B.E. AERONAUTICAL

COURSE DIARY
ACADEMIC YEAR (2011 - 2012)

VI - SEMESTER

Name : _____________________________
USN  : _____________________________
Semester & Section : ________________________

The Mission

“The mission of our Institution is to provide world class education in our chosen fields and prepare people of character, caliber and vision to build the future world”
## INDEX

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Subject / Code</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Schedule of Events</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Scheme of Teaching and Examinations</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>INTRODUCTION TO COMPOSITE MATERIALS</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>AIRCRAFT STRUCTURES-II</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>AERODYNAMICS - II</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>FINITE ELEMENT ANALYSIS</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>THEORY OF VIBRATIONS</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Elective - I: (Group A)</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>AERODYNAMICS LABORATORY</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>PROPULSION LABORATORY</td>
<td></td>
</tr>
</tbody>
</table>
# SCHEDULE OF EVENTS (2012)

**B.E. (Aero) – VI Semester**

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commencement of Semester</td>
<td>Feb 2012</td>
</tr>
<tr>
<td>Internal Test Schedule</td>
<td></td>
</tr>
<tr>
<td>• First Test</td>
<td></td>
</tr>
<tr>
<td>• Second Test</td>
<td></td>
</tr>
<tr>
<td>• Third Test</td>
<td></td>
</tr>
<tr>
<td>End of Semester</td>
<td></td>
</tr>
<tr>
<td>Commencement of Practical Examinations</td>
<td></td>
</tr>
<tr>
<td>Commencement of Theory Examinations</td>
<td></td>
</tr>
<tr>
<td>Commencement of ODD Semester</td>
<td></td>
</tr>
</tbody>
</table>

**OTHER MAJOR EVENTS**

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVJ Memorial Cricket Tournament</td>
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</tr>
<tr>
<td>SWAYAM</td>
<td>March 2012</td>
</tr>
<tr>
<td>Founder’s Day</td>
<td>17th May</td>
</tr>
</tbody>
</table>
## SCHEME OF TEACHING & EXAMINATION
### VI – SEMESTER

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Subject Code</th>
<th>Title</th>
<th>Teaching Dept.</th>
<th>Teaching Hours / week</th>
<th>Examination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Th.</td>
<td>Pr.</td>
</tr>
<tr>
<td>1</td>
<td>06AE61</td>
<td>Introduction to Composite Materials</td>
<td>ME/IEM</td>
<td>04</td>
<td>--</td>
</tr>
<tr>
<td>2</td>
<td>06AE62</td>
<td>Aircraft Structures II</td>
<td>AE</td>
<td>04</td>
<td>--</td>
</tr>
<tr>
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<td>Aerodynamics – II</td>
<td>AE</td>
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<td>AE</td>
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INTRODUCTION TO COMPOSITE MATERIALS

Sub Code: 06AL61  IA Marks: 25
Hrs/ Week: 04  Exam Hours: 03
Total Hours: 52  Exam Marks: 100

PART A
1. INTRODUCTION TO COMPOSITE MATERIALS: 06Hrs

Definition, classification and characteristics of composite materials – fibrous composites, laminated. Matrix materials

2. FIBER REINFORCED PLASTIC PROCESSING: 06Hrs

Lay up and curing, fabricating process - open and closed mould process - hand lay up techniques structural laminate bag molding, production procedures for bag molding.

3. ADVANCED PROCESSING TECHNIQUES AND APPLICATION OF COMPOSITES: 08Hrs

Filament winding, pultrusion, pulforming, thermo - forming, injection, injection molding, liquid molding, blow molding, Automobile, Aircrafts, missiles, Space hardware, Electrical and electronics, marine, recreational and Sports equipment, future potential of composites.

4. FABRICATION OF COMPOSITE STRUCTURES: 06 Hrs

Cutting, machining, drilling, mechanical fasteners and adhesive bonding, joining, computer-aided design and manufacturing, tooling, fabrication equipment.

