

**ANNA UNIVERSITY, CHENNAI**  
**AFFILIATED INSTITUTIONS**  
**R - 2013**  
**B.E. AERONAUTICAL ENGINEERING**  
**I – VIII SEMESTERS CURRICULUM AND SYLLABUS**

**SEMESTER I**

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
<b>THEORY</b>						
1.	HS6151	<u>Technical English – I</u>	3	1	0	4
2.	MA6151	<u>Mathematics – I</u>	3	1	0	4
3.	PH6151	<u>Engineering Physics – I</u>	3	0	0	3
4.	CY6151	<u>Engineering Chemistry – I</u>	3	0	0	3
5.	GE6151	<u>Computer Programming</u>	3	0	0	3
6.	GE6152	<u>Engineering Graphics</u>	2	0	3	4
<b>PRACTICALS</b>						
7.	GE6161	<u>Computer Practices Laboratory</u>	0	0	3	2
8.	GE6162	<u>Engineering Practices Laboratory</u>	0	0	3	2
9.	GE6163	<u>Physics and Chemistry Laboratory - I</u>	0	0	2	1
<b>TOTAL</b>			<b>17</b>	<b>2</b>	<b>11</b>	<b>26</b>

**SEMESTER II**

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
<b>THEORY</b>						
1.	HS6251	<u>Technical English – II</u>	3	1	0	4
2.	MA6251	<u>Mathematics – II</u>	3	1	0	4
3.	PH6251	<u>Engineering Physics – II</u>	3	0	0	3
4.	CY6251	<u>Engineering Chemistry – II</u>	3	0	0	3
5.	GE6252	<u>Basic Electrical and Electronics Engineering</u>	4	0	0	4
6.	GE6253	<u>Engineering Mechanics</u>	3	1	0	4
<b>PRACTICALS</b>						
7.	GE6261	<u>Computer Aided Drafting and Modeling Laboratory</u>	0	1	2	2
8.	GE6262	<u>Physics and Chemistry Laboratory - II</u>	0	0	2	1
<b>TOTAL</b>			<b>19</b>	<b>4</b>	<b>4</b>	<b>25</b>

### SEMESTER III

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
<b>THEORY</b>						
1.	MA6351	<u>Transforms and Partial Differential Equations</u>	3	1	0	4
2.	ME6352	<u>Manufacturing Technology</u>	3	0	0	3
3.	AE6301	<u>Aero Engineering Thermodynamics</u>	3	0	0	3
4.	CE6451	<u>Fluid Mechanics and Machinery</u>	3	0	0	3
5.	CE6452	<u>Solid Mechanics</u>	3	0	0	3
6.	AE6302	<u>Elements of Aeronautics</u>	3	0	0	3
<b>PRACTICAL</b>						
7.	CE6315	<u>Strength of Materials Laboratory</u>	0	0	3	2
8.	CE6461	<u>Fluid Mechanics and Machinery Laboratory</u>	0	0	3	2
9.	AE6311	<u>Thermodynamics Laboratory</u>	0	0	3	2
10.	AE6312	<u>CAM and Manufacturing Laboratory</u>	0	0	3	2
<b>TOTAL</b>			<b>18</b>	<b>1</b>	<b>12</b>	<b>27</b>

### SEMESTER IV

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
<b>THEORY</b>						
1.	MA6459	<u>Numerical Methods</u>	3	1	0	4
2.	AE6401	<u>Aerodynamics - I</u>	3	0	0	3
3.	AE6402	<u>Aircraft Systems and Instruments</u>	3	0	0	3
4.	AT6302	<u>Mechanics of Machines</u>	3	1	0	4
5.	AE6403	<u>Aircraft Structures - I</u>	3	1	0	4
6.	AE6404	<u>Propulsion - I</u>	3	0	0	3
<b>PRACTICAL</b>						
7.	AE6411	<u>Aircraft Structures Laboratory - I</u>	0	0	3	2
8.	AE6412	<u>Aerodynamics Laboratory</u>	0	0	3	2
9.	AE6413	<u>CAD and Aircraft Component Drawing</u>	0	0	4	2
<b>TOTAL</b>			<b>18</b>	<b>3</b>	<b>10</b>	<b>27</b>

### SEMESTER V

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
<b>THEORY</b>						
1.	AE6501	<u>Flight Dynamics</u>	3	1	0	4
2.	AE6502	<u>Aircraft Structures - II</u>	3	1	0	4
3.	AE6503	<u>Aerodynamics - II</u>	3	1	0	4
4.	AE6504	<u>Propulsion - II</u>	3	0	0	3
5.	AE6505	<u>Control Engineering</u>	3	0	0	3
6.	GE6351	<u>Environmental Science and Engineering</u>	3	0	0	3
<b>PRACTICAL</b>						
7.	AE6511	<u>Aircraft Structures Laboratory - II</u>	0	0	3	2
8.	AE6512	<u>Propulsion Laboratory</u>	0	0	3	2
9.	GE6563	<u>Communication Skills - Laboratory Based</u>	0	0	4	2
<b>TOTAL</b>			<b>18</b>	<b>3</b>	<b>10</b>	<b>27</b>

**SEMESTER VI**

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
<b>THEORY</b>						
1.	MG6851	<u>Principles of Management</u>	3	0	0	3
2.	AE6601	<u>Finite Element Methods</u>	3	1	0	4
3.	AE6602	<u>Vibrations and Elements of Aeroelasticity</u>	3	0	0	3
4.	AE6603	<u>Composite Materials and Structures</u>	3	0	0	3
5.	AE6604	<u>Aircraft Materials and Processes</u>	3	0	0	3
6.		Elective – I	3	0	0	3
<b>PRACTICAL</b>						
7.	AE6611	<u>Aero Engine and Airframe Laboratory</u>	0	0	3	2
8.	AE6612	<u>Aircraft Design Project - I</u>	0	0	3	2
9.	AE6613	<u>Computer Aided Simulation Laboratory</u>	0	0	3	2
<b>TOTAL</b>			<b>18</b>	<b>1</b>	<b>9</b>	<b>25</b>

**SEMESTER VII**

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
<b>THEORY</b>						
1.	GE6757	<u>Total Quality Management</u>	3	0	0	3
2.	AE6701	<u>Avionics</u>	3	0	0	3
3.	ME6014	<u>Computational Fluid Dynamics</u>	3	0	0	3
4.	AE6702	<u>Experimental Stress Analysis</u>	3	0	0	3
5.		Elective – II	3	0	0	3
6.		Elective – III	3	0	0	3
<b>PRACTICAL</b>						
7.	AE6711	<u>Aircraft Design Project - II</u>	0	0	3	2
8.	AE6712	<u>Aircraft Systems Laboratory</u>	0	0	3	2
9.	AE6713	<u>Flight Integration Systems and Control Laboratory</u>	0	0	3	2
<b>TOTAL</b>			<b>18</b>	<b>0</b>	<b>9</b>	<b>24</b>

**SEMESTER VIII**

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
<b>THEORY</b>						
1.	AE6801	<u>Wind Tunnel Techniques</u>	3	0	0	3
2.		Elective – IV	3	0	0	3
<b>PRACTICAL</b>						
3.	AE6811	<u>Project Work</u>	0	0	12	6
<b>TOTAL</b>			<b>6</b>	<b>0</b>	<b>12</b>	<b>12</b>

**TOTAL NUMBER OF CREDITS TO BE EARNED FOR AWARD OF THE DEGREE = 193**

## ELECTIVES FOR M.E. AERONAUTICAL ENGINEERING

### SEMESTER VI ELECTIVE – I

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
1.	AE6001	<u>Theory of Elasticity</u>	3	0	0	3
2.	AE6002	<u>Aircraft General Engineering and Maintenance Practices</u>	3	0	0	3
3.	AE6003	<u>Space Mechanics</u>	3	0	0	3
4.	AE6004	<u>Heat Transfer</u>	3	0	0	3

### SEMESTER VII ELECTIVES– II

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
1.	AE6005	<u>Helicopter Theory</u>	3	0	0	3
2.	AE6006	<u>Theory of Plates and Shells</u>	3	0	0	3
3.	AE6007	<u>Fatigue and Fracture</u>	3	0	0	3
4.	AE6008	<u>UAV Systems</u>	3	0	0	3

### ELECTIVES – III

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
1.	AE6009	<u>Industrial Aerodynamics</u>	3	0	0	3
2.	AE6010	<u>Airframe Maintenance and Repair</u>	3	0	0	3
3.	AE6011	<u>Aero Engine Maintenance and Repair</u>	3	0	0	3
4.	AE6012	<u>Air Traffic Control and Planning</u>	3	0	0	3

### SEMESTER VIII ELECTIVES – IV

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
1.	AE6013	<u>Hypersonic Aerodynamics</u>	3	0	0	3
2.	AE6014	<u>Experimental Aerodynamics</u>	3	0	0	3
3.	AE6015	<u>Rockets and Missiles</u>	3	0	0	3
4.	AE6016	<u>Structural Dynamics</u>	3	0	0	3

**OBJECTIVES:**

- To enable learners of Engineering and Technology develop their basic communication skills in English.
- To emphasize specially the development of speaking skills amongst learners of Engineering and Technology.
- To ensure that learners use the electronic media such as internet and supplement the learning materials used in the classroom.
- To inculcate the habit of reading and writing leading to effective and efficient communication.

**UNIT I****9+3**

Listening - Introducing learners to GIE - Types of listening - Listening to audio (verbal & sounds); Speaking - Speaking about one's place, important festivals etc. – Introducing oneself, one's family / friend; Reading - Skimming a reading passage – Scanning for specific information - Note-making; Writing - Free writing on any given topic (My favourite place / Hobbies / School life, etc.) - Sentence completion - Autobiographical writing (writing about one's leisure time activities, hometown, etc.); Grammar - Prepositions - Reference words - Wh-questions - Tenses (Simple); Vocabulary - Word formation - Word expansion (root words / etymology); E-materials - Interactive exercises for Grammar & Vocabulary - Reading comprehension exercises - Listening to audio files and answering questions.

**UNIT II****9+3**

Listening - Listening and responding to video lectures / talks; Speaking - Describing a simple process (filling a form, etc.) - Asking and answering questions - Telephone skills – Telephone etiquette; Reading – Critical reading - Finding key information in a given text - Sifting facts from opinions; Writing - Biographical writing (place, people) - Process descriptions (general/specific) - Definitions - Recommendations – Instructions; Grammar - Use of imperatives - Subject-verb agreement; Vocabulary - Compound words - Word Association (connotation); E-materials - Interactive exercises for Grammar and Vocabulary - Listening exercises with sample telephone conversations / lectures – Picture-based activities.

**UNIT III****9+3**

Listening - Listening to specific task - focused audio tracks; Speaking - Role-play – Simulation - Group interaction - Speaking in formal situations (teachers, officials, foreigners); Reading - Reading and interpreting visual material; Writing - Jumbled sentences - Coherence and cohesion in writing - Channel conversion (flowchart into process) - Types of paragraph (cause and effect / compare and contrast / narrative / analytical) - Informal writing (letter/e-mail/blogs) - Paraphrasing; Grammar - Tenses (Past) - Use of sequence words - Adjectives; Vocabulary - Different forms and uses of words, Cause and effect words; E-materials - Interactive exercises for Grammar and Vocabulary - Excerpts from films related to the theme and follow up exercises - Pictures of flow charts and tables for interpretations.

**UNIT IV****9+3**

Listening - Watching videos / documentaries and responding to questions based on them; Speaking - Responding to questions - Different forms of interviews - Speaking at different types of interviews; Reading - Making inference from the reading passage - Predicting the content of a reading passage; Writing - Interpreting visual materials (line graphs, pie charts etc.) - Essay writing – Different types of essays; Grammar - Adverbs – Tenses – future time reference; Vocabulary - Single word substitutes - Use of abbreviations and acronyms; E-materials - Interactive exercises for Grammar and Vocabulary - Sample interviews - film scenes - dialogue writing.

## UNIT V

9+3

Listening - Listening to different accents, Listening to Speeches/Presentations, Listening to broadcast and telecast from Radio and TV; Speaking - Giving impromptu talks, Making presentations on given topics; Reading - Email communication - Reading the attachment files having a poem/joke/proverb - Sending their responses through email; Writing - Creative writing, Poster making; Grammar - Direct and indirect speech; Vocabulary - Lexical items (fixed / semi fixed expressions); E-materials - Interactive exercises for Grammar and Vocabulary - Sending emails with attachment – Audio / video excerpts of different accents - Interpreting posters.

**TOTAL (L:45+T:15): 60 PERIODS**

### OUTCOMES:

Learners should be able to

- speak clearly, confidently, comprehensibly, and communicate with one or many listeners using appropriate communicative strategies.
- write cohesively and coherently and flawlessly avoiding grammatical errors, using a wide vocabulary range, organizing their ideas logically on a topic.
- read different genres of texts adopting various reading strategies.
- listen/view and comprehend different spoken discourses/excerpts in different accents

### TEXTBOOKS:

1. Department of English, Anna University. Mindscapes: English for Technologists and Engineers. Orient Blackswan, Chennai. 2012
2. Dhanavel, S.P. English and Communication Skills for Students of Science and Engineering. Orient Blackswan, Chennai. 2011

### REFERENCES:

1. Raman, Meenakshi & Sangeetha Sharma. Technical Communication: Principles and Practice. Oxford University Press, New Delhi. 2011.
2. Regional Institute of English. English for Engineers. Cambridge University Press, New Delhi. 2006.
3. Rizvi, Ashraf. M. Effective Technical Communication. Tata McGraw-Hill, New Delhi. 2005
4. Rutherford, Andrea. J Basic Communication Skills for Technology. Pearson, New Delhi. 2001.
5. Viswamohan, Aysha. English for Technical Communication. Tata McGraw-Hill, New Delhi. 2008.

### EXTENSIVE Reading (Not for Examination)

1. Kalam, Abdul. Wings of Fire. Universities Press, Hyderabad. 1999.

### WEBSITES:

1. <http://www.usingenglish.com>
2. <http://www.uefap.com>

### TEACHING METHODS:

- Lectures
- Activities conducted individually, in pairs and in groups like self introduction, peer introduction, group poster making, grammar and vocabulary games, etc.
- Discussions
- Role play activities
- Short presentations
- Listening and viewing activities with follow up activities like discussion, filling up worksheets, writing exercises (using language lab wherever necessary/possible) etc.

## EVALUATION PATTERN:

### Internal assessment: 20%

3 tests of which two are pen and paper tests and the other is a combination of different modes of assessment like

- Project
- Assignment
- Reviews
- Creative writing
- Poster making, etc.

All the four skills are to be tested with equal weightage given to each.

- ✓ Speaking assessment: Individual speaking activities, Pair work activities like role play, Interview, Group discussions
- ✓ Reading assessment: Reading passages with comprehension questions graded from simple to complex, from direct to inferential
- ✓ Writing assessment: Writing paragraphs, essays etc. Writing should include grammar and vocabulary.
- ✓ Listening/Viewing assessment: Lectures, dialogues, film clippings with questions on verbal as well as audio/visual content.

### End Semester Examination: 80%

MA6151

MATHEMATICS – I

L T P C  
3 1 0 4

### OBJECTIVES:

- To develop the use of matrix algebra techniques this is needed by engineers for practical applications.
- To make the student knowledgeable in the area of infinite series and their convergence so that he/ she will be familiar with limitations of using infinite series approximations for solutions arising in mathematical modeling.
- To familiarize the student with functions of several variables. This is needed in many branches of engineering.
- To introduce the concepts of improper integrals, Gamma, Beta and Error functions which are needed in engineering applications.
- To acquaint the student with mathematical tools needed in evaluating multiple integrals and their usage.

### UNIT I MATRICES

9+3

Eigenvalues and Eigenvectors of a real matrix – Characteristic equation – Properties of eigenvalues and eigenvectors – Statement and applications of Cayley-Hamilton Theorem – Diagonalization of matrices – Reduction of a quadratic form to canonical form by orthogonal transformation – Nature of quadratic forms.

### UNIT II SEQUENCES AND SERIES

9+3

Sequences: Definition and examples – Series: Types and Convergence – Series of positive terms – Tests of convergence: Comparison test, Integral test and D'Alembert's ratio test – Alternating series – Leibnitz's test – Series of positive and negative terms – Absolute and conditional convergence.

**UNIT III APPLICATIONS OF DIFFERENTIAL CALCULUS 9+3**  
Curvature in Cartesian co-ordinates – Centre and radius of curvature – Circle of curvature – Evolutes – Envelopes - Evolute as envelope of normals.

**UNIT IV DIFFERENTIAL CALCULUS OF SEVERAL VARIABLES 9+3**  
Limits and Continuity – Partial derivatives – Total derivative – Differentiation of implicit functions – Jacobian and properties – Taylor’s series for functions of two variables – Maxima and minima of functions of two variables – Lagrange’s method of undetermined multipliers.

**UNIT V MULTIPLE INTEGRALS 9+3**  
Double integrals in cartesian and polar coordinates – Change of order of integration – Area enclosed by plane curves – Change of variables in double integrals – Area of a curved surface - Triple integrals – Volume of Solids.

**TOTAL (L:45+T:15): 60 PERIODS**

**OUTCOMES:**

- This course equips students to have basic knowledge and understanding in one fields of materials, integral and differential calculus.

**TEXT BOOKS:**

1. Bali N. P and Manish Goyal, “A Text book of Engineering Mathematics”, Eighth Edition, Laxmi Publications Pvt Ltd., 2011.
2. Grewal. B.S, “Higher Engineering Mathematics”, 41<sup>st</sup> Edition, Khanna Publications, Delhi, 2011.

**REFERENCES:**

1. Dass, H.K., and Er. Rajnish Verma, “Higher Engineering Mathematics”, S. Chand Private Ltd., 2011.
2. Glyn James, “Advanced Modern Engineering Mathematics”, 3<sup>rd</sup> Edition, Pearson Education, 2012.
3. Peter V. O’Neil, “Advanced Engineering Mathematics”, 7th Edition, Cengage learning, 2012.
4. Ramana B.V, “Higher Engineering Mathematics”, Tata McGraw Hill Publishing Company, New Delhi, 2008.
5. Sivarama Krishna Das P. and Rukmangadachari E., “Engineering Mathematics”, Volume I, Second Edition, PEARSON Publishing, 2011.

**PH6151 ENGINEERING PHYSICS – I L T P C**  
**3 0 0 3**

**OBJECTIVES:**

- To enhance the fundamental knowledge in Physics and its applications relevant to various streams of Engineering and Technology.

**UNIT I CRYSTAL PHYSICS 9**  
Lattice – Unit cell – Bravais lattice – Lattice planes – Miller indices – d spacing in cubic lattice – Calculation of number of atoms per unit cell – Atomic radius – Coordination number – Packing factor for SC, BCC, FCC and HCP structures – Diamond and graphite structures (qualitative treatment) - Crystal growth techniques –solution, melt (Bridgman and Czochralski) and vapour growth techniques (qualitative)





**OBJECTIVES:**

- To make the students conversant with basics of polymer chemistry.
- To make the student acquire sound knowledge of second law of thermodynamics and second law based derivations of importance in engineering applications in all disciplines.
- To acquaint the student with concepts of important photophysical and photochemical processes and spectroscopy.
- To develop an understanding of the basic concepts of phase rule and its applications to single and two component systems and appreciate the purpose and significance of alloys.
- To acquaint the students with the basics of nano materials, their properties and applications.

**UNIT I POLYMER CHEMISTRY****9**

Introduction: Classification of polymers – Natural and synthetic; Thermoplastic and Thermosetting. Functionality – Degree of polymerization. Types and mechanism of polymerization: Addition (Free Radical, cationic and anionic); condensation and copolymerization. Properties of polymers: T<sub>g</sub>, Tacticity, Molecular weight – weight average, number average and polydispersity index. Techniques of polymerization: Bulk, emulsion, solution and suspension. Preparation, properties and uses of Nylon 6,6, and Epoxy resin.

**UNIT II CHEMICAL THERMODYNAMICS****9**

Terminology of thermodynamics - Second law: Entropy - entropy change for an ideal gas, reversible and irreversible processes; entropy of phase transitions; Clausius inequality. Free energy and work function: Helmholtz and Gibbs free energy functions (problems); Criteria of spontaneity; Gibbs-Helmholtz equation (problems); Clausius-Clapeyron equation; Maxwell relations – Van't Hoff isotherm and isochore(problems).

**UNIT III PHOTOCHEMISTRY AND SPECTROSCOPY****9**

Photochemistry: Laws of photochemistry - Grotthuss-Draper law, Stark-Einstein law and Lambert-Beer Law. Quantum efficiency – determination- Photo processes - Internal Conversion, Inter-system crossing, Fluorescence, Phosphorescence, Chemiluminescence and Photo-sensitization. Spectroscopy: Electromagnetic spectrum - Absorption of radiation – Electronic, Vibrational and rotational transitions. UV-visible and IR spectroscopy – principles, instrumentation (Block diagram only).

