications of various tools like QFD and TPM for quality improvement.
ME23712.5 Implement ISO-9000 & ISO-14000 in manufacturing and service sectors

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| ME23712.1 | - | - | - | - | - | - | - | - | 2 | - | 2 | - | 2 | 2 | - |
| ME23712.2 | - | - | - | - | - | 1 | - | - | 3 | 2 | 1 | - | 2 | 2 | - |
| ME23712.3 | 1 | 1 | 1 | 1 | 3 | 1 | - | - | 2 | 1 | 2 | - | 2 | 2 | - |
| ME23712.4 | 1 | 1 | 1 | 1 | 3 | 1 | - | - | 2 | - | 2 | - | 2 | 2 | - |
| ME23712.5 | - | - | - | - | - | 2 | 3 | 1 | 1 | 2 | 2 | - | 1 | 1 | - |
| Average | 1 | 1 | 1 | 1 | 3 | 1.25 | 3 | 1 | 2 | 1.67 | 1.8 | - | 1.8 | 1.8 | - |

| AE23E17 | AERO ENGINE MAINTENANCE AND REPAIR | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| | | PE | 3 | 0 | 0 | 3 |

**OBJECTIVES**

- Apply maintenance procedure to piston engines
- Understand the propeller theory
- Identify the jet engine components and faults
- Apply non-destructive testing procedures
- Apply overhauling procedure to engines

**UNIT I PISTON ENGINES 9**

Engine operating conditions at various altitudes–Engine power measurements– Classification of engine lubricants and fuels – Induction, Exhaust and coolingsystem-Maintenanceandinspectionchecktobecarriedout-inspectionandmaintenanceandtroubleshooting-Inspection of all engine components-Daily and routine checks-Overhaul procedures-Compression testing of cylinders-Special inspection schedules.

**UNIT II PROPELLERS 9**

Propeller theory-operation, construction assembly and installation-Pitch change mechanism- Propeller axially system-Damage and repair criteria-General Inspection procedures-Checks on constant speed propellers - Pitch setting, Propeller Balancing, Blade cuffs, Governor/Propeller operating conditions–Damage and repair criteria.

**UNIT III JET ENGINES 9**

Types of jet engines – Fundamental principles – Inspection and Maintenance- permissible limits of damage and repair criteria of engine components- internal inspection of engines- compressor washing- field balancing of compressor fans- Component maintenance procedures - Systems maintenance procedures - use of instruments for online maintenance - Special inspection procedures-Foreign Object Damage - Blade damage.

**UNIT IV TESTING AND INSPECTION 9**

Symptoms of failure - Fault diagnostics -Rectification during testing equipment for overhaul: Tools and equipments requirements for various checks and alignment during overhauling - Tools for inspection - Tools for safety and for visual inspection - Methods and instruments for non-destructive testing techniques -Engine testing: Engine testing procedures and schedule preparation - Online maintenance.

**UNITV OVERHAULING 9**

Engine Overhaul - Overhaul procedures - Inspections and cleaning of components - Repairs schedules for overhaul - Balancing of Gas turbine components. Trouble Shooting: Procedures for trouble shooting - Condition monitoring of the engine on ground and at altitude - engine health monitoring and corrective methods.

**Total Contact Hours: 45**

**TEXTBOOK**

1. Kroes & Wild, “Aircraft Powerplants", McGraw Hill, New York, 7th Edition

**REFERENCES**

1. Irving E Treager , “Aircraft Gas Turbine Engine”, Technology” McGraw Hill, New York, 3rd Edition

After successful completion of the course students will demonstrate the following outcomes:

1.

**AE123E17.1** Knowledge gaining sheet metal repair
**AE123E17.2** Evaluate different methods plastic repair
**AE123E17.3** Understand jacking and rigging procedure
**AE123E17.4** Analysis of trouble shooting in aircraft
**AE123E17.5** Understand safety procedures in aircraft