PART B

5. MACRO-MECHANICAL BEHAVIOR OF A LAMINA: 06 Hrs

Stress-strain relation for an orthotropic lamina- Restriction on elastic constants-Strengths of an orthotropic lamina and Failure theories for an orthotropic lamina.

6. MICRO-MECHANICAL BEHAVIOR OF A LAMINA: 06 Hrs

Determination of elastic constants-Rule of mixtures, transformation of coordinates, micro-mechanics based analysis and experimental determination of material constants.
7. MACRO-MECHANICAL BEHAVIOR OF A LAMINATE: 06 Hrs

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

8. METAL MATRIX COMPOSITES: 08 Hrs

Reinforcement materials, types, characteristics and selection of base metals. Application of MMC’s.

TEXT BOOKS:

REFERENCE:

Scheme of Examination:
One Question to be set from each chapter. Students have to answer any FIVE full questions out of EIGHT questions, choosing at least TWO questions from Part A and TWO questions from Part B.
# LESSON PLAN

**SUB CODE:** 06AE61  
**SUBJECT:** INTRODUCTION TO COMPOSITE MATERIALS

<table>
<thead>
<tr>
<th>Period</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>INTRODUCTION TO COMPOSITE MATERIALS</td>
</tr>
<tr>
<td>2</td>
<td>Definition, classification</td>
</tr>
<tr>
<td>3</td>
<td>classification</td>
</tr>
<tr>
<td>4</td>
<td>classification</td>
</tr>
<tr>
<td>5.</td>
<td>characteristics of composite materials</td>
</tr>
<tr>
<td>6</td>
<td>characteristics of composite materials</td>
</tr>
<tr>
<td>7</td>
<td>fibrous composites</td>
</tr>
<tr>
<td>8</td>
<td>laminated. Matrix materials</td>
</tr>
<tr>
<td>9</td>
<td>FIBER REINFORCED PLASTIC PROCESSING</td>
</tr>
<tr>
<td>10</td>
<td>Lay up and curing,</td>
</tr>
<tr>
<td>11</td>
<td>fabricating process</td>
</tr>
<tr>
<td>12</td>
<td>open and closed mould process</td>
</tr>
<tr>
<td>13</td>
<td>hand lay up techniques</td>
</tr>
<tr>
<td>14</td>
<td>structural laminate bag molding</td>
</tr>
<tr>
<td>15</td>
<td>production procedures for bag molding.</td>
</tr>
<tr>
<td>16</td>
<td>production procedures for bag molding</td>
</tr>
<tr>
<td>17</td>
<td>ADVANCED PROCESSING TECHNIQUES AND APPLICATION OF COMPOSITES</td>
</tr>
<tr>
<td>18</td>
<td>Filament winding,</td>
</tr>
<tr>
<td>19</td>
<td>pultrusion</td>
</tr>
<tr>
<td>20</td>
<td>pulforming</td>
</tr>
<tr>
<td>21</td>
<td>thermo - forming</td>
</tr>
<tr>
<td>22</td>
<td>injection, injection molding</td>
</tr>
<tr>
<td>23</td>
<td>liquid molding, blow molding</td>
</tr>
<tr>
<td>24</td>
<td>Automobile, Aircrafts, missiles</td>
</tr>
<tr>
<td>25</td>
<td>Space hardware, Electrical and electronics</td>
</tr>
<tr>
<td>26</td>
<td>marine, recreational and Sports equipment</td>
</tr>
<tr>
<td>27</td>
<td>future potential of composites</td>
</tr>
<tr>
<td>28</td>
<td>FABRICATION OF COMPOSITE STRUCTURES</td>
</tr>
<tr>
<td>29</td>
<td>Cutting, machining,</td>
</tr>
<tr>
<td>30</td>
<td>drilling, mechanical fasteners and</td>
</tr>
<tr>
<td>31</td>
<td>adhesive bonding, joining,</td>
</tr>
<tr>
<td>32</td>
<td>computer-aided design and manufacturing</td>
</tr>
<tr>
<td>33</td>