**UNIT IV PHASE RULE AND ALLOYS****9**

Phase rule: Introduction, definition of terms with examples, One Component System- water system - Reduced phase rule - Two Component Systems- classification – lead-silver system, zinc-magnesium system. Alloys: Introduction- Definition- Properties of alloys- Significance of alloying, Functions and effect of alloying elements- Ferrous alloys- Nichrome and Stainless steel – heat treatment of steel; Non-ferrous alloys – brass and bronze.

**UNIT V NANOCHEMISTRY****9**

Basics - distinction between molecules, nanoparticles and bulk materials; size-dependent properties. Nanoparticles: nano cluster, nano rod, nanotube(CNT) and nanowire. Synthesis: precipitation, thermolysis, hydrothermal, solvothermal, electrode position, chemical vapour deposition, laser ablation; Properties and applications

**TOTAL :45 PERIODS****OUTCOMES:**

- The knowledge gained on polymer chemistry, thermodynamics, spectroscopy, phase rule and nano materials will provide a strong platform to understand the concepts on these subjects for further learning.

**TEXT BOOKS:**

1. Jain P.C. and Monica Jain, "Engineering Chemistry", Dhanpat Rai Publishing Company (P) Ltd., New Delhi, 2010
2. Kannan P., Ravikrishnan A., "Engineering Chemistry", Sri Krishna Hi-tech Publishing Company Pvt. Ltd. Chennai, 2009

**REFERENCES:**

1. Dara S.S, Umare S.S, "Engineering Chemistry", S. Chand & Company Ltd., New Delhi 2010
2. Sivasankar B., "Engineering Chemistry", Tata McGraw-Hill Publishing Company, Ltd., New Delhi, 2008.
3. Gowariker V.R. , Viswanathan N.V. and JayadevSreedhar, "Polymer Science", New Age International P (Ltd.), Chennai, 2006.
4. Ozin G. A. and Arsenault A. C., "Nanochemistry: A Chemical Approach to Nanomaterials", RSC Publishing, 2005.

**GE6151****COMPUTER PROGRAMMING****L T P C  
3 0 0 3****OBJECTIVES:****The students should be made to:**

- Learn the organization of a digital computer.
- Be exposed to the number systems.
- Learn to think logically and write pseudo code or draw flow charts for problems.
- Be exposed to the syntax of C.
- Be familiar with programming in C.
- Learn to use arrays, strings, functions, pointers, structures and unions in C.

**UNIT I INTRODUCTION****8**

Generation and Classification of Computers- Basic Organization of a Computer –Number System – Binary – Decimal – Conversion – Problems. Need for logical analysis and thinking – Algorithm – Pseudo code – Flow Chart.

**UNIT II C PROGRAMMING BASICS****10**

Problem formulation – Problem Solving - Introduction to 'C' programming –fundamentals – structure of a 'C' program – compilation and linking processes – Constants, Variables – Data Types – Expressions using operators in 'C' – Managing Input and Output operations – Decision Making and Branching – Looping statements – solving simple scientific and statistical problems.

**UNIT III ARRAYS AND STRINGS****9**

Arrays – Initialization – Declaration – One dimensional and Two dimensional arrays. String- String operations – String Arrays. Simple programs- sorting- searching – matrix operations.

**UNIT IV FUNCTIONS AND POINTERS****9**

Function – definition of function – Declaration of function – Pass by value – Pass by reference – Recursion – Pointers - Definition – Initialization – Pointers arithmetic – Pointers and arrays- Example Problems.

## UNIT V STRUCTURES AND UNIONS

9

Introduction – need for structure data type – structure definition – Structure declaration – Structure within a structure - Union - Programs using structures and Unions – Storage classes, Pre-processor directives.

**TOTAL: 45 PERIODS**

### OUTCOMES:

**At the end of the course, the student should be able to:**

- Design C Programs for problems.
- Write and execute C programs for simple applications.

### TEXTBOOKS:

1. Anita Goel and Ajay Mittal, "Computer Fundamentals and Programming in C", Dorling Kindersley (India) Pvt. Ltd., Pearson Education in South Asia, 2011.
2. Pradip Dey, Manas Ghosh, "Fundamentals of Computing and Programming in C", First Edition, Oxford University Press, 2009
3. Yashavant P. Kanetkar. "Let Us C", BPB Publications, 2011.

### REFERENCES:

1. Byron S Gottfried, "Programming with C", Schaum's Outlines, Second Edition, Tata McGraw-Hill, 2006.
2. Dromey R.G., "How to Solve it by Computer", Pearson Education, Fourth Reprint, 2007.
3. Kernighan, B.W and Ritchie, D.M, "The C Programming language", Second Edition, Pearson Education, 2006.
4. Rajaram.M. and Uma Maheswari, 'Computer programming with C', pearson 2014.

**GE6152**

**ENGINEERING GRAPHICS**

**L T P C**  
**2 0 3 4**

### OBJECTIVES:

- To develop in students, graphic skills for communication of concepts, ideas and design of Engineering products.
- To expose them to existing national standards related to technical 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.

## UNIT I PLANE CURVES AND FREE HAND SKETCHING

5+9

Basic Geometrical constructions, Curves used in engineering practices: Conics – Construction of ellipse, parabola and hyperbola by eccentricity method – Construction of cycloid – construction of involutes of square and circle – Drawing of tangents and normal to the above curves, Scales: Construction of Diagonal and Vernier scales.

Visualization concepts and Free Hand sketching: Visualization principles –Representation of Three Dimensional objects – Layout of views- Free hand sketching of multiple views from pictorial views of objects

## UNIT II PROJECTION OF POINTS, LINES AND PLANE SURFACES

5+9

Orthographic projection- principles-Principal planes-First angle projection-projection of points. Projection of straight lines (only First angle projections) inclined to both the principal planes - Determination of true lengths and true inclinations by rotating line method and traces Projection of planes (polygonal and circular surfaces) inclined to both the principal planes by rotating object

method.

**UNIT III PROJECTION OF SOLIDS**

**5+9**

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

**UNIT IV PROJECTION OF SECTIONED SOLIDS AND DEVELOPMENT OF SURFACES**

**5+9**

Sectioning of above solids in simple vertical position when the cutting plane is inclined to the one of the principal planes and perpendicular to the other – obtaining true shape of section. Development of lateral surfaces of simple and sectioned solids – Prisms, pyramids cylinders and cones. Development of lateral surfaces of solids with cut-outs and holes

**UNIT V ISOMETRIC AND PERSPECTIVE PROJECTIONS**

**6+9**

Principles of isometric projection – isometric scale – Isometric projections of simple solids and truncated solids - Prisms, pyramids, cylinders, cones- combination of two solid objects in simple vertical positions and miscellaneous problems. Perspective projection of simple solids-Prisms, pyramids and cylinders by visual ray method .

**COMPUTER AIDED DRAFTING (Demonstration Only)**

**3**

Introduction to drafting packages and demonstration of their use.

**TOTAL: 75 PERIODS**

**OUTCOMES:**

On Completion of the course the student will be able to

- perform free hand sketching of basic geometrical constructions and multiple views of objects.
- do orthographic projection of lines and plane surfaces.
- draw projections and solids and development of surfaces.
- prepare isometric and perspective sections of simple solids.
- demonstrate computer aided drafting.

**TEXT BOOK:**

1. Bhatt N.D. and Panchal V.M., “Engineering Drawing”, Charotar Publishing House, 50<sup>th</sup> Edition, 2010.

**REFERENCES:**

1. Gopalakrishna K.R., “Engineering Drawing” (Vol. I&II combined), Subhas Stores, Bangalore, 2007.
2. Luzzader, Warren.J. and Duff, John M., “Fundamentals of Engineering Drawing with an introduction to Interactive Computer Graphics for Design and Production, Eastern Economy Edition, Prentice Hall of India Pvt. Ltd, New Delhi, 2005.
3. Shah M.B., and Rana B.C., “Engineering Drawing”, Pearson, 2<sup>nd</sup> Edition, 2009.
4. Venugopal K. and Prabhu Raja V., “Engineering Graphics”, New Age International (P) Limited, 2008.
5. Natrajan K.V., “A text book of Engineering Graphics”, Dhanalakshmi Publishers, Chennai, 2009.
6. Basant Agarwal and Agarwal C.M., “Engineering Drawing”, Tata McGraw Hill Publishing Company Limited, New Delhi, 2008.

**Publication of Bureau of Indian Standards:**

1. IS 10711 – 2001: Technical products Documentation – Size and lay out of drawing sheets.
2. IS 9609 (Parts 0 & 1) – 2001: Technical products Documentation – Lettering.
3. IS 10714 (Part 20) – 2001 & SP 46 – 2003: Lines for technical drawings.
4. IS 11669 – 1986 & SP 46 – 2003: Dimensioning of Technical Drawings.

5. IS 15021 (Parts 1 to 4) – 2001: Technical drawings – Projection Methods.

**Special points applicable to University Examinations on Engineering Graphics:**

1. There will be five questions, each of either or type covering all units of the syllabus.
2. All questions will carry equal marks of 20 each making a total of 100.
3. The answer paper shall consist of drawing sheets of A3 size only. The students will be permitted to use appropriate scale to fit solution within A3 size.
4. The examination will be conducted in appropriate sessions on the same day

**GE6161**

**COMPUTER PRACTICES LABORATORY**

**L T P C**  
**0 0 3 2**

**OBJECTIVES:**

**The student should be made to:**

- Be familiar with the use of Office software.
- Be exposed to presentation and visualization tools.
- Be exposed to problem solving techniques and flow charts.
- Be familiar with programming in C.
- Learn to use Arrays, strings, functions, structures and unions.

**LIST OF EXPERIMENTS:**

1. Search, generate, manipulate data using MS office/ Open Office
2. Presentation and Visualization – graphs, charts, 2D, 3D
3. Problem formulation, Problem Solving and Flowcharts
4. C Programming using Simple statements and expressions
5. Scientific problem solving using decision making and looping.
6. Simple programming for one dimensional and two dimensional arrays.
7. Solving problems using String functions
8. Programs with user defined functions – Includes Parameter Passing
9. Program using Recursive Function and conversion from given program to flow chart.
10. Program using structures and unions.

**TOTAL : 45 PERIODS**

**OUTCOMES:**

**At the end of the course, the student should be able to:**

- Apply good programming design methods for program development.
- Design and implement C programs for simple applications.
- Develop recursive programs.

**LIST OF EQUIPMENTS FOR A BATCH OF 30 STUDENTS:**

Standalone desktops with C compiler      30 Nos.

(or)

Server with C compiler supporting 30 terminals or more.

**OBJECTIVES:**

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

**GROUP A (CIVIL & MECHANICAL)****I CIVIL ENGINEERING PRACTICE****9****Buildings:**

- (a) Study of plumbing and carpentry components of residential and industrial buildings. Safety aspects.

**Plumbing Works:**

- (a) Study of pipeline joints, its location and functions: valves, taps, couplings, unions, reducers, elbows in household fittings.  
 (b) Study of pipe connections requirements for pumps and turbines.  
 (c) Preparation of plumbing line sketches for water supply and sewage works.  
 (d) Hands-on-exercise:  
     Basic pipe connections – Mixed pipe material connection – Pipe connections with different joining components.  
 (e) Demonstration of plumbing requirements of high-rise buildings.

**Carpentry using Power Tools only:**

- (a) Study of the joints in roofs, doors, windows and furniture.  
 (b) Hands-on-exercise:  
     Wood work, joints by sawing, planing and cutting.

**II MECHANICAL ENGINEERING PRACTICE****13****Welding:**

- (a) Preparation of arc welding of butt joints, lap joints and tee joints.  
 (b) Gas welding practice

**Basic Machining:**

- (a) Simple Turning and Taper turning  
 (b) Drilling Practice

**Sheet Metal Work:**

- (a) Forming & Bending:  
 (b) Model making – Trays, funnels, etc.  
 (c) Different type of joints.

**Machine assembly practice:**

- (a) Study of centrifugal pump  
 (b) Study of air conditioner

**Demonstration on:**

- (a) Smithy operations, upsetting, swaging, setting down and bending. Example – Exercise – Production of hexagonal headed bolt.  
 (b) Foundry operations like mould preparation for gear and step cone pulley.  
 (c) Fitting – Exercises – Preparation of square fitting and vee – fitting models.

## GROUP B (ELECTRICAL & ELECTRONICS)

- III ELECTRICAL ENGINEERING PRACTICE** **10**
1. Residential house wiring using switches, fuse, indicator, lamp and energy meter.
  2. Fluorescent lamp wiring.
  3. Stair case wiring
  4. Measurement of electrical quantities – voltage, current, power & power factor in RLC circuit.
  5. Measurement of energy using single phase energy meter.
  6. Measurement of resistance to earth of an electrical equipment.
- IV ELECTRONICS ENGINEERING PRACTICE** **13**
1. Study of Electronic components and equipments – Resistor, colour coding measurement of AC signal parameter (peak-peak, rms period, frequency) using CR.
  2. Study of logic gates AND, OR, EOR and NOT.
  3. Generation of Clock Signal.
  4. Soldering practice – Components Devices and Circuits – Using general purpose PCB.
  5. Measurement of ripple factor of HWR and FWR.

**TOTAL: 45 PERIODS**

### **OUTCOMES:**

- ability to fabricate carpentry components and pipe connections including plumbing works.
- ability to use welding equipments to join the structures.
- ability to fabricate electrical and electronics circuits.

### **REFERENCES:**

1. Jeyachandran K., Natarajan S. & Balasubramanian S., “A Primer on Engineering Practices Laboratory”, Anuradha Publications, 2007.
2. Jeyapooan T., Saravanapandian M. & Pranitha S., “Engineering Practices Lab Manual”, Vikas PUBLISHING House Pvt.Ltd, 2006.
3. Bawa H.S., “Workshop Practice”, Tata McGraw – Hill Publishing Company Limited, 2007.
4. Rajendra Prasad A. & Sarma P.M.M.S., “Workshop Practice”, Sree Sai Publication, 2002.
5. Kannaiah P. & Narayana K.L., “Manual on Workshop Practice”, Scitech Publications, 1999.

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

#### **CIVIL**

- |   |          |
|---|----------|
| 1. Assorted components for plumbing consisting of metallic pipes, plastic pipes, flexible pipes, couplings, unions, elbows, plugs and other fittings. | 15 Sets. |
| 2. Carpentry vice (fitted to work bench)  | 15 Nos.  |
| 3. Standard woodworking tools   | 15 Sets. |
| 4. Models of industrial trusses, door joints, furniture joints  | 5 each   |
| 5. Power Tools: (a) Rotary Hammer   | 2 Nos    |
| (b) Demolition Hammer   | 2 Nos    |
| (c) Circular Saw  | 2 Nos    |
| (d) Planer  | 2 Nos    |
| (e) Hand Drilling Machine   | 2 Nos    |
| (f) Jigsaw  | 2 Nos    |



## MECHANICAL

- |   |           |
|---|-----------|
| 1. Arc welding transformer with cables and holders                            | 5 Nos.    |
| 2. Welding booth with exhaust facility  | 5 Nos.    |
| 3. Welding accessories like welding shield, chipping hammer, wire brush, etc. | 5 Sets.   |
| 4. Oxygen and acetylene gas cylinders, blow pipe and other welding outfit.    | 2 Nos.    |
| 5. Centre lathe   | 2 Nos.    |
| 6. Hearth furnace, anvil and smithy tools                                     | 2 Sets.   |
| 7. Moulding table, foundry tools  | 2 Sets.   |
| 8. Power Tool: Angle Grinder  | 2 Nos     |
| 9. Study-purpose items: centrifugal pump, air-conditioner                     | One each. |

## ELECTRICAL

- |  |         |
|--|---------|
| 1. Assorted electrical components for house wiring                         | 15 Sets |
| 2. Electrical measuring instruments  | 10 Sets |
| 3. Study purpose items: Iron box, fan and regulator, emergency lamp 1 each |         |
| 4. Megger (250V/500V)  | 1 No.   |
| 5. Power Tools: (a) Range Finder   | 2 Nos   |
| (b) Digital Live-wire detector   | 2 Nos   |

## ELECTRONICS

- |   |         |
|---|---------|
| 1. Soldering guns   | 10 Nos. |
| 2. Assorted electronic components for making circuits                 | 50 Nos. |
| 3. Small PCBs   | 10 Nos. |
| 4. Multimeters  | 10 Nos. |
| 5. Study purpose items: Telephone, FM radio, low-voltage power supply |         |

**GE6163**

**PHYSICS AND CHEMISTRY LABORATORY – I**

**L T P C**  
**0 0 2 1**

**PHYSICS LABORATORY – I**

### OBJECTIVES:

- To introduce different experiments to test basic understanding of physics concepts applied in optics, thermal physics and properties of matter.

### LIST OF EXPERIMENTS

(Any FIVE Experiments)

- (a) Determination of Wavelength, and particle size using Laser  
(b) Determination of acceptance angle in an optical fiber.
- Determination of velocity of sound and compressibility of liquid – Ultrasonic interferometer.
- Determination of wavelength of mercury spectrum – spectrometer grating
- Determination of thermal conductivity of a bad conductor – Lee's Disc method.
- Determination of Young's modulus by Non uniform bending method
- Determination of specific resistance of a given coil of wire – Carey Foster's Bridge

**OUTCOMES:**

- The hands on exercises undergone by the students will help them to apply physics principles of optics and thermal physics to evaluate engineering properties of materials.

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

1. Diode laser, lycopodium powder, glass plate, optical fiber.
2. Ultrasonic interferometer
3. Spectrometer, mercury lamp, grating
4. Lee's Disc experimental set up
5. Traveling microscope, meter scale, knife edge, weights
6. Carey foster's bridge set up  
(vernier Caliper, Screw gauge, reading lens are required for most of the experiments)

**CHEMISTRY LABORATORY- I****OBJECTIVES:**

- To make the student to acquire practical skills in the determination of water quality parameters through volumetric and instrumental analysis.
- To acquaint the students with the determination of molecular weight of a polymer by vacometry.

**LIST OF EXPERIMENTS**

(Any FIVE Experiments)

- 1 Determination of DO content of water sample by Winkler's method.
- 2 Determination of chloride content of water sample by argentometric method.
- 3 Determination of strength of given hydrochloric acid using pH meter.
- 4 Determination of strength of acids in a mixture using conductivity meter.
- 5 Estimation of iron content of the water sample using spectrophotometer.  
(1,10- phenanthroline / thiocyanate method).
- 6 Determination of molecular weight of polyvinylalcohol using Ostwald viscometer.
- 7 Conductometric titration of strong acid vs strong base.

**TOTAL: 30 PERIODS**

**OUTCOMES:**

- The students will be outfitted with hands-on knowledge in the quantitative chemical analysis of water quality related parameters.

**REFERENCES:**

1. Daniel R. Palleros, "Experimental organic chemistry" John Wiley & Sons, Inc., New York 2001.
2. Furniss B.S. Hannaford A.J, Smith P.W.G and Tatchel A.R., "Vogel's Textbook of practical organic chemistry", LBS Singapore 1994.
3. Jeffery G.H., Bassett J., Mendham J. and Denny vogel's R.C, "Text book of quantitative analysis chemical analysis", ELBS 5th Edn. Longman, Singapore publishers, Singapore, 1996.
4. Kolthoff I.M., Sandell E.B. et al. "Quantitative chemical analysis", Mcmillan, Madras 1980.

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

1. Iodine flask	-	30 Nos
2. pH meter	-	5 Nos
3. Conductivity meter	-	5 Nos
4. Spectrophotometer	-	5 Nos
5. Ostwald Viscometer	-	10 Nos

**Common Apparatus : Pipette, Burette, conical flask, porcelain tile, dropper (each 30 Nos.)**

**OBJECTIVES:**

- To make learners acquire listening and speaking skills in both formal and informal contexts.
- To help them develop their reading skills by familiarizing them with different types of reading strategies.
- To equip them with writing skills needed for academic as well as workplace contexts.
- To make them acquire language skills at their own pace by using e-materials and language lab components.

**UNIT I****9+3**

Listening - Listening to informal conversations and participating; Speaking - Opening a conversation (greetings, comments on topics like weather) - Turn taking - Closing a conversation (excuses, general wish, positive comment, thanks); Reading - Developing analytical skills, Deductive and inductive reasoning - Extensive reading; Writing - Effective use of SMS for sending short notes and messages - Using 'emojicons' as symbols in email messages; Grammar - Regular and irregular verbs - Active and passive voice; Vocabulary - Homonyms (e.g. 'can') - Homophones (e.g. 'some', 'sum'); E-materials - Interactive exercise on Grammar and vocabulary – blogging; Language Lab - Listening to different types of conversation and answering questions.