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23E17.1 | 3 | 1 | 1 | | 3 | - | - | 2 | - | - | - | - | 2 | 2 | - |
| AE23E17.2 | 3 | 2 | 2 | - | 3 | - | - | - | - | - | - | 1 | 2 | 2 | - |
| AE23E17.3 | 3 | 2 | 2 | - | 3 | - | - | - | - | - | - | 1 | 2 | 2 | - |
| AE23E17.4 | 2 | 2 | 2 | - | 3 | - | - | - | - | - | - | 1 | 2 | 2 | - |
| AE23E17.5 | 1 | 2 | 2 | | 1 | - | - | 2 | - | 2 | - | 2 | 1 | 1 | - |
| Average | 2.4 | 1,8 | 1.8 | - | 2.6 | - | - | 2 | - | 2 | - | 1.25 | 1.8 | 1.8 | - |

| AE23E18 | ENTREPRENEURSHIP FOR ENGINEERS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

- Learn basic concepts in entrepreneurship, develop mind-set and skills necessary to explore entrepreneurship
- Apply process of problem - opportunity identification and validation through human centred approach to design thinking in building solutions as part of engineering projects
- Analyse market types, conduct market estimation, identify customers, create customer persona, develop the skills to create a compelling value proposition and build a Minimum Viable Product
- Explore business models, create business plan, conduct financial analysis and feasibility analysis to assess the financial viability of a venture ideas & solutions built with domain expertise
- Prepare and present an investible pitch deck of their practice venture to attract stakeholders

**UNIT I ENTREPRENEURIAL MINDSET 9**

Introduction to Entrepreneurship: Definition – Types of Entrepreneurs – Emerging Economics – Developing and Understanding an Entrepreneurial Mindset – Importance of Technology Entrepreneurship – Benefits to the Society.

Case Analysis: Study cases of successful & failed engineering entrepreneurs - Foster Creative Thinking: Engage in a series of Problem-Identification and Problem-Solving tasks

**UNIT II OPPORTUNITIES 9**

Problems and Opportunities – Ideas and Opportunities – Identifying problems in society – Creation of opportunities – Exploring Market Types – Estimating the Market Size, - Knowing the Customer and Consumer - Customer Segmentation - Identifying niche markets – Customer discovery and validation; Market research techniques, tools for validation of ideas and opportunities

Activity Session: Identify emerging sectors / potential opportunities in existing markets - Customer Interviews: Conduct preliminary interviews with potential customers for Opportunity Validation - Analyse feedback to refine the opportunity.

**UNIT III PROTOTYPING & ITERATION 9**

Prototyping – Importance in entrepreneurial process – Types of Prototypes - Different methods – Tools & Techniques.

Hands-on sessions on prototyping tools (3D printing, electronics, software), Develop a prototype based on identified opportunities; Receive feedback and iterate on the prototypes.

**UNIT IV BUSINESS MODELS & PITCHING 9**

Business Model and Types - Lean Approach - 9 block Lean Canvas Model - Riskiest assumptions to Business Models – Using Business Model Canvas as a Tool – Pitching Techniques: Importance of pitching - Types of pitches - crafting a compelling pitch – pitch presentation skills - using storytelling to gain investor/customer attention.

Activity Session: Develop a business model canvas for the prototype; present and receive feedback from peers and mentors - Prepare and practice pitching the business ideas- Participate in a Pitching Competition and present to a panel of judges - receive & reflect feedback

**UNIT V ENTREPRENEURIAL ECOSYSTEM 9**

Understanding the Entrepreneurial Ecosystem – Components: Angels, Venture Capitalists, Maker Spaces, Incubators, Accelerators, Investors. Financing models – equity, debt, crowdfunding, etc, Support from the government and corporates. Navigating Ecosystem Support: Searching & Identifying the Right Ecosystem Partner – Leveraging the Ecosystem - Building the right stakeholder network

Activity Session: Arrangement of Guest Speaker Sessions by successful entrepreneurs and entrepreneurial ecosystem leaders (incubation managers; angels; etc), Visit one or two entrepreneurial ecosystem players (Travel and visit a research park or incubator or makerspace or interact with startup founders).