<td>tooling</td>
</tr>
<tr>
<td>34</td>
<td>fabrication equipment</td>
</tr>
<tr>
<td>35</td>
<td>MACRO-MECHANICAL BEHAVIOR OF A LAMINA</td>
</tr>
<tr>
<td>36</td>
<td>Stress-strain relation for an orthotropic lamina</td>
</tr>
<tr>
<td>37</td>
<td>Stress-strain relation for an orthotropic lamina</td>
</tr>
<tr>
<td>38</td>
<td>Restriction on elastic constants-Strengths of an orthotropic lamina and</td>
</tr>
<tr>
<td>39</td>
<td>Restriction on elastic constants-Strengths of an orthotropic lamina and</td>
</tr>
<tr>
<td>40</td>
<td>Failure theories for an orthotropic lamina</td>
</tr>
<tr>
<td>41</td>
<td>Failure theories for an orthotropic lamina</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>42</td>
<td>Failure theories for an orthotropic lamina</td>
</tr>
<tr>
<td>43</td>
<td><strong>MICRO-MECHANICAL BEHAVIOR OF A LAMINA</strong></td>
</tr>
<tr>
<td>44</td>
<td>Determination of elastic constants</td>
</tr>
<tr>
<td>45</td>
<td>Determination of elastic constants</td>
</tr>
<tr>
<td>46</td>
<td>Rule of mixtures</td>
</tr>
<tr>
<td>47</td>
<td>Transformation of coordinates</td>
</tr>
<tr>
<td>48</td>
<td>Micro-mechanics based analysis and</td>
</tr>
<tr>
<td>49</td>
<td>Experimental determination of material constants</td>
</tr>
<tr>
<td>50</td>
<td><strong>MACRO-MECHANICAL BEHAVIOR OF A LAMINATE</strong></td>
</tr>
<tr>
<td>51</td>
<td>Classical plate theory</td>
</tr>
<tr>
<td>52</td>
<td>Stress and strain variation in a laminate</td>
</tr>
<tr>
<td>53</td>
<td>Resultant forces and moments</td>
</tr>
<tr>
<td>54</td>
<td>Resultant forces and moments</td>
</tr>
<tr>
<td>55</td>
<td>A B &amp; D matrices</td>
</tr>
<tr>
<td>56</td>
<td>Strength analysis of a laminate</td>
</tr>
<tr>
<td>57</td>
<td>Strength analysis of a laminate</td>
</tr>
<tr>
<td>58</td>
<td><strong>METAL MATRIX COMPOSITES</strong></td>
</tr>
<tr>
<td>59</td>
<td>Reinforcement materials</td>
</tr>
<tr>
<td>60</td>
<td>Reinforcement materials</td>
</tr>
<tr>
<td>61</td>
<td>Types, characteristics and selection of base metals. Application of MMC’s</td>
</tr>
<tr>
<td>62</td>
<td>Types, characteristics and selection of base metals. Application of MMC’s</td>
</tr>
</tbody>
</table>
Sixth Semester B.E. Degree Examination, June-July 2009
Introduction to Composite Materials

Time: 3 hrs.
Max. Marks: 100

Note: Answer any FIVE full questions, selecting at least TWO questions from each part.

PART – A

1. a. Define composites. Classify them in accordance with the materials and reinforcement types. (10 Marks)
   b. Explain the role of matrix and fibres in laminated composites. (05 Marks)
   c. Highlight the mechanical properties of fibrous composites. (05 Marks)

2. a. Discuss i) Lay-up ii) Vacuum bag moulding techniques of preparing laminated composites. (15 Marks)
   b. Highlight the desirable properties of carbon and Aramid fibres. (05 Marks)

3. Discuss the following techniques of processing composites, highlighting the merits, demerits and applications
   i) filament winding
   ii) Pultrusion
   iii) Injection moulding. (20 Marks)