**UNIT II****9+3**

Listening - Listening to situation based dialogues; Speaking - Conversation practice in real life situations, asking for directions (using polite expressions), giving directions (using imperative sentences), Purchasing goods from a shop, Discussing various aspects of a film (they have already seen) or a book (they have already read); Reading - Reading a short story or an article from newspaper, Critical reading, Comprehension skills; Writing - Writing a review / summary of a story / article, Personal letter (Inviting your friend to a function, congratulating someone for his / her success, thanking one's friends / relatives); Grammar - modal verbs, Purpose expressions; Vocabulary - Phrasal verbs and their meanings, Using phrasal verbs in sentences; E-materials - Interactive exercises on Grammar and vocabulary, Extensive reading activity (reading stories / novels), Posting reviews in blogs - Language Lab - Dialogues (Fill up exercises), Recording students' dialogues.

**UNIT III****9+3**

Listening - Listening to the conversation - Understanding the structure of conversations; Speaking - Conversation skills with a sense of stress, intonation, pronunciation and meaning - Seeking information – expressing feelings (affection, anger, regret, etc.); Reading - Speed reading – reading passages with time limit - Skimming; Writing - Minutes of meeting – format and practice in the preparation of minutes - Writing summary after reading articles from journals - Format for journal articles – elements of technical articles (abstract, introduction, methodology, results, discussion, conclusion, appendices, references) - Writing strategies; Grammar - Conditional clauses - Cause and effect expressions; Vocabulary - Words used as nouns and verbs without any change in the spelling (e.g. 'rock', 'train', 'ring'); E-materials - Interactive exercise on Grammar and vocabulary - Speed Reading practice exercises; Language Lab - Intonation practice using EFLU and RIE materials – Attending a meeting and writing minutes.

**UNIT IV****9+3**

Listening - Listening to a telephone conversation, Viewing model interviews (face-to-face, telephonic and video conferencing); Speaking - Role play practice in telephone skills - listening and responding, -asking questions, -note taking – passing on messages, Role play and mock interview for grasping interview skills; Reading - Reading the job advertisements and the profile of the company concerned – scanning; Writing - Applying for a job – cover letter - résumé preparation – vision, mission and goals of the candidate; Grammar - Numerical expressions - Connectives (discourse markers); Vocabulary - Idioms and their meanings – using idioms in sentences; E-materials - Interactive exercises on

Grammar and Vocabulary - Different forms of résumés- Filling up a résumé / cover letter; Language Lab - Telephonic interview – recording the responses - e-résumé writing.

## **UNIT V**

**9+3**

Listening - Viewing a model group discussion and reviewing the performance of each participant - Identifying the characteristics of a good listener; Speaking - Group discussion skills – initiating the discussion – exchanging suggestions and proposals – expressing dissent/agreement – assertiveness in expressing opinions – mind mapping technique; Reading - Note making skills – making notes from books, or any form of written materials - Intensive reading; Writing – Checklist - Types of reports – Feasibility / Project report – report format – recommendations / suggestions – interpretation of data (using charts for effective presentation); Grammar - Use of clauses; Vocabulary – Collocation; E-materials - Interactive grammar and vocabulary exercises - Sample GD - Pictures for discussion, Interactive grammar and vocabulary exercises; Language Lab - Different models of group discussion.

**TOTAL (L:45+T:15): 60 PERIODS**

### **OUTCOMES:**

Learners should be able to

- Speak convincingly, express their opinions clearly, initiate a discussion, negotiate, argue using appropriate communicative strategies.
- Write effectively and persuasively and produce different types of writing such as narration, description, exposition and argument as well as creative, critical, analytical and evaluative writing.
- Read different genres of texts, infer implied meanings and critically analyse and evaluate them for ideas as well as for method of presentation.
- Listen/view and comprehend different spoken excerpts critically and infer unspoken and implied meanings.

### **TEXTBOOKS:**

1. Department of English, Anna University. Mindscapes: English for Technologists and Engineers. Orient Blackswan, Chennai. 2012
2. Dhanavel, S.P. English and Communication Skills for Students of Science and Engineering. Orient Blackswan, Chennai. 2011

### **REFERENCES:**

1. Anderson, Paul V. Technical Communication: A Reader-Centered Approach. Cengage. New Delhi. 2008
2. Muralikrishna, & Sunita Mishra. Communication Skills for Engineers. Pearson, New Delhi. 2011
3. Riordan, Daniel. G. Technical Communication. Cengage Learning, New Delhi. 2005
4. Sharma, Sangeetha & Binod Mishra. Communication Skills for Engineers and Scientists. PHI Learning, New Delhi. 2009
5. Smith-Worthington, Darlene & Sue Jefferson. Technical Writing for Success. Cengage, Mason USA. 2007

### **EXTENSIVE Reading (Not for Examination)**

1. Khera, Shiv. You can Win. Macmillan, Delhi. 1998.

### **Websites**

1. <http://www.englishclub.com>
2. <http://owl.english.purdue.edu>

## TEACHING METHODS:

- Lectures
- Activities conducted individually, in pairs and in groups like individual writing and presentations, group discussions, interviews, reporting, etc
- Long presentations using visual aids
- Listening and viewing activities with follow up activities like discussions, filling up worksheets, writing exercises (using language lab wherever necessary/possible) etc
- Projects like group reports, mock interviews etc using a combination of two or more of the language skills

## EVALUATION PATTERN:

### Internal assessment: 20%

3 tests of which two are pen and paper tests and the other is a combination of different modes of assessment like

- Project
- Assignment
- Report
- Creative writing, etc.

All the four skills are to be tested with equal weightage given to each.

- ✓ Speaking assessment: Individual presentations, Group discussions
- ✓ Reading assessment: Reading passages with comprehension questions graded following Bloom's taxonomy
- ✓ Writing assessment: Writing essays, CVs, reports etc. Writing should include grammar and vocabulary.
- ✓ Listening/Viewing assessment: Lectures, dialogues, film clippings with questions on verbal as well as audio/visual content graded following Bloom's taxonomy.

### End Semester Examination: 80%

MA6251

MATHEMATICS – II

L T P C  
3 1 0 4

### OBJECTIVES:

- To make the student acquire sound knowledge of techniques in solving ordinary differential equations that model engineering problems.
- To acquaint the student with the concepts of vector calculus needed for problems in all engineering disciplines.
- To develop an understanding of the standard techniques of complex variable theory so as to enable the student to apply them with confidence, in application areas such as heat conduction, elasticity, fluid dynamics and flow the of electric current.
- To make the student appreciate the purpose of using transforms to create a new domain in which it is easier to handle the problem that is being investigated.

### UNIT I VECTOR CALCULUS

9+3

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 parallelepipeds.



**OBJECTIVES:**

- To enrich the understanding of various types of materials and their applications in engineering and technology.

**UNIT I CONDUCTING MATERIALS****9**

Conductors – classical free electron theory of metals – Electrical and thermal conductivity – Wiedemann – Franz law – Lorentz number – Draw backs of classical theory – Quantum theory – Fermi distribution function – Effect of temperature on Fermi Function – Density of energy states – carrier concentration in metals.

**UNIT II SEMICONDUCTING MATERIALS****9**

Intrinsic semiconductor – carrier concentration derivation – Fermi level – Variation of Fermi level with temperature – electrical conductivity – band gap determination – compound semiconductors -direct and indirect band gap- derivation of carrier concentration in n-type and p-type semiconductor – variation of Fermi level with temperature and impurity concentration — Hall effect –Determination of Hall coefficient – Applications.

**UNIT III MAGNETIC AND SUPERCONDUCTING MATERIALS****9**

Origin of magnetic moment – Bohr magneton – comparison of Dia, Para and Ferro magnetism – Domain theory – Hysteresis – soft and hard magnetic materials – antiferromagnetic materials – Ferrites and its applications

Superconductivity: properties – Type I and Type II superconductors – BCS theory of superconductivity(Qualitative) - High  $T_c$  superconductors – Applications of superconductors – SQUID, cryotron, magnetic levitation.

**UNIT IV DIELECTRIC MATERIALS****9**

Electrical susceptibility – dielectric constant – electronic, ionic, orientational and space charge polarization – frequency and temperature dependence of polarisation – internal field – Clausius – Mosotti relation (derivation) – dielectric loss – dielectric breakdown – uses of dielectric materials (capacitor and transformer) – ferroelectricity and applications.

**UNIT V ADVANCED ENGINEERING MATERIALS****9**

Metallic glasses: preparation, properties and applications. Shape memory alloys (SMA): Characteristics, properties of NiTi alloy, application, Nanomaterials– Preparation -pulsed laser deposition – chemical vapour deposition – Applications – NLO materials –Birefringence- optical Kerr effect – Classification of Biomaterials and its applications

**TOTAL: 45 PERIODS****OUTCOMES:**

- The students will have the knowledge on physics of materials and that knowledge will be used by them in different engineering and technology applications.

**TEXT BOOKS:**

- Arumugam M., Materials Science. Anuradha publishers, 2010
- Pillai S.O., Solid State Physics. New Age International(P) Ltd., publishers, 2009

**REFERENCES:**

- Palanisamy P.K. Materials Science. SCITECH Publishers, 2011
- Senthilkumar G. Engineering Physics II. VRB Publishers, 2011
- Mani P. Engineering Physics II. Dhanam Publications, 2011
- Marikani A. Engineering Physics. PHI Learning Pvt., India, 2009

**OBJECTIVES:**

- To make the students conversant with boiler feed water requirements, related problems and water treatment techniques.
- Principles of electrochemical reactions, redox reactions in corrosion of materials and methods for corrosion prevention and protection of materials.
- Principles and generation of energy in batteries, nuclear reactors, solar cells, wind mills and fuel cells.
- Preparation, properties and applications of engineering materials.
- Types of fuels, calorific value calculations, manufacture of solid, liquid and gaseous fuels.

**UNIT I WATER TECHNOLOGY****9**

Introduction to boiler feed water-requirements-formation of deposits in steam boilers and heat exchangers- disadvantages (wastage of fuels, decrease in efficiency, boiler explosion) prevention of scale formation -softening of hard water -external treatment zeolite and demineralization - internal treatment- boiler compounds (phosphate, calgon, carbonate, colloidal) - caustic embrittlement -boiler corrosion-priming and foaming- desalination of brackish water –reverse osmosis.

**UNIT II ELECTROCHEMISTRY AND CORROSION****9**

Electrochemical cell - redox reaction, electrode potential- origin of electrode potential- oxidation potential- reduction potential, measurement and applications - electrochemical series and its significance - Nernst equation (derivation and problems). Corrosion- causes- factors- types- chemical, electrochemical corrosion (galvanic, differential aeration), corrosion control - material selection and design aspects - electrochemical protection – sacrificial anode method and impressed current cathodic method. Paints- constituents and function. Electroplating of Copper and electroless plating of nickel.

**UNIT III ENERGY SOURCES****9**

Introduction- nuclear energy- nuclear fission- controlled nuclear fission- nuclear fusion- differences between nuclear fission and fusion- nuclear chain reactions- nuclear reactor power generator- classification of nuclear reactor- light water reactor- breeder reactor- solar energy conversion- solar cells- wind energy. Batteries and fuel cells:Types of batteries- alkaline battery- lead storage battery- nickel-cadmium battery- lithium battery- fuel cell H<sub>2</sub> -O<sub>2</sub> fuel cell- applications.

**UNIT IV ENGINEERING MATERIALS****9**

Abrasives: definition, classification or types, grinding wheel, abrasive paper and cloth. Refractories: definition, characteristics, classification, properties – refractoriness and RUL, dimensional stability, thermal spalling, thermal expansion, porosity; Manufacture of alumina, magnesite and silicon carbide, Portland cement- manufacture and properties - setting and hardening of cement, special cement- waterproof and white cement–properties and uses. Glass - manufacture, types, properties and uses.

**UNIT V FUELS AND COMBUSTION****9**

Fuel: Introduction- classification of fuels- calorific value- higher and lower calorific values- coal-analysis of coal (proximate and ultimate)- carbonization- manufacture of metallurgical coke (Otto Hoffmann method) - petroleum- manufacture of synthetic petrol (Bergius process)- knocking-octane number - diesel oil- cetane number - natural gas- compressed natural gas(CNG)- liquefied petroleum gases(LPG)- producer gas- water gas. Power alcohol and bio diesel. Combustion of fuels: introduction- theoretical calculation of calorific value- calculation of stoichiometry of fuel and air ratio- ignition temperature- explosive range - flue gas analysis (ORSAT Method).

**TOTAL: 45 PERIODS**





**UNIT V FUNDAMENTALS OF COMMUNICATION ENGINEERING****12**

Types of Signals: Analog and Digital Signals – Modulation and Demodulation: Principles of Amplitude and Frequency Modulations.

Communication Systems: Radio, TV, Fax, Microwave, Satellite and Optical Fibre (Block Diagram Approach only).

**TOTAL: 60 PERIODS****OUTCOMES:**

- ability to identify the electrical components explain the characteristics of electrical machines.
- ability to identify electronics components and use of them to design circuits.

**TEXT BOOKS:**

1. Mittle N., "Basic Electrical Engineering", Tata McGraw Hill Edition, New Delhi, 1990.
2. Sedha R.S., "Applied Electronics", S. Chand & Co., 2006.

**REFERENCES:**

1. Muthusubramanian R, Salivahanan S and Muraleedharan K A, "Basic Electrical, Electronics and Computer Engineering", Tata McGraw Hill, Second Edition, 2006.
2. Nagsarkar T K and Sukhija M S, "Basics of Electrical Engineering", Oxford press 2005.
3. Mehta V K, "Principles of Electronics", S.Chand & Company Ltd, 1994.
4. Mahmood Nahvi and Joseph A. Edminister, "Electric Circuits", Schaum' Outline Series, McGraw Hill, 2002.
5. Premkumar N, "Basic Electrical Engineering", Anuradha Publishers, 2003.

**GE6253****ENGINEERING MECHANICS****L T P C  
3 1 0 4****OBJECTIVES:**

- To develop capacity to predict the effect of force and motion in the course of carrying out the design functions of engineering.

**UNIT I BASICS AND STATICS OF PARTICLES****12**

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****12**

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

**UNIT III PROPERTIES OF SURFACES AND SOLIDS****12**

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****12**

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 ELEMENTS OF RIGID BODY DYNAMICS****12**

Friction force – Laws of sliding friction – equilibrium analysis of simple systems with sliding friction – wedge 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 : 60 PERIODS****OUTCOMES:**

- ability to explain the differential principles applies to solve engineering problems dealing with force, displacement, velocity and acceleration.
- ability to analyse the forces in any structures.
- ability to solve rigid body subjected to dynamic forces.

**TEXT BOOKS:**

1. Beer, F.P and Johnston Jr. E.R., "Vector Mechanics for Engineers (In SI Units): Statics and Dynamics", 8<sup>th</sup> Edition, Tata McGraw-Hill Publishing company, New Delhi (2004).
2. Vela Murali, "Engineering Mechanics", Oxford University Press (2010)

**REFERENCES:**

1. Hibbeler, R.C and Ashok Gupta, "Engineering Mechanics: Statics and Dynamics", 11<sup>th</sup> Edition, Pearson Education 2010.
2. Irving H. Shames and Krishna Mohana Rao. G., "Engineering Mechanics – Statics and Dynamics", 4<sup>th</sup> Edition, Pearson Education 2006.
3. Meriam J.L. and Kraige L.G., " Engineering Mechanics- Statics - Volume 1, Dynamics- Volume 2", Third Edition, John Wiley & Sons,1993.
4. Rajasekaran S and Sankarasubramanian G., "Engineering Mechanics Statics and Dynamics", 3<sup>rd</sup> Edition, Vikas Publishing House Pvt. Ltd., 2005.
5. Bhavikatti, S.S and Rajashekarappa, K.G., "Engineering Mechanics", New Age International (P) Limited Publishers, 1998.
6. Kumar, K.L., "Engineering Mechanics", 3<sup>rd</sup> Revised Edition, Tata McGraw-Hill Publishing company, New Delhi 2008.

**GE6261 COMPUTER AIDED DRAFTING AND MODELING LABORATORY****L T P C  
0 1 2 2****OBJECTIVES:**

- To develop skill to use software to create 2D and 3D models.

**LIST OF EXERCISES USING SOFTWARE CAPABLE OF DRAFTING AND MODELING**

1. Study of capabilities of software for Drafting and Modeling – Coordinate systems (absolute, relative, polar, etc.) – Creation of simple figures like polygon and general multi-line figures.
2. Drawing of a Title Block with necessary text and projection symbol.
3. Drawing of curves like parabola, spiral, involute using Bspline or cubic spline.
4. Drawing of front view and top view of simple solids like prism, pyramid, cylinder, cone, etc, and dimensioning.
5. Drawing front view, top view and side view of objects from the given pictorial views (eg. V-block, Base of a mixie, Simple stool, Objects with hole and curves).

6. Drawing of a plan of residential building ( Two bed rooms, kitchen, hall, etc.)
7. Drawing of a simple steel truss.
8. Drawing sectional views of prism, pyramid, cylinder, cone, etc,
9. Drawing isometric projection of simple objects.
10. Creation of 3-D models of simple objects and obtaining 2-D multi-view drawings from 3-D model.

Note: Plotting of drawings must be made for each exercise and attached to the records written by students.

**TOTAL: 45 PERIODS**

**OUTCOMES:**

- ability to use the software packers for drafting and modeling
- ability to create 2D and 3D models of Engineering Components

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

Sl.No	Description of Equipment	Quantity
1.	Pentium IV computer or better hardware, with suitable graphics facility	30 No.
2.	Licensed software for Drafting and Modeling.	30 Licenses
3.	Laser Printer or Plotter to print / plot drawings	2 No.

**GE6262**

**PHYSICS AND CHEMISTRY LABORATORY – II**

**L T P C**  
**0 0 2 1**

**PHYSICS LABORATORY – II**

**OBJECTIVES:**

- To introduce different experiments to test basic understanding of physics concepts applied in optics, thermal physics and properties of matter.

**LIST OF EXPERIMENTS**

**(Any FIVE Experiments)**

1. Determination of Young's modulus by uniform bending method
2. Determination of band gap of a semiconductor
3. Determination of Coefficient of viscosity of a liquid –Poiseuille's method
4. Determination of Dispersive power of a prism - Spectrometer
5. Determination of thickness of a thin wire – Air wedge method
6. Determination of Rigidity modulus – Torsion pendulum

**OUTCOMES:**

- The students will have the ability to test materials by using their knowledge of applied physics principles in optics and properties of matter.

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

1. Traveling microscope, meter scale, Knife edge, weights
2. Band gap experimental set up
3. Burette, Capillary tube, rubber tube, stop clock, beaker and weighing balance
4. spectrometer, prism, sodium vapour lamp.
5. Air-wedge experimental set up.
6. Torsion pendulum set up.  
(vernier Caliper, Screw gauge, reading lens are required for most of the experiments)

## CHEMISTRY LABORATORY - II

### OBJECTIVES:

- To make the student acquire practical skills in the wet chemical and instrumental methods for quantitative estimation of hardness, alkalinity, metal ion content, corrosion in metals and cement analysis.

### LIST OF EXPERIMENTS

#### (Any FIVE Experiments)

- Determination of alkalinity in water sample
- Determination of total, temporary & permanent hardness of water by EDTA method
- Estimation of copper content of the given solution by EDTA method
- Estimation of iron content of the given solution using potentiometer
- Estimation of sodium present in water using flame photometer
- Corrosion experiment – weight loss method
- Conductometric precipitation titration using  $\text{BaCl}_2$  and  $\text{Na}_2\text{SO}_4$
- Determination of CaO in Cement.

**TOTAL: 30 PERIODS**

### OUTCOMES:

- The students will be conversant with hands-on knowledge in the quantitative chemical analysis of water quality related parameters, corrosion measurement and cement analysis.

### REFERENCES:

- Daniel R. Palleros, "Experimental organic chemistry" John Wiley & Sons, Inc., New York, 2001.
  - Furniss B.S. Hannaford A.J, Smith P.W.G and Tatchel A.R., "Vogel's Textbook of practical organic chemistry, LBS Singapore ,1994.
  - Jeffery G.H, Bassett J., Mendham J. and Denny R.C., "Vogel's Text book of quantitative analysis chemical analysis", ELBS 5th Edn. Longman, Singapore publishers, Singapore, 1996.
  - Kolthoff I.M. and Sandell E.B. et al. Quantitative chemical analysis, McMillan, Madras 1980
- Laboratory classes on alternate weeks for Physics and Chemistry.**

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

- |                       |   |       |
|-----------------------|---|-------|
| 1. Potentiometer      | - | 5 Nos |
| 2. Flame photo meter  | - | 5 Nos |
| 3. Weighing Balance   | - | 5 Nos |
| 4. Conductivity meter | - | 5 Nos |

**Common Apparatus : Pipette, Burette, conical flask, percelain tile, dropper (30 Nos each)**

**OBJECTIVES**

- To introduce Fourier series analysis which is central to many applications in engineering apart from its use in solving boundary value problems.
- To acquaint the student with Fourier transform techniques used in wide variety of situations.
- To introduce the effective mathematical tools for the solutions of partial differential equations that model several physical processes and to develop Z transform techniques for discrete time systems.