**Total Contact Hours: 45**

**REFERENCES**


- Robert D. Hisrich, Michael P. Peters, Dean A. Shepherd, Sabyasachi Sinha (2020). Entrepreneurship, McGrawHill, 11th Edition
- Ries, E. (2011). The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. Crown Business
- Blank, S. G., & Dorf, B. (2012). The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company. K&S Ranch
- Roy, R. (2017). Indian Entrepreneurship: Theory and Practice. New Delhi: Oxford University Press
- Osterwalder, A., & Pigneur, Y. (2010). Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers. John Wiley & Sons


**OUTCOMES:**

After successful completion of the course students will demonstrate the following outcomes:

**AE23E18.1** Develop an Entrepreneurial Mind-set and Understand the Entrepreneurial Ecosystem Components and Funding types

**AE23E18.2** Comprehend the process of opportunity identification through design thinking, identify market potential and customers

**AE23E18.3** Generate and develop creative ideas through ideation techniques

**AE23E18.4** Create prototypes to materialize design concepts and conduct testing to gather feedback and refine prototypes to build a validated MVP

**AE23E18.5** Analyse and refine business models to ensure sustainability and profitability Prepare and deliver an investible pitch deck of their practice venture to attract stakeholders

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| AE23E18.1 | 3 | 1 | 1 | | 3 | - | - | 2 | - | - | - | - | 2 | 2 | - |
| AE23E18.2 | 3 | 2 | 2 | - | 3 | - | - | - | - | - | - | 1 | 2 | 2 | - |
| AE23E18.3 | 3 | 2 | 2 | - | 3 | - | - | - | - | - | - | 1 | 2 | 2 | - |
| AE23E18.4 | 3 | 2 | 2 | - | 3 | - | - | - | - | - | - | 1 | 2 | 2 | - |
| AE23E18.5 | 3 | 2 | 2 | | 1 | - | - | 2 | - | 2 | - | 2 | 1 | 1 | - |
| Average | 3 | 1,8 | 1.8 | - | 2.6 | - | - | 2 | - | 2 | - | 1.25 | 1.8 | 1.8 | - |

| Subject Code | Subject Name | Category | L | T | P | C |
|---|---|---|---|---|---|---|
| AE23E19 | SPACEFLIGHT MECHANICS | PE | 3 | 0 | 0 | 3 |

**OBJECTIVES**

- 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 lifetime

**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 libration 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 Contact Hours: 45**

**TEXTBOOKS**

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.

**REFERENCES**

1. Sutton, G.P., "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 5th Edition,1993.

After successful completion of the course students will demonstrate the following outcomes:

- To understand the space environment and its effect on spacecrafts and satellites
- To understand the concepts of the general *n*-body problem using the fundamental concepts of orbital mechanics.
- To understand various methods employed for satellite injection
- To perform calculations related to trajectory computation for interplanetary travel
- To perform calculations related to trajectory computation for flight of ballistic missiles.

| CO | PO | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **1** | **2** | **3** |
| AE23E19.1 | 1 | 1 | 1 | 1 | - | 1 | - | 1 | 1 | 1 | - | 1 | 2 | 3 | - |
| AE23E19.2 | 2 | 2 | 1 | 1 | - | 1 | - | 1 | 1 | 1 | - | 1 | 2 | 3 | - |
| AE23E19.3 | 2 | 1 | 1 | 1 | - | 1 | - | 1 | 1 | 1 | - | 1 | 2 | 2 | - |
| AE23E19.4 | 1 | 1 | 1 | 1 | - | 1 | - | 1 | 1 | 1 | - | 1 | 2 | 3 | - |
| AE23E19.5 | 1 | 1 | 1 | 1 | - | 1 | - | 1 | 1 | 1 | - | 2 | 1 | 3 | - |
| **Average** | 1.4 | 1.2 | 1 | 1 | - | 1 | - | 1 | 1 | 1 | - | 1.2 | 1.8 | 2.8 | - |

# OPEN ELECTIVES

| OAE2301 | FUNDAMENTALS OF JET PROPULSION | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVES**

- To understand the principles of operation of jet and rocket propulsion.
- Also to understand about the types, operation and performance of various parts of the gas turbine engines.

**UNIT I FUNDAMENTALS OF GAS TURBINE ENGINES 8**

Illustration of working of gas turbine engine – The thrust equation – Factors affecting thrust – Effect of pressure, velocity and temperature changes of air entering compressor – Methods of thrust augmentation – Characteristics of turboprop, turbofan and turbojet – Performance characteristics.

**UNIT II BASICS OF GAS TURBINE ENGINE COMPONENTS 9**

Subsonic and supersonic inlets for gas turbine engines – inlet performance – axial flow and centrifugal flow compressors and their efficiencies & principle of operation – gas turbine combustion chambers & types – axial flow turbines and their performance – jet engine nozzles and their efficiency

**UNIT III RAMJET PROPULSION 8**

Operating principle of ramjet engine – various components of ramjet engines and their efficiencies – Combustion in ramjet engine – critical, subcritical and supercritical modes of operation -ramjet engine and its performance characteristics – sample ramjet design calculations – flame stability problems in ramjet combustors –integral ram rockets.