4. a. Explain the different methods of joining composites and discuss the challenges that exist during joining. (10 Marks)
   b. Discuss the potential applications of polymer band fibre reinforced composites in various fields. (10 Marks)

PART – B

5. a. Write the expression relating stresses and strains for 2D orthotropic laminate. (06 Marks)
   b. Discuss the various failure theories related to laminated composites. (14 Marks)

6. a. Derive an expression for Young’s modulus of a composite in terms of volume fraction of matrix fibre and elastic moduli of matrix and fibre under iso-strain condition. (10 Marks)
   b. For a composite of epoxy resin reinforced with 20 vol% of carbon fibres subjected to longitudinal loading calculate
      i) elastic modulus of composite
      ii) ratio of \( \frac{\sigma_c}{\sigma_e} \) (Fibre stress to stress in composite)

Assume – \( E_{carbon\ fibre} = 900 \text{ GPa} \)
\( E_{epoxy} = 30 \text{ GPa} \) (10 Marks)

7. Derive the following matrices with respect to an laminated composite material.
   i) \( [A] \) ii) \( [B] \) (20 Marks)

8. a. Discuss any one technique of producing metal matrix composites. (10 Marks)
   b. Bring out the potential applications of metal matrix composites. (05 Marks)
   c. Explain what is meant by wettability and discuss the measures to improve it. (05 Marks)
Sixth Semester B.E. Degree Examination, May/June 2010

Introduction to Composite Materials

Time: 3 hrs.  Max. Marks: 100

Note: Answer any FIVE full questions, selecting at least TWO questions from each part.

PART – A

1. a. Define a composite material. (03 Marks)
    b. Explain the characteristics of fibrous composites, laminated composites and particulate composites, with figure. (12 Marks)
    c. Write a note on types of reinforcement and matrix materials. (05 Marks)

2. a. Explain hand lay up technique, with neat sketches. (10 Marks)
    b. Explain the production procedure for vacuum bag moulding technique, with neat sketches. (10 Marks)

3. a. With neat sketches, explain the following processes:
    i) Filament winding
    ii) Blow moulding. (16 Marks)
    b. Explain the applications of composites in missiles and marine applications. (04 Marks)

4. a. Explain the various methods used for cutting cured composites. (07 Marks)
    b. Explain the mechanical fastening and adhesive bonding of composites. (08 Marks)
    c. Write a note on drilling of composites. (05 Marks)

PART – B

5. a. Write the number of independent elastic constants for three dimensional anisotropic, monoclinic, orthotropic, transversely isotropic and isotropic materials. (05 Marks)
    b. Write reduced stiffness and compliance matrix for an isotropic material. (07 Marks)
    c. Write a note on Kirchoff’s hypothesis. (08 Marks)

6. a. Derive an expression for elastic modules of a composite in terms of elastic moduli and volume fraction of matrix and fibre phases. (06 Marks)
    b. Write a note on experimental determination of material constants. (06 Marks)
    c. A tensile load of 500 N is applied to an epoxy glass fibre composite. If the cross section of the composite is 1 mm² and the volume of the fibre is 30%, calculate the stress in the fibre when:
       i) The load axis is parallel to the fibre (06 Marks)
       ii) The load axis is perpendicular to the fibre

    Take the values of Young’s modulus for the glass fibre as 86 GN/m² and for matrix as 3.38 GN/m². (08 Marks)

7. a. On the basis of classical lamination theory derive the expressions for force and momentum resultants of a general laminate. (10 Marks)
    b. Show that for an antisymmetric cross ply laminate, extension stiffness $A_{22} = A_{11}$, coupling stiffness $B_{22} = -B_{11}$ and bending stiffness $D_{22} = D_{11}$. (10 Marks)

8. a. Describe any one method of fabrication of MMC’s. (08 Marks)
    b. Discuss some of the common base metals and reinforcement materials used in MMC’s. (06 Marks)
    c. List some important applications of MMC’s and FRP’s. (06 Marks)
AIRCRAFT STRUCTURES II

<table>
<thead>
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<th>06AE62</th>
<th>IA Marks:</th>
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PART A

1. INTRODUCTION TO AIRCRAFT STRUCTURAL DESIGN: 06Hrs

Structural layout of the Airplane and components, Structural design V-n diagram, loads acting on major components such as wing, fuselage, tails, landing gear etc., Concept of allowable stress and margin of safety.