**UNIT I PARTIAL DIFFERENTIAL EQUATIONS****9 + 3**

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

**UNIT II FOURIER SERIES****9 + 3**

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

**UNIT III APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATIONS****9 + 3**

Classification of PDE – Method of separation of variables - Solutions of one dimensional wave equation – One dimensional equation of heat conduction – Steady state solution of two dimensional equation of heat conduction (excluding insulated edges).

**UNIT IV FOURIER TRANSFORMS****9 + 3**

Statement of Fourier integral theorem – Fourier transform pair – Fourier sine and cosine transforms – Properties – Transforms of simple functions – Convolution theorem – Parseval's identity.

**UNIT V Z - TRANSFORMS AND DIFFERENCE EQUATIONS****9 + 3**

Z- transforms - Elementary properties – Inverse Z - transform (using partial fraction and residues) – Convolution theorem - Formation of difference equations – Solution of difference equations using Z - transform.

**TOTAL (L:45+T:15): 60 PERIODS****OUTCOMES**

- The understanding of the mathematical principles on transforms and partial differential equations would provide them the ability to formulate and solve some of the physical problems of engineering.

**TEXT BOOKS**

1. Veerarajan. T., "Transforms and Partial Differential Equations", Tata McGraw Hill Education Pvt. Ltd., New Delhi, Second reprint, 2012.
2. Grewal. B.S., "Higher Engineering Mathematics", 42nd Edition, Khanna Publishers, Delhi, 2012.
3. Narayanan.S., Manicavachagom Pillay.T.K and Ramanaiah.G "Advanced Mathematics for Engineering Students" Vol. II & III, S.Viswanathan Publishers Pvt Ltd. 1998.

**REFERENCES**

1. Bali.N.P and Manish Goyal, "A Textbook of Engineering Mathematics", 7<sup>th</sup> Edition, Laxmi Publications Pvt Ltd , 2007.
2. Ramana.B.V., "Higher Engineering Mathematics", Tata Mc-GrawHill Publishing Company Limited, NewDelhi, 2008.

3. Glyn James, "Advanced Modern Engineering Mathematics", 3<sup>rd</sup> Edition, Pearson Education, 2007.
4. Erwin Kreyszig, "Advanced Engineering Mathematics", 8<sup>th</sup> Edition, Wiley India, 2007.
5. Ray Wylie. C and Barrett.L.C, "Advanced Engineering Mathematics" Tata Mc Graw Hill Education Pvt Ltd, Sixth Edition, New Delhi, 2012.
6. Datta.K.B., "Mathematical Methods of Science and Engineering", Cengage Learning India Pvt Ltd, Delhi, 2013.

**ME6352**

**MANUFACTURING TECHNOLOGY**

**L T P C**  
**3 0 0 3**

**OBJECTIVES**

- The automobile components such as piston, connecting rod, crankshaft, engine block, front axle, frame, body etc., are manufactured by various types of production processes involving casting, welding, machining, metal forming, power metallurgy etc. Hence B.E. Automobile Engineering students must study this course Production Technology.

**UNIT I CASTING**

**8**

Casting types, procedure to make sand mould, types of core making, moulding tools, machine moulding, special moulding processes – CO<sub>2</sub> moulding; shell moulding, investment moulding, permanent mould casting, pressure die casting, centrifugal casting, continuous casting, casting defects.

**UNIT II WELDING**

**8**

Classification of welding processes. Principles of Oxy-acetylene gas welding. A.C metal arc welding, resistance welding, submerged arc welding, tungsten inert gas welding, metal inert gas welding, plasma arc welding, thermit welding, electron beam welding, laser beam welding, defects in welding, soldering and brazing.

**UNIT III MACHINING**

**13**

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. Basics of CNC machines. 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 FORMING AND SHAPING OF PLASTICS**

**7**

Types of plastics - Characteristics of the forming and shaping processes – Moulding of Thermoplastics – Working principles and typical applications of - Injection moulding – Plunger and screw machines – Blow moulding – Rotational moulding – Film blowing – Extrusion - Typical industrial applications – Thermoforming – Processing of Thermosets – Working principles and typical applications - Compression moulding – Transfer moulding – Bonding of Thermoplastics – Fusion and solvent methods – Induction and Ultrasonic methods

**UNIT V METAL FORMING AND POWDER METALLURGY**

**9**

Principles and applications of the following processes: Forging, Rolling, Extrusion, Wire drawing and Spinning, Powder metallurgy – Principal steps involved advantages, disadvantages and limitations of powder metallurgy.

**TOTAL: 45 PERIODS**

## OUTCOMES:

- The Students can able to use different manufacturing process and use this in industry for component production

## TEXT BOOKS

1. Hajra Choudhury, "Elements of Workshop Technology", Vol. I and II, Media Promoters and Publishers Pvt., Ltd., Mumbai, 2005.
2. Nagendra Parashar B.S. and Mittal R.K., "Elements of Manufacturing Processes", Prentice-Hall of India Private Limited, 2007.

## REFERENCES

1. Serope Kalpajian, Steven R.Schmid, "Manufacturing Processes for Engineering Materials", Fourth Edition, Pearson Education, Inc. 2007.
2. Jain. R.K. and S.C. Gupta, "Production Technology", Khanna Publishers. 16<sup>th</sup> Edition,2001.
3. "H.M.T. Production Technology – Handbook", Tata McGraw-Hill, 2000.
4. Roy. A. Linberg, "Process and Materials of Manufacture", PHI, 2000.
5. Adithan. M and Gupta. A.B., "Manufacturing Technology", New Age, 2006.

**AE6301**

**AERO ENGINEERING THERMODYNAMICS**

**L T P C**  
**3 0 0 3**

## OBJECTIVES:

- To achieve an understanding of principles of thermodynamics and to be able to use it in accounting for the bulk behavior of the simple physical systems.
- To provide in-depth study of thermodynamic principles, thermodynamics of state, basic thermodynamic relations, Properties of pure substances
- To enlighten the basic concepts of heat transfer and propulsion cycles.

### **UNIT I BASIC CONCEPT AND FIRST LAW**

**9**

Concept of continuum, macroscopic approach, thermodynamic systems – closed, open and isolated. Property, state, path and process, quasi-static process, work, modes of work, Zeroth law of thermodynamics- concept of temperature and heat, internal energy, specific heat capacities, enthalpy - concept of ideal and real gases. First law of thermodynamics - applications to closed and open systems - steady flow processes with reference to various thermal equipments.

### **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 - thermodynamic temperature scale - clausius inequality, concept of entropy, entropy of ideal gas, principle of increase of entropy.

### **UNIT III THERMODYNAMIC AVAILABILITY AND AIR STANDARD CYCLES**

**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 - exergy in steady flow processes: expressions for exergy in steady flow processes – exergy dissipation and entropy generation - otto, diesel, dual and brayton cycles - air standard efficiency - mean effective pressure.



**UNIT IV PROPERTIES OF PURE SUBSTANCE AND POWER CYCLE 8**  
Properties of pure substances – thermodynamic properties of pure substances in solid, liquid and vapour phases, phase rule, P-V, P-T, T-V, T-S, H-S diagrams, PVT surfaces, thermodynamic properties of steam - calculations of work done and heat transfer in non-flow and flow processes - standard rankine cycle, reheat and regeneration cycle.

**UNIT V BASICS OF PROPULSION AND HEAT TRANSFER 10**  
Classification of jet engines - simple jet propulsion system – thrust equation – specific impulse –ideal and non-ideal cycle analysis - conduction in parallel, radial and composite wall – basics of convective and radiation heat transfer.

**TOTAL: 45 PERIODS**

(Use of standard thermodynamic tables, Mollier diagram and tables are permitted)

**OUTCOMES**

- Apply Mathematical foundations, principles in solving thermodynamics problems.
- Critically analyse the problem, and solve the problems related to heat transfer and propulsion

**TEXT BOOKS:**

1. Nag.P.K., “Engineering Thermodynamics”, Tata McGraw-Hill, New Delhi, 2007.
2. Rathakrishnan E., “Fundamentals of Engineering Thermodynamics”, Prentice-Hall India, 2005.

**REFERENCES:**

1. Ramalingam K.K. “Thermodynamics”, Sci-Tech Publications, 2006
2. Holman.J.P., “Thermodynamics”, 3rd Edition, McGraw-Hill, 2007.
3. Venwylen and Sontag, “Classical Thermodynamics”, Wiley Eastern, 1987
4. Arora C.P, “ Thermodynamics”, Tata McGraw-Hill, New Delhi, 2003.
5. Merala C, Pother, Craig W, Somerton, “Thermodynamics for Engineers”, Schaum Outline Series, Tata McGraw-Hill, New Delhi, 2004.

**CE6451 FLUID MECHANICS AND MACHINERY L T P C**  
**3 0 0 3**

**OBJECTIVES:**

- The applications of the conservation laws to flow through pipes and hydraulic machines are studied
- To understand the importance of dimensional analysis.
- To understand the importance of various types of flow in pumps and turbines.

**UNIT I FLUID PROPERTIES AND FLOW CHARACTERISTICS 8**  
Units and dimensions- Properties of fluids- mass density, specific weight, specific volume, specific gravity, viscosity, compressibility, vapor pressure, surface tension and capillarity. Flow characteristics – concept of control volume - application of continuity equation, energy equation and momentum equation.

**UNIT II FLOW THROUGH CIRCULAR CONDUITS 8**  
Hydraulic and energy gradient - Laminar flow through circular conduits and circular annuli-Boundary layer concepts – types of boundary layer thickness – Darcy Weisbach equation –friction factor- Moody diagram- commercial pipes- minor losses – Flow through pipes in series and parallel.

**UNIT III      DIMENSIONAL ANALYSIS****9**

Need for dimensional analysis – methods of dimensional analysis – Similitude –types of similitude - Dimensionless parameters- application of dimensionless parameters – Model analysis.

**UNIT IV      PUMPS****10**

Impact of jets - Euler's equation - Theory of roto-dynamic machines – various efficiencies– velocity components at entry and exit of the rotor- velocity triangles - Centrifugal pumps– working principle - work done by the impeller - performance curves - Reciprocating pump- working principle – Rotary pumps –classification.

**UNIT V      TURBINES****10**

Classification of turbines – heads and efficiencies – velocity triangles. Axial, radial and mixed flow turbines. Pelton wheel, Francis turbine and Kaplan turbines- working principles - work done by water on the runner – draft tube. Specific speed - unit quantities – performance curves for turbines – governing of turbines.

**TOTAL: 45 PERIODS****OUTCOMES:**

- Upon completion of this course, the students can able to apply mathematical knowledge to predict the properties and characteristics of a fluid.
- Can critically analyse the performance of pumps and turbines.

**TEXT BOOK:**

1. Modi P.N. and Seth, S.M. "Hydraulics and Fluid Mechanics", Standard Book House, New Delhi 2004.

**REFERENCES:**

1. Streeter, V. L. and Wylie E. B., "Fluid Mechanics", McGraw Hill Publishing Co. 2010
2. Kumar K. L., "Engineering Fluid Mechanics", Eurasia Publishing House(p) Ltd., New Delhi 2004
3. Robert W.Fox, Alan T. McDonald, Philip J.Pritchard, "Fluid Mechanics and Machinery", 2011.
4. Graebel. W.P, "Engineering Fluid Mechanics", Taylor & Francis, Indian Reprint, 2011

**CE6452****SOLID MECHANICS****L T P C  
3 0 0 3****OBJECTIVES:**

- To introduce various behavior of structural components under various loading conditions.

**UNIT I      INTRODUCTION****8**

Definition of stress, strain and their relations – relations between material constants – axial loading - statically determinate and indeterminate problems in tension & compression – plane truss analysis – method of joints – method of sections – 3-D trusses – thermal stresses – impact loading.

**UNIT II      STRESSES IN BEAMS****10**

Shear force & bending moment diagrams: bending and shear stress variation in beams of symmetric sections, a typical spar section: beams of uniform strength - beams of two materials.

**UNIT III      DEFLECTION OF BEAMS****10**

Double integration method – macaulay's method – moment area method – conjugate beam method – principle of superposition – maxwell's reciprocal theorem.

**UNIT IV TORSION – SPRINGS – COLUMNS 10**  
Torsion of solid and hollow circular shafts – shear stress variation – open and closed-coiled helical springs – stresses in helical springs – classification of columns – euler buckling – columns with different end conditions.

**UNIT V BIAxIAL STRESSES 7**  
Stresses in thin-walled pressure vessels – combined loading of circular shaft with bending, torsion and axial loadings – Mohr’s circle and its construction – determination of principal stresses.  
**TOTAL: 45 PERIODS**

**OUTCOMES**

- Solve the problems related to the structural components under various loading conditions.

**TEXT BOOKS:**

1. William Nash, "Strength of Materials", Tata McGraw Hill, 2004
2. Timoshenko and Young "Strength of Materials" Vol. I & II

**REFERENCES:**

1. Dym,C.L., and Shames,I.H., ‘Solid Mechanics’, McGraw Hill, Kogakusha, Tokyo, 1973.
2. Stephen Timoshenko, ‘Strength of Materials’, Vol I & II, CBS Publishers and Distributors, Third Edition.
3. Timoshenko,S. and Young, D.H., ‘Elements of Strength of Materials’, T.Van Nostrand Co. Inc., Princeton, N.J., 1977.

**AE6302 ELEMENTS OF AERONAUTICS L T P C**  
**3 0 0 3**

**OBJECTIVES:**

- To introduce the concepts of flying, International standard atmosphere, structural aspects of airplanes, brief description of systems, instruments and power plants used in airplanes.

**UNIT I HISTORY OF FLIGHT 8**  
Balloon flight – ornithopters - early airplanes by wright brothers, biplanes and monoplanes, developments in aerodynamics, materials, structures and propulsion over the years.

**UNIT II BASICS OF FLIGHT MECHANICS 9**  
Physical properties and structure of the atmosphere, temperature, pressure and altitude relationships, newton’s law of motions applied to aeronautics - evolution of lift, drag and moment. aerofoils, mach number, maneuvers.

**UNIT III AIRCRAFT CONFIGURATIONS 10**  
Different types of flight vehicles, classifications. components of an airplane and their functions. conventional control, powered control, basic instruments for flying - typical systems for control actuation.

**UNIT IV AIRPLANE STRUCTURES AND MATERIALS 9**  
General types of construction, monocoque, semi-monocoque and geodesic constructions, typical wing and fuselage structure. metallic and non-metallic materials, use of aluminium alloy, titanium, stainless steel and composite materials. stresses and strains – hooke’s law – stress - strain diagrams - elastic constants.

**UNIT V POWER PLANTS****9**

Basic ideas about piston, turboprop and jet engines - use of propeller and jets for thrust production - comparative merits, principles of operation of rocket, types of rockets and typical applications, exploration into space.

**TOTAL: 45 PERIODS****OUTCOMES**

- Identify the component of Flight
- Identify suitable materials for Aircraft structure
- Perform basic calculation on Mechanics using Newton law for lift, drag and moment.

**TEXT BOOKS:**

1. Anderson, J.D., "Introduction to Flight", McGraw-Hill, 1995.
2. Stephen. A. Brandt, "Introduction to Aeronautics: A design perspective" American Institute of Aeronautics & Astronautics, 1997

**REFERENCES:**

1. Kermode, A.C., "Mechanics of Flight", Himalayan Book, 1997

**CE6315****STRENGTH OF MATERIALS LABORATORY****L T P C  
0 0 3 2****OBJECTIVES**

To supplement the theoretical knowledge gained in Mechanics of Solids with practical testing for determining the strength of materials under externally applied loads. This would enable the student to have a clear understanding of the design for strength and stiffness

**LIST OF EXPERIMENTS**

1. Tension test on a mild steel rod
2. Double shear test on Mild steel and Aluminium rods
3. Torsion test on mild steel rod
4. Impact test on metal specimen
5. Hardness test on metals - Brinnell and Rockwell Hardness Number
6. Deflection test on beams
7. Compression test on helical springs
8. Strain Measurement using Rosette strain gauge
9. Effect of hardening- Improvement in hardness and impact resistance of steels.
10. Tempering- Improvement Mechanical properties Comparison
  - (i) Unhardened specimen
  - (ii) Quenched Specimen and
  - (iii) Quenched and tempered specimen.
11. Microscopic Examination of
  - (i) Hardened samples and
  - (ii) Hardened and tempered samples.

**TOTAL: 45 PERIODS****OUTCOMES:**

- Ability to perform different destructive testing
- Ability to characteristic materials

### LIST OF EQUIPMENT FOR BATCH OF 30 STUDENTS

S.No.	NAME OF THE EQUIPMENT	Qty.
1	Universal Tensile Testing machine with double 1 shear attachment – 40 Ton Capacity	1
2	Torsion Testing Machine (60 NM Capacity)	1
3	Impact Testing Machine (300 J Capacity)	1
4	Brinell Hardness Testing Machine	1
5	Rockwell Hardness Testing Machine	1
6	Spring Testing Machine for tensile and compressive loads (2500 N)	1
7	Metallurgical Microscopes	3
8	Muffle Furnace (800 C)	1

**CE6461**

**FLUID MECHANICS AND MACHINERY LABORATORY**

**L T P C**

**0 0 3 2**

**OBJECTIVES:**

Upon Completion of this subject, the students can able to have hands on experience in flow measurements using different devices and also perform calculation related to losses in pipes and also perform characteristic study of pumps, turbines etc.,

**LIST OF EXPERIMENTS**

1. Determination of the Coefficient of discharge of given Orifice meter.
2. Determination of the Coefficient of discharge of given Venturi meter.
3. Calculation of the rate of flow using Rota meter.
4. Determination of friction factor for a given set of pipes.
5. Conducting experiments and drawing the characteristic curves of centrifugal pump/ submergible pump
6. Conducting experiments and drawing the characteristic curves of reciprocating pump.
7. Conducting experiments and drawing the characteristic curves of Gear pump.
8. Conducting experiments and drawing the characteristic curves of Pelton wheel.
9. Conducting experiments and drawing the characteristics curves of Francis turbine.
10. Conducting experiments and drawing the characteristic curves of Kaplan turbine.

**TOTAL: 45 PERIODS**

**OUTCOMES:**

- Ability to use the measurement equipments for flow measurement
- Ability to do performance trust on different fluid machinery

### LIST OF EQUIPMENT FOR BATCH OF 30 STUDENTS

S. No.	NAME OF THE EQUIPMENT	Qty.
1	Orifice meter setup	1
2	Venturi meter setup	1
3	Rotameter setup	1
4	Pipe Flow analysis setup	1
5	Centrifugal pump/submergible pump setup	1
6	Reciprocating pump setup	1

7	Gear pump setup	1
8	Pelton wheel setup	1
9	Francis turbine setup	1
10	Kaplan turbine setup	1

AE6311

THERMODYNAMICS LABORATORY

L T P C  
0 0 3 2

### OBJECTIVES

- To enhance the basic knowledge in applied thermodynamics

### LIST OF EXPERIMENTS

- Performance test on a 4-stroke engine
- Valve timing of a 4 – stroke engine and port timing of a 2 stroke engine
- Determination of effectiveness of a parallel flow heat exchanger
- Determination of effectiveness of a counter flow heat exchanger
- Determination of heating value of a fuel
- Determination of specific heat of solid
- Determination of thermal conductivity of solid.
- Determination of thermal resistance of a composite wall.
- COP test on a vapour compression refrigeration test rig
- COP test on a vapour compression air-conditioning test rig

**TOTAL: 45 PERIODS**

### OUTCOMES

- Ability to perform test on diesel/petrol engine
- Ability to explain the characteristics of the diesel/Petrol engine
- Ability to determine the properties of the fuels.

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

Sl.No	Details of Equipments	Qty Req.	Experiment No.
1.	4 stroke twin cylinder diesel engine	1	1
2.	Cut section model of 4 stroke diesel engine and cut section model of 2 stroke petrol engine	1	2
3.	Parallel and counter flow heat exchanger test rig	1	3,4
4.	Bomb Calorimeter	1	5
5.	Vapour compression refrigeration test rig	1	9
6.	Vapour compression air-conditioning test rig	1	10
7.	Conductive heat transfer set up	1	7
8.	Composite wall	1	8

**OBJECTIVES**

- To teach and train the students in the lab about the design and drafting of aero components

**LIST OF EXPERIMENTS**

- Design and modeling of rectangular plate with hole.
- Design and modeling of spar components.
- Design and modeling of aerofoil sections.
- Design and modeling of cut section for wings.
- Design and modeling of machine component.
- Design and modeling of bulk head.
- Design and analysis of a truss.
- Design and analysis of beam distributed load.
- Facing and Turning (Taper, Step) operations in CNC.
- Drilling operations in CNC.