**UNIT IV HYPERSONIC AIRBREATHING PROPULSION 9**

Introduction to hypersonic air breathing propulsion, hypersonic vehicles and supersonic combustion- need for supersonic combustion for hypersonic propulsion – salient features of scramjet engine and its applications for hypersonic vehicles – problems associated with supersonic combustion – engine/airframe integration aspects of hypersonic vehicles

**UNIT V ROCKET PROPULSION 10**

Operating principle – specific impulse of a rocket – internal ballistics –solid propellant rockets – selection criteria of solid propellants –liquid propellant rockets – selection of liquid propellants – various feed systems for liquid rockets -thrust control in liquid rockets – cooling in liquid rockets and the associated heat transfer problems – advantages of liquid rockets over solid rockets - introduction to hybrid propulsion – advantages and limitations of hybrid propulsion -.Electrical propulsion – Arcjet, resistojet – MPD thrusters, nuclear propulsion.

**TOTAL: 45 PERIODS**

**TEXTBOOKS**

1. Hill, P.G. & Peterson, C.R. “Mechanics & Thermodynamics of Propulsion” Pearson education (2009).

**REFERENCES**

1. Cohen, H. Rogers, G.F.C. and Saravanamuttoo, H.I.H. “Gas Turbine Theory”, Pearson Education Canada; 6th edition, 2008.
2. Oates, G.C., “Aero thermodynamics of Aircraft Engine Components”, AIAA Education Series, New York, 1985.
3. “Rolls Royce Jet Engine”, Rolls Royce; 4th revised edition, 986.
4. Mathur, M.L. and Sharma, R.P., “Gas Turbine, Jet and Rocket Propulsion”, Standard Publishers & Distributors, Delhi, 2nd edition,2014.

| OAE2302 | INTRODUCTION TO SPACE FLIGHT | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**UNIT I HISTORY OF INTERNATIONAL SPACE FLIGHT** **9**

Manned space flight – Mercury, Gemini, Apollo, Skylab, Apollo-Soyuz, Space shuttle, Soviet manned spaceflights and International manned space flight. Unmanned space flight – Earth observation, space environment, planetary exploration, space exploration, commercial satellites, military satellites.

**UNIT II INDIAN SPACE RESEARCH ORGANIZATION** **9**

Organisation structure, Test facilities, Launch facilities, tracking and control facilities, Launch vehicles – SLV, ASLV, PSLV, GSLV, GSLV III and future launch vehicles. Satellite programmes, human space flight programme. Chandrayaan, Mangalyaan

**UNIT III SKY COORDINATES AND MOTIONS** **9**

Sky coordinates and motions - Earth Rotation - Sky coordinates - seasons - phases of the Moon - the Moon's orbit and eclipses - timekeeping (side real vs synodic period)

**UNIT IV ORBITAL PRINCIPLES** **9**

Kepler’s laws, Newton's laws - angular momentum, total energy, orbital velocities, orbital properties – field of view, ground track, maximum time in view, number of revolutions per day, and revisit time. Useful orbits – low earth orbits, polar orbits, geostationary orbits, sun-synchronous orbit. Orbit establishment, orbital maneuvers – simple impulse maneuver, Hoffmann transfer, simple plane changes

**UNIT V SATELLITE DESIGN** **9**

Mission, payload, launch vehicle and site selection, subsystems - attitude reference and control, power, thermal, orbital maintenance, data handling, TT&C, onboard computer, structure. Ground support systems.

**TOTAL: 45 PERIODS**

**TEXTBOOKS**

1. Bruce A. Campbell and Samuel Walter McCandless, Jr., Introduction to Space Sciences and Spacecraft Applications, Gulf Professional Publishing (1996)

**REFERENCES**

1. Brown, C. D., Spacecraft Mission Design , 2nd ed., AIAA Edu. Series (1998).

2. Escobal, P. R., Methods of Orbit Determination, 2nd ed., Krieger Pub. Co. (1976).

3. Web link: https://www.isro.gov.in/