2. UNSYMMETRICAL BENDING: 06Hrs

Bending stresses in beams of unsymmetrical sections – Bending of symmetric sections with skew loads

3. SHEAR FLOW IN OPEN SECTIONS: 06Hrs

Thin walled beams, Concept of shear flow, shear centre, Elastic axis. With one axis of symmetry, with wall effective and ineffective in bending, unsymmetrical beam sections.

4. SHEAR FLOW IN CLOSED SECTIONS: 08Hrs

Bredt – Batho formula, Single and multi – cell structures, Approximate methods, Shear flow in single & multi-cell structures under torsion. Shear flow in single and multi-cell under bending with walls effective and ineffective.

PART B

5. BUCKLING OF PLATEES: 06Hrs

Rectangular sheets under compression, Local buckling stress of thin walled sections, Crippling stresses by Needham’s and Gerard’s methods, Thin walled column strength. Sheet – stiffener panels. Effective width, inter rivet and sheet wrinkling failures.

6. STRESS ANALYSIS IN WING AND FUSELAGE: 08Hrs

Procedure – Shear and bending moment distribution for semi cantilever and other types of wings and fuselage, thin webbed beam. With parallel and non parallel flanges, Shear resistant web beams, Tension field web beams (Wagner’s).
7. DESIGN OF AIRCRAFT STRUCTURE: 06 Hrs


8. JOINTS AND FITTINGS AND INTRODUCTION TO POST BUCKLING: 06 Hrs

General theory for the design of fittings, Estimation of fitting design loads, design of riveted, bolted and welding joints, post buckling of structures, concept of effective width.

TEXT BOOKS:

REFERENCE:
3. D Williams & Edward Arnold, An Introduction to the Theory of Aircraft Structures

Scheme of Examination:
One Question to be set from each chapter. Students have to answer any FIVE full questions out of EIGHT questions, choosing at least TWO questions from Part A and TWO questions from Part B.
Sixth Semester B.E. Degree Examination, June-July 2009
Aircraft Structures - II

Time: 3 hrs.

Note: Answer any FIVE full questions, selecting at least TWO questions from each part.

Max. Marks: 100

1. a. Draw a typical manoeuvre loading flight envelope and outline the significance of various lines and corner points. (11 Marks)
b. An airplane weighing 6350 kg flying horizontally at a velocity of 225 m/sec was pulled upwards into a curved flight path of radius 765 m by the pilot. Calculate
i) Balancing tail load.
ii) Wing lift and
iii) Airplane load factor.

2. a. Discuss the notations and sign conventions used for forces, moments and displacements in the study of an arbitrary structural member subjected to loads and moments. (06 Marks)
b. Figure Q2 (b) shows an angle purlin subjected to positive bending moments $M_x$ and $M_y$ as shown. The dimensional details and the geometrical properties are also furnished as follows:

![Diagram](image)

i) Calculate the location of the centroid with respect to the base 3.4.
ii) Calculate the direct stresses induced at points (3) and (2) respectively. (14 Marks)

3. a. Determine the position of the shear center of the thin walled channel section shown in the figure Q3 (a).