**TOTAL: 45 PERIODS****OUTCOMES**

Ability to design and model difficult aero component and perform structural analysis using available software packages

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

Sl.No.	Name of the Equipment	Quantity	Experiment No.
1	Computer nodes	30	1 to 8
2	Modeling Packages	30 licenses	1 to 6
3	FEA&CAM SOFTWARE	30 licenses	7 & 8
4	UPS	1	1 to 8
5.	CNC Machine	1	9,10
5	Printer	2	All

**OBJECTIVES**

- This course aims at providing the necessary basic concepts of a few numerical methods and give procedures for solving numerically different kinds of problems occurring in engineering and technology

**UNIT I SOLUTION OF EQUATIONS AND EIGENVALUE PROBLEMS****10+3**

Solution of algebraic and transcendental equations - Fixed point iteration method – Newton Raphson method- Solution of linear system of equations - Gauss elimination method – Pivoting - Gauss Jordan method – Iterative methods of Gauss Jacobi and Gauss Seidel - Matrix Inversion by Gauss Jordan method - Eigenvalues of a matrix by Power method.

**UNIT II INTERPOLATION AND APPROXIMATION****8+3**

Interpolation with unequal intervals - Lagrange's interpolation – Newton's divided difference interpolation – Cubic Splines - Interpolation with equal intervals - Newton's forward and backward difference formulae.

**UNIT III NUMERICAL DIFFERENTIATION AND INTEGRATION 9+3**  
Approximation of derivatives using interpolation polynomials - Numerical integration using Trapezoidal, Simpson's 1/3 rule – Romberg's method - Two point and three point Gaussian quadrature formulae – Evaluation of double integrals by Trapezoidal and Simpson's 1/3 rules.

**UNIT IV INITIAL VALUE PROBLEMS FOR ORDINARY DIFFERENTIAL EQUATIONS 9+3**  
Single Step methods - Taylor's series method - Euler's method - Modified Euler's method - Fourth order Runge-Kutta method for solving first order equations - Multi step methods - Milne's and Adams-Bashforth predictor corrector methods for solving first order equations.

**UNIT V BOUNDARY VALUE PROBLEMS IN ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS 9+3**  
Finite difference methods for solving two-point linear boundary value problems - Finite difference techniques for the solution of two dimensional Laplace's and Poisson's equations on rectangular domain – One dimensional heat flow equation by explicit and implicit (Crank Nicholson) methods – One dimensional wave equation by explicit method.

**TOTAL (L:45+T:15): 60 PERIODS**

#### **OUTCOMES**

- The students will have a clear perception of the power of numerical techniques, ideas and would be able to demonstrate the applications of these techniques to problems drawn from industry, management and other engineering fields.

#### **TEXT BOOKS**

1. Grewal. B.S., and Grewal. J.S., " Numerical methods in Engineering and Science", Khanna Publishers, New Delhi, 9<sup>th</sup> Edition, 2007.
2. Gerald. C. F., and Wheatley. P. O., " Applied Numerical Analysis", Pearson Education, Asia, New Delhi, 6<sup>th</sup> Edition, 2006.

#### **REFERENCES**

1. Chapra. S.C., and Canale.R.P., "Numerical Methods for Engineers, 5<sup>th</sup> Edition, Tata McGraw - Hill, New Delhi, 2007.
2. Brian Bradie. "A friendly introduction to Numerical analysis", Pearson Education, Asia, New Delhi, 2007.
3. Sankara Rao. K., "Numerical methods for Scientists and Engineers", 3<sup>rd</sup> Edition, Prentice Hall of India Private Ltd., New Delhi, 2007.

**AE6401**

**AERODYNAMICS - I**

**L T P C**  
**3 0 0 3**

#### **OBJECTIVES:**

- To introduce the concepts of mass, momentum and energy conservation relating to aerodynamics.
- To make the student understand the concept of vorticity, irrotationality, theory of airfoils and wing sections.
- To introduce the basics of viscous flow.



- UNIT I INTRODUCTION TO LOW SPEED FLOW 9**  
 Euler equation, incompressible bernoulli's equation. circulation and vorticity, green's lemma and stoke's theorem, barotropic flow, kelvin's theorem, streamline, stream function, irrotational flow, potential function, equipotential lines, elementary flows and their combinations.
- UNIT II TWO DIMENSIONAL INVISCID INCOMPRESSIBLE FLOW 9**  
 Ideal Flow over a circular cylinder, D'Alembert's paradox, magnus effect, Kutta joukowski's theorem, starting vortex, kutta condition, real flow over smooth and rough cylinder.
- UNIT III AIRFOIL THEORY 9**  
 Cauchy-riemann relations, complex potential, methodology of conformal transformation, kutta-joukowski transformation and its applications, thin airfoil theory and its applications.
- UNIT IV SUBSONIC WING THEORY 9**  
 Vortex filament, biot and savart law, bound vortex and trailing vortex, horse shoe vortex, lifting line theory and its limitations.
- UNIT V INTRODUCTION TO BOUNDARY LAYER THEORY 9**  
 Boundary layer and boundary layer thickness, displacement thickness, momentum thickness, energy thickness, shape parameter, boundary layer equations for a steady, two dimensional incompressible flow, boundary layer growth over a flat plate, critical reynolds number, blasius solution, basics of turbulent flow.

**TOTAL: 45 PERIODS**

**OUTCOMES**

- An ability to apply airfoil theory to predict air foil perform
- A knowledge of incompressible flow
- An explosive to Boundary layer theory

**TEXT BOOKS:**

1. Houghton, E.L., and Caruthers, N.B., "Aerodynamics for Engineering students", Edward Arnold Publishers Ltd., London, 1989.
2. Anderson, J.D., "Fundamentals of Aerodynamics", McGraw Hill Book Co., 1999

**REFERENCES:**

1. Milne Thomson, L.H., "Theoretical Aerodynamics", Macmillan, 1985
2. John J Bertin., "Aerodynamics for Engineers", Pearson Education Inc, 2002
3. Clancey, L J., " Aerodynamics", Pitman, 1986
4. Kuethe, A.M and Chow, C.Y, "Foundations of Aerodynamics", Fifth Edition, John Wiley & Sons, 2000.

**AE6402 AIRCRAFT SYSTEMS AND INSTRUMENTS L T P C**  
**3 0 0 3**

**OBJECTIVES:**

- To impart knowledge of the hydraulic and pneumatic systems components and types of instruments and its operation including navigational instruments to the students

**UNIT I AIRCRAFT SYSTEMS 8**  
 Hydraulic systems – Study of typical workable systems – components – hydraulic systems controllers – modes of operation – pneumatic systems – working principles – typical pneumatic power system –

brake system – components, landing gear systems – classification – shock absorbers – retractive mechanism.

**UNIT II AIRPLANE CONTROL SYSTEMS 12**

Conventional Systems – power assisted and fully powered flight controls – power actuated systems – engine control systems – push pull rod system – operating principles – modern control systems – digital fly by wire systems – auto pilot system, active control technology

**UNIT III ENGINE SYSTEMS 8**

Fuel systems – piston and jet engines – components - multi-engine fuel systems, 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 – vapour cycle systems, boot-strap air cycle system – evaporative vapour cycle systems – evaporation air cycle systems – oxygen systems – fire protection systems, deicing and anti icing system.

**UNIT V AIRCRAFT INSTRUMENTS 9**

Flight instruments and navigation instruments – accelerometers, air speed indicators – mach meters – altimeters - gyroscopic instruments– principles and operation – study of various types of engine instruments – tachometers – temperature gauges – pressure gauge – operation and principles.

**TOTAL: 45 PERIODS**

**OUTCOMES**

- Know the operation of airplane control system, Engine system, Air conditioning and pressing system.
- Know the operation of air data Instruments system

**TEXT BOOKS:**

1. Mekinley, J.L. and R.D. Bent, "Aircraft Power Plants", McGraw Hill 1993.
2. Pallet, E.H.J, "Aircraft Instruments & Principles", Pitman & Co 1993.

**REFERENCES:**

1. Treager, S., "Gas Turbine Technology", McGraw Hill 1997.
2. Mckinley, J.L. and Bent R.D. "Aircraft Maintenance & Repair", McGraw Hill, 1993.
3. Handbooks of Airframe and Power plant Mechanics, US dept. of Transportation, Federal, Aviation Administration, The English Book Store, New Delhi, 1995

**AT6302**

**MECHANICS OF MACHINES**

**L T P C  
3 1 0 4**

**OBJECTIVES:**

- To understand the principles in the formation of mechanisms and their kinematics.
- To understand the effect of friction in different machine elements.
- To analyse the forces and toques acting on simple mechanical systems
- To understand the importance of balancing and vibration.

**UNIT I KINEMATIC OF MECHANICS 10**

Mechanisms – Terminology and definitions – kinematics inversions of 4 bar and slide crank chain – kinematics analysis in simple mechanisms – velocity and acceleration polygons – Analytical methods – computer approach – cams – classifications – displacement diagrams - layout of plate cam profiles – derivatives of followers motion – circular arc and tangent cams.



**UNIT II ENERGY METHODS** **10**  
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**  
Euler's column curve – inelastic buckling – effect of initial curvature – the Southwell plot – columns with eccentricity – use of energy methods – theory of beam columns – beam columns with different end conditions – stresses in beam columns.

**UNIT IV FAILURE THEORIES** **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**  
Thermal stresses – impact loading – Fatigue – Creep - Stress Relaxation

**TOTAL (L:45+T:15): 60 PERIODS**

**OUTCOMES**

- Ability to perform linear static analysis of determinate and indeterminate aircraft structural components
- Ability to design the component using different theories of failure

**TEXT BOOKS:**

1. Timoshenko and Gere, "Mechanics of Materials", Tata McGraw Hill, 1993.
2. Megson T M G, "Aircraft Structures for Engineering students" Elsevier Science and Technology, 2007
3. Peery and Azar, "Aircraft Structures"

**REFERENCES:**

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", 2<sup>nd</sup> Edition, McGraw – Hill, N.Y, 1999.

**AE6404**

**PROPULSION - I**

**L T P C**  
**3 0 0 3**

**OBJECTIVES:**

- To introduce basic concepts and salient features of engine components of jet propelled engines which are operated in atmosphere to students. This course is also aimed at making students familiarize with advanced jet propulsion methods like hypersonic propulsion.

**UNIT I FUNDAMENTALS OF AIR BREATHING ENGINES** **8**

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 – 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            INLETS, NOZZLES AND COMBUSTION CHAMBERS FOR JET ENGINES            10**

Internal flow and Stall in subsonic inlets – relation between minimum area ratio and external deceleration ratio – diffuser performance – supersonic inlets – starting problem on supersonic inlets – shock swallowing by area variation – real flow in nozzles and nozzle efficiency – losses in nozzles – equilibrium flow and frozen flow in nozzles- two phase flow in nozzles – ejector and variable area nozzles - interaction of nozzle flow with adjacent surfaces – thrust reversal- classification of combustion chambers – combustion chamber performance – effect of operating variables on performance – flame stabilization

**UNIT III            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 – free vortex and constant reaction designs of axial flow compressor – performance characteristics of centrifugal and axial flow compressors– stage efficiency calculations - cascade testing

**UNIT IV            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

**UNIT V            RAMJET PROPULSION            9**

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.

**TOTAL: 45 PERIODS**

**OUTCOMES**

- Ability to identify the engine components of jet propelled engines
- Know the details of advanced Jet propulsion and hypersonic propulsion

**TEXT BOOKS:**

1. Hill, P.G. & Peterson, C.R. "Mechanics & Thermodynamics of Propulsion" Addison – Wesley Longman INC, 1999.
2. James Award, "Aerospace Propulsion System"

**REFERENCES:**

1. Cohen, H. Rogers, G.F.C. and Saravana muttoo, H.I.H. "Gas Turbine Theory", Longman, 1989.
2. Oates, G.C., "Aero thermodynamics of Aircraft Engine Components", AIAA Education Series, New York, 1985.
3. Rolls Royce, "Jet Engine", 5<sup>th</sup> Edition, Rolls Royce Technical Publications, 2005.
4. Mathur, M.L. and Sharma, R.P., "Gas Turbine, Jet and Rocket Propulsion", Standard Publishers & Distributors, Delhi, 1999.

**OBJECTIVES**

- To study the properties of materials used in Aircraft structure.
- To study the failure of different component under different loading condition

**LIST OF EXPERIMENTS**

1. Determination of young's modulus for metallic materials
2. Determination of flexural strength of metallic materials.
3. Deflection of a simply-supported beam
4. Deflection of a cantilever beam.
5. Verification of superposition theorem
6. Verification of maxwell's reciprocal theorem
7. Influence line study on beams
8. Buckling load estimation of slender eccentric columns
9. Construction of south well plot
10. Study of non-destructive testing procedures
11. Determination of flexural rigidity of composite beams
12. Shear failure of bolted and riveted Joints
13. Calibration of proving ring and spring
14. Truss and frame analysis.

(Only 10 experiments will be conducted)

**TOTAL: 45 PERIODS**

**OUTCOMES**

- Ability to perform non-destructive testing to predict the properties of metabolic materials used in aircraft application

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

Sl. No.	Name of the Equipment	Quantity	Experiment No.
1	100 kN Universal Testing Machine	1	1,2,11,12
2	Beams with weight hangers and dial gauges	6	3,4,5,6,7
3	Truss model and frame model	2	14
4	Column set up with dial gauges	2	8,9

**OBJECTIVES**

- To predict different aerodynamic propulsion used in aero application

**LIST OF EXPERIMENTS**

1. Application of Bernoulli's Equation – venturimeter and orifice meter.
2. Frictional loss in laminar flow through pipes.
3. Frictional loss in turbulent flow through pipes.
4. Calibration of a subsonic Wind tunnel.
5. Determination of lift for the given airfoil section.

6. Pressure distribution over a smooth circular cylinder.
7. Pressure distribution over a rough circular cylinder.
8. Pressure distribution over a symmetric aerofoil.
9. Pressure distribution over a cambered aerofoil.
10. Flow visualization studies in subsonic flows.

**TOTAL: 45 PERIODS**

### OUTCOMES

- Ability to use the fundamental dynamic principle in aircraft application.

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

Sl. No.	Name of the Equipment	Quantity	Experiment No.
1	Venturimeter	1	1
2	Orificemeter	1	1
3	Pipe friction apparatus	1	2,3
4	Subsonic Wind tunnel	1	4,5,6,7,8,9,10
5	Models(aerofoil, rough and smooth cylinder , flat plate)	2	5,6,7,8,9

**AE6413**

**CAD AND AIRCRAFT COMPONENT DRAWING**

**L T P C**  
**0 0 4 2**

### OBJECTIVES

- To introduce the concept of design of basic structural components and to draft both manually and using modelling package.

### LIST OF EXERCISES

1. Design and drafting of riveted joints
2. Design and drafting of welded joints.
3. Design and drafting control components cam
4. Design and drafting control components bell crank
5. Design and drafting control components gear
6. Design and drafting control components push-pull rod
7. Three view diagram of a typical aircraft
8. Layout of typical wing structure.
9. Layout of typical fuselage structure.
10. Layout of control system

**TOTAL : 60 PERIODS**

### OUTCOMES

- Ability to design and draw different joints and components using manual drafting method.

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

SI.No	Equipments	Quantity	Experiments No.
1	Drawing Boards, Drafting machines	30	1, 5

**OBJECTIVES**

- To study the performance of airplanes under various operating conditions and the static and dynamic response of aircraft for both voluntary and involuntary changes in flight conditions

**UNIT I CRUISING FLIGHT PERFORMANCE 9**

Forces and moments acting on a flight vehicle - Equation of motion of a rigid flight vehicle - Different types of drag –estimation of parasite drag co-efficient by proper area method- 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 - Power available and power required curves. Maximum speed in level flight - Conditions for minimum drag and power required

**UNIT II MANOEUVERING FLIGHT PERFORMANCE 10**

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

**UNIT III STATIC LONGITUDINAL STABILITY 10**

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 - Stick fixed stability - Basic equilibrium equation - Stability criterion - 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-Symmetric maneuvers - Stick force gradients - Stick \_ force per 'g' - Aerodynamic balancing.

**UNIT IV LATERAL AND DIRECTIONAL STABILITY 8**

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

**UNIT V DYNAMIC STABILITY 8**

Introduction to dynamic longitudinal stability: - Modes of stability, effect of freeing the stick - Brief description of lateral and directional. dynamic stability - Spiral, divergence, Dutch roll, auto rotation and spin.

**TOTAL (L:45+T:15): 60 PERIODS****OUTCOMES**

- Ability to analyse the performance of aircraft under various Flight conditions such as take off, cruise, landing, climbing, gliding, turning and other maneuvers.

**TEXT BOOK**

- Perkins, C.D., and Hage, R.E., "Airplane Performance stability and Control", John Wiley & Son:, Inc, NY, 1988.
- Nelson, R.C. "Flight Stability and Automatic Control", McGraw-Hill Book Co., 2004.
- Mc Cornick. W., "Aerodynamics, Aeronautics and Flight Mechanics", John Wiley, NY, 1979.

**REFERENCES**

- Etkin, B., "Dynamics of Flight Stability and Control", Edn. 2, John Wiley, NY, 1982.
- Babister, A.W., "Aircraft Dynamic Stability and Response", Pergamon Press, Oxford, 1980.
- Dommasch, D.O., Sherby, S.S., and Connolly, T.F., "Aeroplane Aero dynamics", Third Edition, Issac Pitman, London, 1981.
- Mc Cornick B. W, "Aerodynamics, Aeronautics and Flight Mechanics", John Wiley, NY, 1995.



**OBJECTIVES:**

- To provide the students various methods for analysis of aircraft wings and fuselage.
- To provide the the behavior of major aircraft structural components.

**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****8**

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

**UNIT V STRESS ANALYSIS OF WING AND FUSELAGE****10**

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.

**TOTAL (L:45+T:15): 60 PERIODS****OUTCOMES**

- Ability to analyse the aircraft wings and fuselage
- Ability to demonstrate the behavior of major aircraft structural components.

**TEXT BOOKS:**

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

**REFERENCES:**

1. Rivello, R.M., "Theory and Analysis of Flight Structures", McGraw Hill, 1993.
2. Howard D Curtis, "Fundamentals of Aircraft Structural Analysis", WCB-McGraw Hill, 1997

**OBJECTIVES:**

- To introduce the concepts of compressibility,
- To make the student understand the theory behind the formation of shocks and expansion fans in Supersonic flows.
- To introduce the methodology of measurements in Supersonic flows.

**UNIT I FUNDAMENTAL ASPECTS OF COMPRESSIBLE FLOW 9**

Compressibility, continuity, momentum and energy equations for steady one dimensional flow, compressible bernoulli's equation, area – mach number – velocity relation, mach cone, mach angle, one dimensional isentropic flow through variable area duct, critical conditions, characteristic mach number, area-mach number relation, maximum discharge velocity – operating characteristics of nozzles- introduction to hypersonic flows

**UNIT II SHOCK AND EXPANSION WAVES 10**

Normal shock relations, Prandtl's relation, Hugoniot equation, Rayleigh Supersonic Pitot tube equation, Moving normal shock waves, Oblique shocks,  $\theta - \delta - M$  relation, Shock Polar, Reflection of oblique shocks, left running and right running waves, Interaction of oblique shock waves, slip line, shock-boundary layer interaction – transonic lambda shock – compression corner effect – incident shock interaction - Rayleigh flow, Fanno flow, Expansion waves, Prandtl-Meyer expansion, Maximum turning angle, Simple and non-simple regions.

**UNIT III TWO DIMENSIONAL COMPRESSIBLE FLOW 9**

Potential equation for 2-dimensional compressible flow, Linearisation of potential equation, perturbation potential, Linearised Pressure Coefficient, Linearised subsonic flow, Prandtl-Glauert rule, Linearised supersonic flow, Method of characteristics.

**UNIT IV HIGH SPEED FLOW OVER AIRFOILS, WINGS AND AIRPLANE CONFIGURATION 9**

Critical Mach number, Drag divergence Mach number, Shock Stall, Supercritical Airfoil Sections, Transonic area rule, Swept wing, Airfoils for supersonic flows, Lift, drag, Pitching moment and Centre of pressure for supersonic profiles, Shock-expansion theory, wave drag, supersonic wings, Design considerations for supersonic aircraft- aerodynamic heating.

**UNIT V EXPERIMENTAL TECHNIQUES FOR HIGH SPEED FLOWS 8**

Wind tunnels for transonic, Supersonic and hypersonic flows, shock tube, Gun tunnels-peculiar problems in the operation of hypersonic tunnels - Supersonic flow visualization methods

**TOTAL (L:45+T:15): 60 PERIODS**

**OUTCOMES**

- Understanding characteristics of fluid flows
- Knowledge gained in shock phenomenon and fluid waves.
- understanding fluid flow characteristics over wings airfoils and airplanes.
- Usage of wind tunnels for evaluating flow behaviours.

**TEXT BOOKS:**

1. Anderson, J. D, "Modern Compressible Flow", McGraw-Hill & Co., 2002.
2. Rathakrishnan., E, "Gas Dynamics", Prentice Hall of India, 2004.

**REFERENCES:**

1. Shapiro, A. H., "Dynamics and Thermodynamics of Compressible Fluid Flow", Ronald Press, 1982.
2. Zucrow, M. J. and Anderson, J. D., "Elements of Gas Dynamics", McGraw- Hill & Co., 1989.
3. Oosthuizen, P.H., & Carscallen, W.E., "Compressible Fluid Flow", McGraw- Hill & Co., 1997



**REFERENCES:**

1. James Award, "Aerospace Propulsion System"
2. Hieter and Pratt, "Hypersonic Air Breathing Propulsion"

**AE6505****CONTROL ENGINEERING****L T P C****3 0 0 3****OBJECTIVES:**

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

**UNIT I INTRODUCTION****9**

Historical review, Simple pneumatic, hydraulic and thermal systems, Series and parallel system, Analogies, mechanical and electrical components, Development of flight control systems.

**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, Output to input ratios.

**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, Concept and construction, frequency response.

**UNIT V SAMPLED DATA SYSTEMS****9**

Z-Transforms Introduction to digital control system, Digital Controllers and Digital PID controllers

**TOTAL: 45 PERIODS****OUTCOMES:**

- Ability to apply mathematical knowledge to model the systems and analyse the frequency domain
- Ability to check the stability of the both time and frequency domain

**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., New York, U.S.A. 1995.
3. Naresh K Sinha, "Control Systems", New Age International Publishers, New Delhi, 1998.

**OBJECTIVES**

To the study of nature and the facts about environment.

- To finding and implementing scientific, technological, economic and political solutions to environmental problems.
- To study the interrelationship between living organism and environment.
- To appreciate the importance of environment by assessing its impact on the human world; envision the surrounding environment, its functions and its value.
- To study the dynamic processes and understand the features of the earth's interior and surface.
- To study the integrated themes and biodiversity, natural resources, pollution control and waste management.

**UNIT I ENVIRONMENT, ECOSYSTEMS AND BIODIVERSITY****12**

Definition, scope and importance of Risk and hazards; Chemical hazards, Physical hazards, Biological hazards in the environment – concept of an ecosystem – structure and function of an ecosystem – producers, consumers and decomposers-Oxygen cycle and Nitrogen cycle – energy flow in the ecosystem – ecological succession processes – Introduction, types, characteristic features, structure and function of the (a) forest ecosystem (b) grassland ecosystem (c) desert ecosystem (d) aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries) – Introduction to biodiversity definition: genetic, species and ecosystem diversity – biogeographical classification of India – value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values – Biodiversity at global, national and local levels – India as a mega-diversity nation – hot-spots of biodiversity – threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts – endangered and endemic species of India – conservation of biodiversity: In-situ and ex-situ conservation of biodiversity. Field study of common plants, insects, birds  
Field study of simple ecosystems – pond, river, hill slopes, etc.

**UNIT II ENVIRONMENTAL POLLUTION****10**

Definition – causes, effects and control measures of: (a) Air pollution (Atmospheric chemistry- Chemical composition of the atmosphere; Chemical and photochemical reactions in the atmosphere - formation of smog, PAN, acid rain, oxygen and ozone chemistry;- Mitigation procedures- Control of particulate and gaseous emission, Control of SO<sub>2</sub>, NO<sub>x</sub>, CO and HC) (b) Water pollution : Physical and chemical properties of terrestrial and marine water and their environmental significance; Water quality parameters – physical, chemical and biological; absorption of heavy metals - Water treatment processes. (c) Soil pollution - soil waste management: causes, effects and control measures of municipal solid wastes – (d) Marine pollution (e) Noise pollution (f) Thermal pollution (g) Nuclear hazards–role of an individual in prevention of pollution – pollution case studies –  
Field study of local polluted site – Urban / Rural / Industrial / Agricultural.

**UNIT III NATURAL RESOURCES****10**

Forest resources: Use and over-exploitation, deforestation, case studies- timber extraction, mining, dams and their effects on forests and tribal people – Water resources: Use and overutilization of surface and ground water, dams-benefits and problems – Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies – Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies – Energy resources: Growing energy needs, renewable and non renewable energy sources, use of alternate energy sources. Energy Conversion processes – Biogas – production and uses, anaerobic digestion; case studies – Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification – role of an individual in conservation of natural resources – Equitable use of resources

for sustainable lifestyles. Introduction to Environmental Biochemistry: Proteins –Biochemical degradation of pollutants, Bioconversion of pollutants.

Field study of local area to document environmental assets – river / forest / grassland / hill / mountain.

#### **UNIT IV SOCIAL ISSUES AND THE ENVIRONMENT 7**

From unsustainable to sustainable development – urban problems related to energy – water conservation, rain water harvesting, watershed management – resettlement and rehabilitation of people; its problems and concerns, case studies – role of non-governmental organization- environmental ethics: Issues and possible solutions – 12 Principles of green chemistry- nuclear accidents and holocaust, case studies. – wasteland reclamation – consumerism and waste products – environment production act – Air act – Water act – Wildlife protection act – Forest conservation act – The Biomedical Waste (Management and Handling) Rules; 1998 and amendments- scheme of labeling of environmentally friendly products (Ecomark). enforcement machinery involved in environmental legislation- central and state pollution control boards- disaster management: floods, earthquake, cyclone and landslides.

Public awareness.

#### **UNIT V HUMAN POPULATION AND THE ENVIRONMENT 6**

Population growth, variation among nations – population explosion – family welfare programme – environment and human health – human rights – value education – HIV / AIDS – women and child welfare –Environmental impact analysis (EIA)- -GIS-remote sensing-role of information technology in environment and human health – Case studies.

**TOTAL : 45 PERIODS**

#### **OUTCOMES:**

Environmental Pollution or problems cannot be solved by mere laws. Public participation is an important aspect which serves the environmental Protection. One will obtain knowledge on the following after completing the course.

- Public awareness of environmental is at infant stage.
- Ignorance and incomplete knowledge has lead to misconceptions
- Development and improvement in std. of living has lead to serious environmental disasters

#### **TEXT BOOKS :**

1. Gilbert M.Masters, 'Introduction to Environmental Engineering and Science', 2nd edition, Pearson Education (2004).
2. Benny Joseph, 'Environmental Science and Engineering', Tata McGraw-Hill, New Delhi, 2006.

#### **REFERENCES :**

1. Trivedi. R.K., 'Handbook of Environmental Laws, Rules, Guidelines, Compliances and Standards', Vol. I and II, Enviro Media.
2. Cunningham, W.P. Cooper, T.H. Gorhani, 'Environmental Encyclopedia', Jaico Publ., House, Mumbai, 2001.
3. Dharmendra S. Sengar, 'Environmental law', Prentice hall of India PVT LTD, New Delhi, 2007.
4. Rajagopalan, R, 'Environmental Studies-From Crisis to Cure', Oxford University Press, 2005.

**OBJECTIVES:**

- To enable the students understand the behavior of aircraft structural components under different loading conditions.
- To provide the Principle involved in photo elasticity and its applications in stress analysis for composite laminates.

**LIST OF EXPERIMENTS**

1. Unsymmetrical Bending of a Cantilever Beam
2. Combined bending and Torsion of a Hollow Circular Tube
3. Material Fringe Constant of a Photo elastic Models
4. Shear Centre of a Channel Section
5. Free Vibration of a Cantilever Beam
6. Forced Vibration of a cantilever Beam
7. Fabrication of a Composite Laminate.
8. Determination of Elastic constants for a Composite Tensile Specimen.
9. Determination of Elastic constants for a Composite Flexural Specimen.
10. Tension field beam
11. Moire techniques

(Only 10 experiments will be conducted)

**TOTAL: 45 PERIODS**

**OUTCOMES**

- Ability to perform Bending, Torsion, Shear, Vibration test on metallic, composite specimen

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

Sl.No.	Name of the Equipment	Quantity	Experiment No.
1	Photo elasticity set up	1	3
2	100 kN Universal Testing Machine	1	8,9
3	Vibration set up with accesories	1	5,6
4	Wagner beam	1	10
5	Unsymmetrical bending set up	1	1
6	Set up for combined bending and torsion	1	2

**OBJECTIVES:**

- To familiarize students and to expose them practically to various aircraft piston and gas turbine engines
- To give practical exposure to various testing methods of variable area ducts, propellants, jet engine components and rockets
- To practically determine the flow behavior of jets

**LIST OF EXPERIMENTS**

1. Study of aircraft piston and gas turbine engines
2. Velocity profiles of free jets.
3. Velocity profiles of wall jets.
4. Wall pressure measurements of a subsonic ramjet duct.

5. Flame stabilization studies using conical flame holders.
6. Cascade testing of compressor blades
7. Velocity and pressure measurements in co-axial jets
8. Flow visualization of secondary injection in a supersonic cross flow
9. Wall pressure distribution in subsonic diffusers.
10. Wall Pressure measurements in supersonic nozzles

**TOTAL: 45 PERIODS**

### OUTCOMES

- Ability to understand details of piston and gas turbine engine
- Ability to perform various testing on ducts, propellants, jet engine components

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

Sl.No.	Name of the Equipment	Quantity	Experiment No.
1	Goblin engine	1	1
2	Inline engine	1	1
3	Radial/ V- type engine	1	1
4	Jet facility with compressor and storage tank	1	2,3,7,8,10
5	Multitube manometer	2	2,3,4,7,9
6	Wind tunnel	1	6
7	0-5 bar pressure transducer with pressure indicator (or) DSA pressure scanner	8 1	7,10
8	Schlieren/ Shadowgraph set up	1	8
9	Ramjet facility	1	4
10	Conical flame holder	1	5
11	Compressor blade set	1	6

**GE6563**

**COMMUNICATION SKILLS – LABORATORY BASED**

**L T P C**  
**0 0 4 2**

### OBJECTIVES:

- To provide opportunities to learners to practice their communicative skills to make them become proficient users of English.
- To enable learners to fine-tune their linguistic skills (LSRW) with the help of technology to communicate globally.
- To enhance the performance of learners at placement interviews and group discussions and other recruitment procedures.

### UNIT I LISTENING / VIEWING

**10**

Listening and note-taking – Listening to telephonic conversations – Ted talks – Inspiring Speeches – Watching documentaries on personalities, places, socio-cultural events, TV news programmes and discussions to answer different kinds questions, viz., identifying key idea and comprehension questions... so on.

### UNIT II SPEAKING

**12**

Conversation practice – Interview – Group Discussion – Introducing oneself and others – Role play – Debate – Presentation – Panel discussion – Neutral accent.



**UNIT III READING 10**  
 Different genres of text (literature, media, technical) for comprehension – Reading strategies like note-making – reading graphs, charts and graphic organizer – Sequencing sentences – reading online sources like e-books, e-journals and e-newspapers.

**UNIT IV WRITING 12**  
 Blogs – Tweets – Online resume/ – e-mails – SMS and Online texting – Report writing – Describing charts and tables – Writing for media on current events.

**UNIT V VOCABULARY 8**  
 Idioms and Phrases – Proverbs – Collocations – Chunks of language.

**UNIT VI GRAMMAR 8**  
 Sentence structures – Subject-Verb agreement – Pronoun-Antecedent agreement – Tense forms – Active and passive voices – Direct and Indirect speeches – Cohesive devices.

**TOTAL: 60 PERIODS**

**Teaching Methods:**

1. To be totally learner-centric with minimum teacher intervention as the course revolves around practice.
2. Suitable audio/video samples from Podcast/YouTube to be used for illustrative purposes.
3. Portfolio approach for writing to be followed. Learners are to be encouraged to blog, tweet, text and email employing appropriate language.
4. GD/Interview/Role Play/Debate could be conducted off the laboratory (in a regular classroom) but learners are to be exposed to telephonic interview and video conferencing.
5. Learners are to be assigned to read/write/listen/view materials outside the classroom as well for gaining proficiency and better participation in the class.

**Lab Infrastructure:**

S. No.	Description of Equipment (minimum configuration)	Qty Required
1	<b>Server</b>	1 No.
	• PIV System	
	• 1 GB RAM / 40 GB HDD	
	• OS: Win 2000 server	
	• Audio card with headphones	
2	<b>Client Systems</b>	60 Nos.
	• PIII System	
	• 256 or 512 MB RAM / 40 GB HDD	
	• OS: Win 2000	
	• Audio card with headphones	
	• JRE 1.3	
3	Handicam	1 No.
4	Television 46"	1 No.
5	Collar mike	1 No.
6	Cordless mike	1 No.
7	Audio Mixer	1 No.
8	DVD recorder/player	1 No.
9	LCD Projector with MP3/CD/DVD provision for Audio/video facility	1 No.

## Evaluation:

### Internal: 20 marks

Record maintenance: Students should write a report on a regular basis on the activities conducted, focusing on the details such as the description of the activity, ideas emerged, learning outcomes and so on. At the end of the semester records can be evaluated out of 20 marks.

### External: 80 marks

Online Test	- 35 marks
Interview	- 15 marks
Presentation	- 15 marks
Group Discussion	- 15 marks

### Note on Internal and External Evaluation:

1. Interview – mock interview can be conducted on one-on-one basis.
2. Speaking – example for role play:
  - a. Marketing engineer convincing a customer to buy his product.
  - b. Telephonic conversation- fixing an official appointment / placing an order / enquiring and so on.
3. Presentation – should be extempore on simple topics
4. Discussion – topics of different kinds; general topics, case studies and abstract concept

## OUTCOMES:

### At the end of the course, learners should be able to

- Take international examination such as IELTS and TOEFL
- Make presentations and Participate in Group Discussions.
- Successfully answer questions in interviews.

## REFERENCES:

1. Barker, A. **Improve Your Communication Skills**. New Delhi: Kogan Page India Pvt. Ltd., 2006.
2. Craven, Miles. **Listening Extra – A resource book of multi-level skills activities**. Cambridge University Press, 2004.
3. Gammidge, Mick. **Speaking Extra - A resource book of multi-level skills activities**. Cambridge University Press, 2004.
4. Hartley, Peter. **Group Communication**. London: Routledge, 2004.
5. John Seely. **The Oxford Guide to Writing and Speaking**. New Delhi: Oxford University Press, 2004.
6. Naterop, Jean & Rod Revell. **Telephoning in English**. Cambridge University Press, 1987.
7. Ramesh, Gopalswamy and Mahadevan Ramesh. **The ACE of Soft Skills**. New Delhi: Pearson, 2010.

## Web Sources:

[www.humanresources.about.com](http://www.humanresources.about.com)  
[www.careerride.com](http://www.careerride.com)

**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: 45 PERIODS****OUTCOME :**

- Upon completion of the course, students will be able to have clear understanding of managerial functions like planning, organizing, staffing, leading & controlling and have same basic knowledge on international aspect of management

**TEXTBOOKS:**

- Stephen P. Robbins & Mary Coulter, "Management", 10<sup>th</sup> Edition, Prentice Hall (India) Pvt. Ltd., 2009.
- JAF Stoner, Freeman R.E and Daniel R Gilbert "Management", 6<sup>th</sup> Edition, Pearson Education, 2004.

**REFERENCES:**

- Stephen A. Robbins & David A. Decenzo & Mary Coulter, "Fundamentals of Management" 7<sup>th</sup> Edition, Pearson Education, 2011.
- Robert Kreitner & Mamata Mohapatra, "Management", Biztantra, 2008.
- Harold Koontz & Heinz Weihrich "Essentials of management" Tata Mc Graw Hill, 1998.
- Tripathy PC & Reddy PN, "Principles of Management", Tata McGraw Hill, 1999.

**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 - longitudinal and lateral vibration. Use of local and natural coordinates.

**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 element.

**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 (L:45+T:15): 60 PERIODS****OUTCOME**

- Upon completion of this course, the Students can able to understand different mathematical Techniques used in FEM analysis and use of them in Structural and thermal problem

**TEXT BOOKS:**

- Tirupathi.R. Chandrapatha and Ashok D. Belegundu, "Introduction to Finite Elements in Engineering", Printice Hall India, Third Edition, 2003.
- Rao. S.S., "Finite Element Methods in Engineering," Butterworth and Heinemann, 2001
- Reddy J.N., "An Introduction to Finite Element Method", McGraw Hill, 2000.

**REFERENCES:**

- Krishnamurthy, C.S., "Finite Element Analysis", Tata McGraw Hill, 2000.
- Bathe, K.J. and Wilson, E.L., "Numerical Methods in Finite Elements Analysis", Prentice Hall of India, 1985.
- Robert D Cook, David S Malkus, Michael E Plesha, "Concepts and Applications of Finite Element Analysis", 4<sup>th</sup> edition, John Wiley and Sons, Inc., 2003.
- Larry J Segerlind, "Applied Finite Element Analysis", Second Edition, John Wiley and Sons, Inc. 1984.

**OBJECTIVES:**

- To study the effect of time dependent forces on mechanical systems and to get the natural characteristics of system with more degree of freedom systems.
- To study the aeroelastic effects of aircraft wing.

**UNIT I SINGLE DEGREE OF FREEDOM SYSTEMS 10**

Introduction to simple harmonic motion, D'Alembert's principle, free vibrations – damped vibrations – forced vibrations, with and without damping – support excitation – transmissibility - vibration measuring instruments.

**UNIT II MULTI DEGREES OF FREEDOM SYSTEMS 10**

Two degrees of freedom systems - static and dynamic couplings - vibration absorber- principal coordinates - principal modes and orthogonal conditions - eigen value problems - hamilton's principle - lagrangean equations and application.

**UNIT III CONTINUOUS SYSTEMS 8**

Vibration of elastic bodies - vibration of strings – longitudinal, lateral and torsional vibrations

**UNIT IV APPROXIMATE METHODS 9**

Approximate methods - rayleigh's method - dunkerlay's method – rayleigh-ritz method, matrix iteration method.

**UNIT V ELEMENTS OF AEROELASTICITY 8**

Vibration due to coupling of bending and torsion - aeroelastic problems - collars triangle - wing divergence - aileron control reversal – flutter – buffeting. – elements of servo elasticity

**TOTAL: 45 PERIODS****OUTCOMES**

- Gaining understanding of single and multi degree vibrating systems
- Ability to use numerical techniques for vibration problems
- Knowledge acquired in aero elasticity and fluttering

**TEXT BOOKS:**

1. Leonard Meirovitch, "Elements of Vibration Analysis". McGraw Hill International Edition, 2007
2. Grover. G.K., "Mechanical Vibrations", 7<sup>th</sup> Edition, Nem Chand Brothers, Roorkee, India, 2003
3. Thomson W T, 'Theory of Vibration with Application' - CBS Publishers, 1990.

**REFERENCES:**

1. William Weaver, Stephen P. Timoshenko, Donovan H. Yound, Donovan H. Young. 'Vibration Problems in Engineering' – John Wiley and Sons, New York, 2001
2. Bisplinghoff R.L., Ashely H and Hogman R.L., "Aeroelasticity", Addison Wesley Publication, New York, 1983.
3. William W Seto, "Mechanical Vibrations" – McGraw Hill, Schaum Series.
4. TSE. F.S., Morse, I.F., Hinkle, R.T., "Mechanical Vibrations" – Prentice Hall, New York, 1984.
5. Den Hartog, "Mechanical Vibrations" Crastre Press, 2008.

**OBJECTIVES:**

- To make the student understand the analysis of composite laminates under different loading conditions and different environmental conditions.

**UNIT I MICROMECHANICS****10**

Introduction - advantages and application of composite materials – types of reinforcements and matrices - micro mechanics – mechanics of materials approach, elasticity approach- bounding techniques – fiber volume ratio – mass fraction – density of composites. effect of voids in composites.

**UNIT II MACROMECHANICS****10**

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 in plane strengths of a lamina - experimental characterization of lamina. failure theories of a lamina. hygrothermal effects on lamina.

**UNIT III LAMINATED PLATE THEORY****10**

Governing differential equation for a laminate. stress – strain relations for a laminate. different types of laminates. in plane and flexural constants of a laminate. hygrothermal stresses and strains in a laminate. failure analysis of a laminate. impact resistance and interlaminar stresses. netting analysis

**UNIT IV FABRICATION PROCESS AND REPAIR METHODS****8**

Various open and closed mould processes, manufacture of fibers, importance of repair and different types of repair techniques in composites – autoclave and non-autoclave methods.

**UNIT V SANDWICH CONSTRUCTIONS****7**

Basic design concepts of sandwich construction - materials used for sandwich construction - failure modes of sandwich panels - bending stress and shear flow in composite beams.

**TOTAL: 45 PERIODS****OUTCOMES**

- Understanding the mechanics of composite materials
- Ability to analyse the laminated composites for various loading cases
- Knowledge gained in manufacture of composites

**TEXT BOOKS:**

1. Dam Ishai., "Mechanics of Composite Materials,"
2. Autar K Kaw, 'Mechanics of Composite Materials', CRC Press, 1997.
3. Madhuji Mukhopadhyay, 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.

**OBJECTIVES**

- To study the types of mechanical behaviour of materials for aircraft applications

**UNIT I ELEMENTS OF AEROSPACE MATERIALS 9**

Structure of solid materials – Atomic structure of materials – crystal structure – miller indices – density – packing factor – space lattices – x-ray diffraction – imperfection in crystals – physical metallurgy - general requirements of materials for aerospace applications

**UNIT II MECHANICAL BEHAVIOUR OF MATERIALS 9**

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

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

Types of corrosion – effect of corrosion on mechanical properties – stress corrosion cracking – corrosion resistance materials used for space vehicles heat treatment of carbon steels – aluminium alloys, magnesium alloys and titanium alloys – effect of alloying treatment, heat resistance alloys – tool and die steels, magnetic alloys,

**UNIT IV CERAMICS AND COMPOSITES 9**

Introduction – powder metallurgy - modern ceramic materials – cermets - cutting tools – glass ceramic –production of semi fabricated forms - plastics and rubber – carbon/carbon composites, fabrication processes involved in metal matrix composites - shape memory alloys – applications in aerospace vehicle design, open and close mould processes.

**UNIT V HIGH TEMPERATURE MATERIALS CHARACTERIZATION 8**

Classification, production and characteristics – methods and testing – determination of mechanical and thermal properties of materials at elevated temperatures – application of these materials in thermal protection systems of aerospace vehicles – super alloys – high temperature material characterization.

**TOTAL: 45 PERIODS****OUTCOMES**

- Role of corrosion and heat treatment processes of aircraft materials
- Knowledge in usage of composite materials in aircraft component design.
- Exposure to high temperature materials for space applications

**TEXT BOOK**

- Titterton.G., "Aircraft Materials and Processes", V Edition, Pitman Publishing Co., 1995.

**REFERENCES**

- Martin, J.W., "Engineering Materials, Their properties and Applications", Wykedham Publications (London) Ltd., 1987.
- Van Vlack.L.H., "Materials Science for Engineers", Addison Wesley, 1985.
- Raghavan.V., "Materials Science and Engineering", Prentice Hall of India, New Delhi, 1993.

**OBJECTIVES**

- To introduce the knowledge of the maintenance and repair procedures followed for overhaul of aero engines.

**LIST OF EXPERIMENTS**

- Dismantling and reassembling of an aircraft piston engine.
- Study of Camshaft operation, firing order and magneto, valve timing
- Study of lubrication and cooling system
- Study of auxiliary systems, pumps and carburetor
- Aircraft wood gluing-single & double scarf joints
- Welded single & double V-joints.
- Fabric & Riveted Patch repairs
- Tube bending and flaring
- Sheet metal forming
- Preparation of glass epoxy of composite laminates and specimens.

**TOTAL: 45 PERIODS****OUTCOMES**

- Ability to maintain and repair the aero engines.

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

Sl. No	Equipments	Qty
1	Aircraft Piston engines	1
2	Set of basic tools for dismantling and assembly	1 set
3	NDT equipment	1 set
4	Micrometers, depth gauges, vernier calipers	2 sets
5	Valve timing disc	1
6	Shear cutter pedestal type	1
7	Drilling Machine	1
8	Bench Vices	1
9	Radius Bend bars	1
10	Pipe Flaring Tools	1
11	Welding machine	1
12	Glass fibre, epoxy resin	1
13	Strain gauges and strain indicator	1

**OBJECTIVES:**

- To make the student work in groups and understand the Concepts involved in Aerodynamic design, Performance analysis and stability aspects of different types of airplanes
- Comparative studies of different types of airplanes and their specifications and performance details with reference to the design work under taken.
  - Preliminary weight estimation, Selection of design parameters, power plant selection, aerofoil selection, fixing the geometry of Wing, tail, control surfaces Landing gear selection.



3. Preparation of layout drawing, construction of balance and three view diagrams of the airplane under consideration.
4. Drag estimation, Performance calculations, Stability analysis and V-n diagram.

**TOTAL : 45 PERIODS**

**OUTCOMES:**

- Upon completion of the Aircraft Design Project I students will be in a position to design aircraft and demonstrate the performance of the design.

**AE6613**

**COMPUTER AIDED SIMULATION LABORATORY**

**L T P C**  
**0 0 3 2**

**OBJECTIVES:**

- To make the students familiarize with computational fluid dynamics and structural analysis software tools. By employing these tools for Aerospace applications students will have an opportunity to expose themselves to simulation software.

**LIST OF EXPERIMENTS**

1. Simulation of flow through a Converging-diverging nozzle.
2. Simulation of flow through an axial flow compressor blade passage.
3. Simulation of supersonic flow over a wing of biconvex cross section
4. Hot flow simulation through an axial flow turbine blade passage.
5. Simulation of flow through subsonic and supersonic diffusers.
6. Structural analysis of a tapered wing
7. Structural analysis of a fuselage structure
8. Analysis of a composite laminate structure
9. Structural analysis of a landing gear
10. Thermo structural analysis of a composite laminate structure

**TOTAL : 45 PERIODS**

**OUTCOMES**

- Use of different simulation and analysis software to simulate flow behavior and perform structural analysis

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

SI.No	Equipments	Qty
1	Internal server (or) Work station	1
2	Computers	30
3	Modelling packages (i) CATIA (ii) ANSYS (iii) Pro E (iv) NASTRAN	30 licenses
4	UPS	1
5	Printer	1

**OBJECTIVES :**

- To facilitate the understanding of Quality Management principles and process.

**UNIT I INTRODUCTION****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 orientation, Customer satisfaction, Customer complaints, Customer retention - Costs of quality.

**UNIT II TQM PRINCIPLES****9**

Leadership - Strategic quality planning, Quality Councils - Employee involvement - Motivation, Empowerment, Team and Teamwork, Quality circles Recognition and Reward, Performance appraisal - Continuous process improvement - PDCA cycle, 5S, Kaizen - Supplier partnership - Partnering, Supplier selection, Supplier Rating.

**UNIT III TQM TOOLS AND TECHNIQUES I****9**

The seven traditional tools of quality - New management tools - Six sigma: Concepts, Methodology, applications to manufacturing, service sector including IT - Bench marking - Reason to bench mark, Bench marking process - FMEA - Stages, Types.

**UNIT IV TQM TOOLS AND TECHNIQUES II****9**

Control Charts - Process Capability - Concepts of Six Sigma - Quality Function Development (QFD) - Taguchi quality loss function - TPM - Concepts, improvement needs - Performance measures.

**UNIT V QUALITY SYSTEMS****9**

Need for ISO 9000 - ISO 9001-2008 Quality System - Elements, Documentation, Quality Auditing - QS 9000 - ISO 14000 - Concepts, Requirements and Benefits - TQM Implementation in manufacturing and service sectors..

**TOTAL: 45 PERIODS****OUTCOMES:**

- The student would be able to apply the tools and techniques of quality management to manufacturing and services processes.

**TEXTBOOK:**

1. Dale H. Besterfield, et al., "Total quality Management", Pearson Education Asia, Third Edition, Indian Reprint (2006).

**REFERENCES:**

1. James R. Evans and William M. Lindsay, "The Management and Control of Quality", 8<sup>th</sup> Edition, First Indian Edition, Cengage Learning, 2012.
2. Suganthi.L and Anand Samuel, "Total Quality Management", Prentice Hall (India) Pvt. Ltd., 2006.
3. Janakiraman. B and Gopal .R.K., "Total Quality Management - Text and Cases", Prentice Hall (India) Pvt. Ltd., 2006.

**OBJECTIVES:**

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

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

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

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

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

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

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

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

Radio navigation – ADF, DME, VOR, LORAN, DECCA, OMEGA, ILS, MLS – Inertial Navigation Systems (INS) – Inertial sensors, INS block diagram – Satellite navigation systems – GPS.

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

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

**TOTAL: 45 PERIODS****OUTCOMES:**

- Ability to built Digital avionics architecture
- Ability to Design Navigation system
- Ability to design and perform analysis on air system

**TEXT BOOKS:**

1. Albert Helfrick.D., "Principles of Avionics", Avionics Communications Inc., 2004
2. Collinson.R.P.G. "Introduction to Avionics", Chapman and Hall, 1996.

**REFERENCES:**

1. Middleton, D.H., Ed., "Avionics systems, Longman Scientific and Technical", Longman Group UK Ltd., England, 1989.
2. Spitzer, C.R. "Digital Avionics Systems", Prentice-Hall, Englewood Cliffs, N.J.,U.S.A. 1993.
3. Spitzer. C.R. "The Avionics Hand Book", CRC Press, 2000
4. Pallet.E.H.J., "Aircraft Instruments and Integrated Systems", Longman Scientific

**OBJECTIVES:**

- To introduce Governing Equations of viscous fluid flows
- To introduce numerical modeling and its role in the field of fluid flow and heat transfer
- To enable the students to understand the various discretization methods, solution procedures and turbulence modeling.
- To create confidence to solve complex problems in the field of fluid flow and heat transfer by using high speed computers.

**UNIT I GOVERNING EQUATIONS AND BOUNDARY CONDITIONS 8**

Basics of computational fluid dynamics – Governing equations of fluid dynamics – Continuity, Momentum and Energy equations – Chemical species transport – Physical boundary conditions – Time-averaged equations for Turbulent Flow – Turbulent–Kinetic Energy Equations – Mathematical behaviour of PDEs on CFD - Elliptic, Parabolic and Hyperbolic equations.

**UNIT II FINITE DIFFERENCE AND FINITE VOLUME METHODS FOR DIFFUSION 9**

Derivation of finite difference equations – Simple Methods – General Methods for first and second order accuracy – Finite volume formulation for steady state One, Two and Three -dimensional diffusion problems –Parabolic equations – Explicit and Implicit schemes – Example problems on elliptic and parabolic equations – Use of Finite Difference and Finite Volume methods.

**UNIT III FINITE VOLUME METHOD FOR CONVECTION DIFFUSION 10**

Steady one-dimensional convection and diffusion – Central, upwind differencing schemes properties of discretization schemes – Conservativeness, Boundedness, Transportiveness, Hybrid, Power-law, QUICK Schemes.

**UNIT IV FLOW FIELD ANALYSIS 9**

Finite volume methods -Representation of the pressure gradient term and continuity equation – Staggered grid – Momentum equations – Pressure and Velocity corrections – Pressure Correction equation, SIMPLE algorithm and its variants – PISO Algorithms.

**UNIT V TURBULENCE MODELS AND MESH GENERATION 9**

Turbulence models, mixing length model, Two equation (k- ) models – High and low Reynolds number models – Structured Grid generation – Unstructured Grid generation – Mesh refinement – Adaptive mesh – Software tools.

**TOTAL: 45 PERIODS****OUTCOMES:**

Upon completion of this course, the students can able

- To create numerical modeling and its role in the field of fluid flow and heat transfer
- To use the various discretization methods, solution procedures and turbulence modeling to solve flow and heat transfer problems.

**TEXT BOOKS:**

1. Versteeg, H.K., and Malalasekera, W., "An Introduction to Computational Fluid Dynamics: The finite volume Method", Pearson Education Ltd.Second Edition – 2007.
2. Ghoshdastidar, P.S., "Computer Simulation of flow and heat transfer", Tata McGraw Hill Publishing Company Ltd., 1998.

**REFERENCES:**

1. Patankar, S.V. "Numerical Heat Transfer and Fluid Flow", Hemisphere Publishing Corporation, 2004.
2. Chung, T.J., "Computational Fluid Dynamics", Cambridge University, Press, 2002.
3. Ghoshdastidar P.S., "Heat Transfer", Oxford University Press, 2005
4. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 1995.
5. ProdipNiyogi, Chakrabarty, S.K., Laha, M.K. "Introduction to Computational Fluid Dynamics", Pearson Education, 2005.
6. Anil W. Date, "Introduction to Computational Fluid Dynamics", Cambridge University Press, 2005.

**AE6702****EXPERIMENTAL STRESS ANALYSIS****L T P C**  
**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**

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: 45 PERIODS****OUTCOMES**

- Knowledge of stress and strain measurements in loaded components.
- Acquiring information's the usage of strain gauges and photo elastic techniques of measurement .
- Knowledge in NDT in stress analysis

**TEXT BOOKS:**

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.

**AE6711****AIRCRAFT DESIGN PROJECT - II****L T P C  
0 0 3 2****OBJECTIVES:**

Each group of students is assigned to continue the structural design part of the airplane. The following are the assignments are to be carried out.

1. Preliminary design of an aircraft wing – Shrenck’s curve, structural load distribution, shear force, bending moment and torque diagrams
2. Detailed design of an aircraft wing – Design of spars and stringers, bending stress and shear flow calculations – buckling analysis of wing panels
3. Preliminary design of an aircraft fuselage – load distribution on an aircraft fuselage
4. Detailed design of an aircraft fuselage – design of bulkheads and longerons – bending stress and shear flow calculations – buckling analysis of fuselage panels
5. Design of control surfaces - balancing and maneuvering loads on the tail plane and aileron, rudder loads
6. Design of wing-root attachment
7. Landing gear design
8. Preparation of a detailed design report with CAD drawings

**TOTAL: 45 PERIODS****OUTCOMES:**

- On completion of Aircraft design project II the students will be in a position to design aircraft wings, fuselage, loading gears etc., and also able to angle the design in terms of structural point of view.

**AE6712****AIRCRAFT SYSTEMS LABORATORY****L T P C  
0 0 3 2****OBJECTIVES**

- To train the students “ON HAND” experience in maintenance of various air frame systems in aircraft and rectification of common snags.

## 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.

**TOTAL: 45 PERIODS**

## OUTCOMES

- Ability to understand to procedure involved in maintenance of various air frame systems

## LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS

S.No.	Items	Quantity	Experiment No.
1.	Serviceable aircraft with all above systems	1	1,2,3,4,5,6,7,8,9,10
2.	Hydraulic Jacks (Screw Jack)	5	1,2,4,8
3.	Trestle adjustable	5	1,2,4,8
4.	Spirit Level	2	8
5.	Levelling Boards	2	8
6.	Cable Tensiometer	1	8
7.	Adjustable Spirit Level	1	8
8.	Plumb Bob	1	8

## AE6713 FLIGHT INTEGRATION SYSTEMS AND CONTROL LABORATORY

**L T P C**  
**0 0 3 2**

## OBJECTIVES:

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

## LIST OF EXPERIMENTS

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

## Note:

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

**TOTAL: 45 PERIODS**

**OUTCOMES:**

- Ability to understand digital electronics circuits.
- Ability to use microprocessor in Flight control
- Ability to perform stability analysis

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

S.No	Details of Equipments	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.	* Regulated power supply	10	5,6,7
9.	MATLAB software	-	8,9,10

\*Is not needed when regulated power supply is in built.

**AE6801**

**WIND TUNNEL TECHNIQUES**

**L T P C**  
**3 0 0 3**

**OBJECTIVES:**

- The students are exposed to various types and techniques of Aerodynamic data generation on aerospace vehicle configurations in the aerospace industry.

**UNIT I PRINCIPLES OF MODEL TESTING**

**6**

Buckingham Theorem – Non dimensional numbers – Scale effect – Geometric Kinematic and Dynamic similarities.

**UNIT II TYPES AND FUNCTIONS OF WIND TUNNELS**

**6**

Classification and types – special problems of testing in subsonic, transonic, supersonic and hypersonic speed regions – Layouts – sizing and design parameters.

**UNIT III CALIBRATION OF WIND TUNNELS**

**9**

Test section speed – Horizontal buoyancy – Flow angularities – Flow uniformity & turbulence measurements – Associated instrumentation – Calibration of subsonic & supersonic tunnels.

**UNIT IV CONVENTIONAL MEASUREMENT TECHNIQUES**

**12**

Force measurements and measuring systems – Multi component internal and external balances – Pressure measurement system - Steady and Unsteady Pressure- single and multiple measurements - Velocity measurements – Intrusive and Non-intrusive methods – Flow visualization techniques- surface flow, oil and tuft - flow field visualization, smoke and other optical and nonintrusive techniques



**UNIT V SPECIAL WIND TUNNEL TECHNIQUES****12**

Intake tests – store carriage and separation tests - Unsteady force and pressure measurements – wind tunnel model design

**TOTAL: 45 PERIODS****OUTCOMES**

- Ability to use various techniques of Aerodynamic data generation.

**TEXT BOOKS:**

1. Rae, W.H. and Pope, A., "Low Speed Wind Tunnel Testing", John Wiley Publication, 1984.
2. NAL-UNI Lecture Series 12:" Experimental Aerodynamics", NAL SP 98 01 April 1998

**REFERENCES:**

1. Pope, A., and Goin, L., "High Speed Wind Tunnel Testing", John Wiley, 1985.
2. Bradshaw "Experimental Fluid Mechanics".
3. Short term course on Flow visualization techniques, NAL , 2009
4. Lecture course on Advanced Flow diagnostic techniques 17-19 September 2008 NAL, Bangalore

**AE6811****PROJECT WORK**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>0</b>	<b>0</b>	<b>12</b>	<b>6</b>

**OBJECTIVES:**

- To develop the ability to solve a specific problem right from its identification and literature review 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 3 to 4 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: 180 PERIODS****OUTCOMES:**

- On Completion of the project work students will be in a position to take up any challenging practical problems and find solution by formulating proper methodology.

**AE6001****THEORY OF ELASTICITY**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**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, Lamé'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: 45 PERIODS**

**OUTCOMES**

- Ability to use mathematical knowledge to solve problem related to structural elasticity.

**TEXT BOOKS:**

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", 4<sup>th</sup> 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

**AE6002 AIRCRAFT GENERAL ENGINEERING AND MAINTENANCE L T P C**  
**PRACTICES 3 0 0 3**

**OBJECTIVES**

- To teach the students about the basic concepts of aircraft general engineering and maintenance practices.

**UNIT I AIRCRAFT GROUND HANDLING AND SUPPORT EQUIPMENT 10**  
 Mooring, jacking, leveling and towing operations – Preparation – Equipment – precautions – Engine starting procedures – Piston engine, turboprops and turbojets – Engine fire extinguishing – Ground power unit.

**UNIT II GROUND SERVICING OF VARIOUS SUB SYSTEMS 8**  
 Air conditioning and pressurization – Oxygen and oil systems – Ground units and their maintenance.





**UNIT IV NUMERICAL METHODS IN HEAT TRANSFER 12**  
 1-D and 2-D steady and unsteady state heat conduction – composite walls-heat generation-variable thermal conductivity- extended surfaces analysis using finite difference method- Convective heat transfer- Stream function - vorticity method- creeping flow analysis-convection-diffusion 1-D, 2-D analysis using finite difference approximation. Numerical methods applicable to radiation heat transfer.

**UNIT V PROBLEMS IN AEROSPACE ENGINEERING 4**  
 Heat transfer problems in gas turbines, rocket thrust chambers- aerodynamic heating – ablative heat transfer

**TOTAL: 45 PERIODS**

**OUTCOMES**

- Upon completion of this course, the students can able to apply the Students can able to understand and apply different heat transfer principles of different applications.

**TEXT BOOKS:**

1. Yunus,A.Cengel, "Heat Transfet-A Practical Approach", Tata McGraw Hill, Second edition, 2003.
2. Holman,J.P., "Heat Transfer", McGraw Hill Book Co.,Inc., New York, Sixth Edition,1991.
3. Sachdeva,S.C., "Fundamentals of Engineering Heat and Mass Transfer", Wiley EasternLtd., New Delhi,1981.

**REFERENCES:**

1. Lienhard,J.H., A Heat Transfer Text Book, Prentice Hall Inc., 1981.
2. Sutton,G.P., Rocket Propulsion Elements,John Wiley and Sons, Fifth Edition, 1986.
3. Mathur,M. and Sharma,R.P., Gas Turbine and Jet and Rocket Propulsion, Standard Publishers, New Delhi, 1988.

**AE6005 HELICOPTER THEORY L T P C**  
**3 0 0 3**

**OBJECTIVES:**

- To make the student familiarize with the principles involved in helicopters and to study the performance and stability aspects of Helicopter under different operating conditions.

**UNIT I INTRODUCTION 9**  
 Helicopter as an aircraft, Basic features, Layout, Generation of lift, Main rotor, Gearbox, tail rotor, power plant, considerations on blade, flapping and feathering, Rotor controls and various types of rotor, Blade loading, Effect of solidity, profile drag, compressibility etc., Blade area required, number of Blades, Blade form, Power losses, Rotor efficiency.

**UNIT II AERODYNAMICS OF ROTOR BLADE 9**  
 Aerofoil characteristics in forward flight, Hovering and Vortex ring state, Blade stall, maximum lift of the helicopter calculation of Induced Power, High speed limitations; parasite drag, power loading, ground effect.

**UNIT III POWER PLANTS AND FLIGHT PERFORMANCE 9**  
 Piston engines, Gas turbines, Ramjet principle, Comparative performance, Horsepower required, Range and Endurance, Rate of Climb, Best Climbing speed, Ceiling in vertical climb, Autorotation.

**UNIT IV STABILITY AND CONTROL 9**  
 Physical description of effects of disturbances, Stick fixed Longitudinal and lateral dynamic stability, lateral stability characteristics, control response. Differences between stability and control of airplane and helicopter.

**UNIT V ROTOR VIBRATIONS 9**  
 Dynamic model of the rotor, Motion of the rigid blades, flapping motion, lagging motion, feathering motion, Properties of vibrating system, phenomenon of vibration, fuselage response, vibration absorbers, Measurement of vibration in flight. Rotor Blade Design: General considerations, Airfoil selection, Blade construction, Materials, Factors affecting weight and cost, Design conditions, Stress analysis.

**TOTAL: 45 PERIODS**

**OUTCOMES:**

- To perform the Aerodynamics calculation of Rotor blade
- To perform stability and control characteristics of Helicopter
- To perform and control Rotor vibration

**TEXT BOOKS:**

1. John Fay, "The Helicopter and How It Flies", Himalayan Books 1995
2. Lalit Gupta, "Helicopter Engineering", Himalayan Books New Delhi 1996

**REFERENCES:**

1. Joseph Schafer, "Basic Helicopter Maintenance", Jeppesen 1980
2. R W Prouty, "Helicopter Aerodynamics"

**AE6006 THEORY OF PLATES AND SHELLS L T P C**  
**3 0 0 3**

**OBJECTIVES**

- To study the behaviour of the plates and shells with different geometry under various types of loads.

**UNIT I CLASSICAL PLATE THEORY 3**  
 Classical Plate Theory – Assumptions – Differential Equation – Boundary Conditions.

**UNIT II PLATES OF VARIOUS SHADES 15**  
 Navier's Method of Solution for Simply Supported Rectangular Plates – Levy's Method of Solution for Rectangular Plates under Different Boundary Conditions. Governing Equation – Solution for Axisymmetric loading – Annular Plates – Plates of other shapes.

**UNIT III EIGEN VALUE ANALYSIS 8**  
 Stability and free Vibration Analysis of Rectangular Plates.

**UNIT IV APPROXIMATE METHODS 10**  
 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 : 45 PERIODS****OUTCOMES**

- Ability to use different theories to plate and shell
- Perform stability and free vibration calculations
- Use of different methods for stability analysis

**TEXT BOOKS**

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.

**REFERENCES**

1. Flugge, W. “Stresses in Shells”, Springer – Verlag, 1985.
2. Timoshenko, S.P. and Gere, J.M., “Theory of Elastic Stability”, McGraw-Hill Book Co. 1986

**AE6007****FATIGUE AND FRACTURE****L T P C  
3 0 0 3****OBJECTIVES:**

- 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**

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 – Fatigue of composite materials.

**UNIT II STATISTICAL ASPECTS OF FATIGUE BEHAVIOUR****10**

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****10**

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

**UNIT IV FRACTURE MECHANICS****10**

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

**UNIT V FATIGUE DESIGN AND TESTING****8**

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

**TOTAL: 45 PERIODS****OUTCOMES**

- Ability to apply mathematical knowledge to define fatigue behaviors

- Ability to perform fatigue design
- Ability to analyse the fracture due to fatigue

**TEXT BOOKS:**

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

**AE6008**

**UAV SYSTEMS**

**L T P C**  
**3 0 0 3**

**OBJECTIVES:**

- To make the students to understand the basic concepts of UAV systems design.

**UNIT I INTRODUCTION TO UAV**

**9**

History of UAV –classification – Introduction to Unmanned Aircraft Systems--models and prototypes – System Composition-applications

**UNIT II THE DESIGN OF UAV SYSTEMS**

**9**

Introduction to Design and Selection of the System- Aerodynamics and Airframe Configurations- Characteristics of Aircraft Types- Design Standards and Regulatory Aspects-UK,USA and Europe- Design for Stealth--control surfaces-specifications.

**UNIT III AVIONICS HARDWARE**

**9**

Autopilot – AGL-pressure sensors-servos-accelerometer –gyros-actuators- power supply-processor, integration, installation, configuration, and testing

**UNIT IV COMMUNICATION PAYLOADS AND CONTROLS**

**9**

Payloads-Telemetry-tracking-Aerial photography-controls-PID feedback-radio control frequency range –modems-memory system-simulation-ground test-analysis-trouble shooting

**UNIT V THE DEVELOPMENT OF UAV SYSTEMS**

**9**

Waypoints navigation-ground control software- System Ground Testing- System In-flight Testing- Future Prospects and Challenges-Case Studies – Mini and Micro UAVs.

**TOTAL: 45 PERIODS**

**OUTCOMES:**

- Ability to design UAV system
- Ability to identify different hardware for UAV

**REFERENCES:**

1. Reg Austin "Unmanned Aircraft Systems UAV design, development and deployment", Wiley, 2010.
2. Robert C. Nelson, Flight Stability and Automatic Control, McGraw-Hill, Inc, 1998.



3. Kimon P. Valavanis, "Advances in Unmanned Aerial Vehicles: State of the Art and the Road to Autonomy", Springer, 2007
4. Paul G Fahlstrom, Thomas J Gleason, "Introduction to UAV Systems", UAV Systems, Inc, 1998
5. Dr. Armand J. Chaput, "Design of Unmanned Air Vehicle Systems", Lockheed Martin Aeronautics Company, 2001

**AE6009**

**INDUSTRIAL AERODYNAMICS**

**L T P C**  
**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.

**UNIT II          WIND ENERGY COLLECTORS**

**9**

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

**UNIT III          VEHICLE AERODYNAMICS**

**9**

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

**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.

**UNIT V          FLOW INDUCED VIBRATIONS**

**9**

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

**TOTAL: 45 PERIODS**

**OUTCOMES**

- Use of aerodynamics for non- aerodynamics such as vehicle, building.
- Solve the problems and able to analyse 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", Pergamon 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.

**OBJECTIVES:**

- To make the students to understand the Airframe components and the tools used to maintain the components. Defect investigation, methods to carry out investigation and the detailed maintenance and practice procedures.

**UNIT I MAINTENANCE OF AIRCRAFT STRUCTURAL COMPONENTS 9**

Equipments used in welding shop and their maintenance - Ensuring quality welds - Welding jigs and fixtures - Soldering and brazing – laser welding.

Sheet metal repair and maintenance: Selection of materials; Repair schemes; Fabrication of replacement patches; Tools - power/hand; Repair techniques; Peening - Close tolerance fasteners; Sealing compounds; forming/shaping; Calculation of weight of completed repair; Effect of weight - change on surrounding structure. Sheet metal inspection - N.D.T. Testing. Riveted repair design - Damage investigation - Reverse engineering.

**UNIT II PLASTICS AND COMPOSITES IN AIRCRAFT 9**

Review of types of plastics used in airplanes - Maintenance and repair of plastic components - Repair of cracks, holes etc., various repairs schemes - Scopes.

Cleaning of fibre reinforced plastic (FRP) materials prior to repair; Break test - Repair Schemes; FRP/honeycomb sandwich materials; laminated FRP structural members and skin panels; Tools/equipment; Vacuum-bag process. Special precautions – Autoclaves

**UNIT III AIRCRAFT JACKING, ASSEMBLY AND RIGGING 9**

Airplane jacking and weighing and C.G. Location. Balancing of control surfaces - Inspection maintenance. Helicopter flight controls. Tracking and balancing of main rotor.

**UNIT IV REVIEW OF HYDRAULIC AND PNEUMATIC SYSTEM 12**

Trouble shooting and maintenance practices - Service and inspection - Inspection and maintenance of landing gear systems. - Inspection and maintenance of air-conditioning and pressurization system, water and waste system. Installation and maintenance of Instruments - handling - Testing - Inspection. Inspection and maintenance of auxiliary systems - Rain removal system - Position and warning system - Auxiliary Power Units (APUs).

**UNIT V SAFETY PRACTICES 8**

Hazardous materials storage and handling, Aircraft furnishing practices - Equipments. Trouble shooting. Theory and practices.

**TOTAL: 45 PERIODS****OUTCOMES**

- Ability to identify the airframe components
- Ability to perform defect investigation skill to maintain the airframe

**TEXT BOOKS:**

1. Kroes, Watkins, Delp, "Aircraft Maintenance and Repair", McGraw Hill, New York, 1992.

**REFERENCES:**

1. Larry Reithmeir, "Aircraft Repair Manual", Palamar Books, Marquette, 1992.
2. Brimm D.J. Bogges H.E., "Aircraft Maintenance", Pitman Publishing corp., New York, 1940.
3. Delp. Bent and Mckinely "Aircraft Maintenance Repair", McGraw Hill, New York, 1987.

**OBJECTIVES:**

- To make the students to familiarize with the Aircraft engine maintenance procedure and practice.
- Must have knowledge of basics of Aeronautics and engine components.

**UNIT I PISTON ENGINES****9**

Carburetion and Fuel injection systems for small and large engines - Ignition system components - spark plug detail - Engine operating conditions at various altitudes – Engine power measurements – Classification of engine lubricants and fuels – Induction, Exhaust and cooling system - Maintenance and inspection check to be carried out. Inspection and maintenance and trouble shooting - Inspection of all engine components - Daily and routine checks - Overhaul procedures - Compression testing of cylinders - Special inspection schedules - Engine fuel, control and exhaust systems - Engine mount and super charger - Checks and inspection procedures.

**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 – Bearings and seals - Inlets - compressors- turbines- exhaust section – classification and types of lubrication and fuels- Materials used - Details of control, starting around running and operating procedures – 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 - Case studies of different engine systems - Rectification during testing equipments 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 - Equipment for replacement of parts and their repair. Engine testing: Engine testing procedures and schedule preparation - Online maintenance.

**UNIT V 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:45 PERIODS****OUTCOMES**

- Apply maintenance procedure to Aircraft Engines
- Identify the engine components and faults
- Apply non destructive testing procedures to identify the defects
- Apply overhauling procedure to new engines

**REFERENCES:**

1. Kroes & Wild, " Aircraft Power plants ", 7th Edition - McGraw Hill, New York, 1994.

2. Turbomeca, " Gas Turbine Engines ", The English Book Store ", New Delhi, 1993.
3. United Technologies Pratt & Whitney, "The Aircraft Gas turbine Engine and its Operation", The English Book Store, New Delhi.

**AE6012**

**AIR TRAFFIC CONTROL AND PLANNING**

**L T P C**  
**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

**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 co-ordination 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 : 45 PERIODS**

**OUTCOMES**

- Understanding the requirement of air traffic control systems and types of air traffic control system.
- Knowledge in flight information systems and rules of air traffic systems.
- Knowledge in direction indicator systems for air navigation.

**TEXT BOOK**

1. AIP (India) Vol. I & II, "The English Book Store", 17-1, Connaught Circus, New Delhi.

## REFERENCES

1. "Aircraft Manual (India) Volume I", latest Edition – The English Book Store, 17-1, Connaught Circus, New Delhi.
2. "PANS – RAC – ICAO DOC 4444", Latest Edition, The English Book Store, 17-1, Connaught Circus, New Delhi.

**AE6013**

**HYPERSONIC AERODYNAMICS**

**L T P C**  
**3 0 0 3**

## OBJECTIVES

- To introduce fundamental concepts and features peculiar to hypersonic flow to students to familiarize them with the aerodynamical aspects of hypersonic vehicles and the general hypersonic flow theory.

### **UNIT I FUNDAMENTALS OF HYPERSONIC AERODYNAMICS**

**9**

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

### **UNIT II SIMPLE SOLUTION METHODS FOR HYPERSONIC INVISCID FLOWS**

**9**

Local surface inclination methods – Newtonian theory – modified Newtonian law – tangent wedge and tangent cone and shock expansion methods – approximate methods - hypersonic small disturbance theory – thin shock layer theory.

### **UNIT III VISCOUS HYPERSONIC FLOW THEORY**

**9**

Boundary layer equations for hypersonic flow – hypersonic boundary layers – self similar and non self similar boundary layers – solution methods for non self similar boundary layers – aerodynamic heating and its adverse effects on airframe.

### **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 HIGH TEMPERATURE EFFECTS in HYPERSONIC FLOWS**

**9**

Nature of high temperature flows – chemical effects in air – real and perfect gases – Gibb's free energy and entropy - chemically reacting boundary layers – recombination and dissociation.

**TOTAL: 45 PERIODS**

## OUTCOMES

- Knowledge in basics of hypersonic and supersonic aerodynamics
- Acquiring knowledge in theory of hypersonic flow.
- Understanding of boundary layers of hypersonic flow and viscous interaction
- Role of chemical and temperature effects in hypersonic flow.

## TEXT BOOKS:

1. John D. Anderson. Jr., "Hypersonic and High Temperature Gas Dynamics", Mc.Graw hill Series, New York, 1996.

**REFERENCES:**

1. John D. Anderson. Jr., "Modern Compressible flow with historical Perspective", Mc.Graw Hill Publishing Company, New York, 1996.
2. John T. Bertin, "Hypersonic Aerothermodynamics", published by AIAA Inc., Washington. D.C., 1994.

**AE6014****EXPERIMENTAL AERODYNAMICS****L T P C  
3 0 0 3****OBJECTIVES:**

- To provide details, operating principles and limitations of forces, pressure, velocity and temperature measurements. To describe flow visualization techniques and to highlight in depth discussion of analog methods.

**UNIT I BASIC MEASUREMENTS IN FLUID MECHANICS 7**

Objective of experimental studies – Fluid mechanics measurements – Properties of fluids – Measuring instruments – Performance terms associated with measurement systems – Direct measurements - Analogue methods – Flow visualization –Components of measuring systems – Importance of model studies.

**UNIT II CHARACTERISTICS OF MEASUREMENTS 10**

Characteristic features, operation and performance of low speed, transonic, supersonic and special tunnels - Power losses in a wind tunnel – Instrumentation of wind tunnels – Turbulence- Wind tunnel balance –principles, types and classifications -Balance calibration.

**UNIT III FLOW VISUALIZATION AND ANALOGUE METHODS 9**

Principles of Flow Visualization – Hele-Shaw apparatus - Interferometer – Fringe-Displacement method – Schlieren system – Shadowgraph - Hydraulic analogy – Hydraulic jumps – Electrolytic tank

**UNIT IV PRESSURE, VELOCITY AND TEMPERATURE MEASUREMENTS 9**

Measurement of static and total pressures in low and high speed flows- Pitot-Static tube characteristics - Pressure transducers – principle and operation – Velocity measurements - Hot-wire anemometry – LDV – PIV: Temperature measurements.

**UNIT V SPECIAL FLOWS AND UNCERTAINTY ANALYSIS 10**

Experiments on Taylor-Proudman theorem and Ekman layer – Measurements in boundary layers - Data acquisition and processing – Signal conditioning - Uncertainty analysis – Estimation of measurement errors – External estimate of the error – Internal estimate of the error – Uncertainty calculation - Uses of uncertainty analysis.

**TOTAL: 45 PERIODS****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

**TEXT BOOKS:**

1. Rathakrishnan, E., "Instrumentation, Measurements, and Experiments in Fluids," CRC Press – Taylor & Francis, 2007.
2. Robert B Northrop, "Introduction to Instrumentation and Measurements", Second Edition, CRC Press, Taylor & Francis, 2006.

**REFERENCES:**

1. Pope, A., and Goin, L., "High Speed Wind Tunnel Testing", John Wiley, 1985.Bradsaw Experimental Fluid Mechanics.
2. NAL-UNI Lecture Series 12: Experimental Aerodynamics, NAL SP 98 01 April 1998
3. Lecture course on "Advanced Flow diagnostic techniques" 17-19 September 2008 NAL, Bangalore

**AE6015****ROCKETS AND MISSILES****L T P C**  
**3 0 0 3****OBJECTIVES:**

- To give exposure on important topics like rocket motion, rocket aerodynamics and staging & control of rockets to students to enrich their knowledge in the area of missile flight.

**UNIT I CLASSIFICATION OF ROCKETS AND MISSILES****9**

Various methods of classification of missiles and rockets – Basic aerodynamic characteristics of surface to surface, surface to air, air to surface and air to air missiles – Examples of various Indian space launch vehicles and missiles – Current status of Indian rocket programme with respect to international scenario

**UNIT II AERODYNAMICS OF ROCKETS AND MISSILES****10**

Airframe components of rockets and missiles – forces acting on a missile while passing through atmosphere – classification of missiles – slender body aerodynamics – method of describing forces and moments – lift force and lateral moment –lateral aerodynamic damping moment – longitudinal moment – drag estimation – upwash and downwash in missile bodies – rocket dispersion.

**UNIT III ROCKET MOTION IN FREE SPACE AND GRAVITATIONAL FIELD****10**

One dimensional and two-dimensional rocket motions in free space and homogeneous gravitational fields – description of vertical, inclined and gravity turn trajectories – determination of range and altitude – simple approximations to determine burn out velocity and altitude – estimation of culmination time and altitude.

**UNIT IV STAGING OF ROCKETS AND MISSILES****8**

Design philosophy behind multistaging of launch vehicles and ballistic missiles – optimization of multistage vehicles – stage separation techniques in atmosphere and in space – stage separation dynamics and lateral separation characteristics –

**UNIT V CONTROL OF ROCKETS AND MISSILES****8**

Introduction to aerodynamic and jet control methods – various types of aerodynamic control methods for tactical and short range missiles- aerodynamic characteristics - various types of thrust vector control methods including secondary injection thrust vector control for launch vehicles and ballistic missiles – .

**TOTAL: 45 PERIODS****OUTCOMES**

- Knowledge in types of rockets and missiles with respect to Indian & international scenario
- Gaining informations on aerodynamics of rocket and missiles
- Knowledge on stages and remote control of rockets missiles

**TEXT BOOKS:**

1. Cornelisse, J.W., "Rocket Propulsion and Space Dynamics", J.W. Freeman & Co., Ltd, London, 1982
2. Sutton, G.P., "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 5<sup>th</sup> Edition, 1993.

**REFERENCES:**

1. Parker, E.R., "Materials for Missiles and Spacecraft", McGraw Hill Book Co. Inc. 1982.
2. Mathur, M.L., and Sharma, R.P., "Gas Turbine, Jet and Rocket Propulsion", Standard Publishers and Distributors, Delhi, 1988.

**AE6016****STRUCTURAL DYNAMICS****L T P C  
3 0 0 3****OBJECTIVES:**

- To study the effect of periodic and a periodic forces on mechanical systems with matrix approach and also to get the natural characteristics of large sized problems using approximate methods.

**UNIT I FORCE DEFLECTION PROPERTIES OF STRUCTURES 9**

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

**UNIT II PRINCIPLES OF DYNAMICS 9**

Free and forced vibrations of systems with finite degrees of freedom – Response to periodic excitation – Impulse Response Function – Convolution Integral

**UNIT III NATURAL MODES OF VIBRATION 9**

Equations of motion for Multi degree of freedom Systems - Solution of Eigen value problems – Normal coordinates and orthogonality Conditions. Modal Analysis.

**UNIT IV ENERGY METHODS 9**

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

**UNIT V APPROXIMATE METHODS 9**

Approximate methods of evaluating the Eigen frequencies and eigen vectors by reduced, subspace, Lanczos, Power, Matrix condensation and QR methods.

**TOTAL: 45 PERIODS****OUTCOMES**

- Knowing various options of mathematical modeling of structures
- Method of evaluating the response of structures under various dynamically loaded conditions
- Knowledge in natural modes of vibration of structures
- Gaining knowledge in numerical and approximate methods of evaluating natural modes of vibration.

**TEXT BOOKS:**

1. Tse. F.S., Morse. I.E. and Hinkle. H.T., "Mechanical Vibrations: Theory and Applications" , Prentice Hall of India Pvt. Ltd, New Delhi, 2004.
2. Hurty. W.C. and M.F. Rubinstein, "Dynamics of Structures", Prentice Hall of India Pvt. Ltd., New Delhi 1987.



**REFERENCES:**

1. Vierck. R.K., "Vibration Analysis", 2<sup>nd</sup> Edition, Thomas Y. Crowell & Co Harper & Row Publishers, New York, U.S.A. 1989.
2. Timoshenko. S.P., and D.H. Young, "Vibration Problems in Engineering", John Willey & Sons Inc., 1984.
3. Ramamurthi. V., "Mechanical Vibration Practice and Noise Control" Narosa Publishing House Pvt. Ltd, 2008