![Diagram](image)
3 b. Derive an equation to determine the direct stress distribution in the thin walled z section shown in figure Q3 (b) subjected to a positive bending moment M.

\[ 0 \text{ Mark} \]

![Diagram](image)

Fig. Q3 (b)

4 a. Derive Bredt-Bacho formula.

b. Figure Q4 (b) shows a typical 2 cell tubular section as formed by a conventional aerofill shape and having one interior rib. An external applied torque T of 2.45 kNm is acting as shown. Calculate the shear flow pattern of the two cell beam.

\[ 0 \text{ Marks} \]

![Diagram](image)

Fig. Q4 (b)

Area of cell 1 = 6.83 x 10^4 mm^2; Area of cell 2 = 2.5 x 10^4 mm^2;
Length segments: AB = 680 mm; BC = 640 mm; CD = 400 mm; DA = 645 mm; AB = 340 mm

PART - B


b. A thin walled column of length 1 m has the cross section as shown in figure Q5 (b). If the ends of the column are pinned and free to warp, calculate the buckling load and the mode, given the following data (with usual notations):

\[ E = 70000 \text{ N/mm}^2; \ G = 30000 \text{ N/mm}^2 \]
\[ I_{xx} = 1.17 \times 10^6 \text{ mm}^4; \ I_{yy} = 0.67 \times 10^6 \text{ mm}^4; \ I_s = 5.32 \times 10^6 \text{ mm}^4 \]
\[ A = 600 \text{ mm}^2; \ J = 800 \text{ mm}^4; \ r = 2488 \times 10^4 \text{ mm}^6 \]

Centroid location \( x = 33.3 \text{ mm} \) and shear centre location \( x_y = -76.2 \text{ mm} \) and \( \gamma = 0 \)

\[ 0 \text{ Marks} \]

![Diagram](image)

Fig. Q5 (b)

2 of 3
6. a. What are the different loads that a fuselage of an aircraft is subjected to? (06 Marks)
   b. A wing spar has the dimensions shown in the figure Q6 (b) and carries a uniformly distributed load of 15 N/mm along its complete length. Each flange has a cross section of 500 mm² and the top flange being horizontal. If the flanges are assumed to resist all the direct loads while the spar web is effective only in shear, determine the flange loads and the shear loads in the web at sections at 1 m and 2 m from the free end. (14 Marks)

![Fig. Q6 (b)](image)

7. a. Define fatigue. What are the various ways through which fatigue damages are produced? Briefly explain each one. (14 Marks)
   b. What are the modes of crack growth? Briefly explain. (06 Marks)

8. a. Define the following terms as applied to aircraft structural analysis, i) Factor of safety ii) Ultimate load iii) Fitting factor iv) Design fitting load. (04 Marks)
   b. What are the types of failures that could be encountered in a bolt with bush and lug fitting? (05 Marks)
   c. Analyse the efficiency of the bolt and lug joint given in figure Q8 (c) for the loading and other details furnished.
   - Bolt dia (d) = 12.5 mm; Bush thickness (t) = 1.5 mm; Applied load = P = 66750 N;
   - T = 14.5 mm (thickness); \( \alpha = 36 \) mm (width); \( R = 18 \) mm
   - Material properties (with usual notation)
   - Lug: \( F_s = 445 \) N/mm²; \( F_y = 265 \) N/mm²; \( F_r = 575 \) N/mm²
   - Bolt Bush: \( F_s = 515 \) N/mm²; \( F_y = 1205 \) N/mm²
   - Factor safety = 1.5; Fitting factor = 1.2 (11 Marks)

![Fig. Q8 (c)](image)
Sixth Semester B.E. Degree Examination, May/June 2010
Aircraft Structures – II

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, selecting at least TWO questions from each part.

PART – A

1 a. Explain the four basic flight loading conditions that are likely to result in maximum loads in the flight. (10 Marks)
   b. Draw a typical gust envelope. (10 Marks)

2 a. Develop the expression for direct stress for the case of unsymmetrical bending. (10 Marks)
   b. A beam having the cross – section shown in Fig.2(b) is subjected to a pure bending moment of 1500 Nm in a vertical plane. Calculate the maximum direct stress due to bending. Axis of origin is shown at a centroid. (10 Marks)

   ![Fig.2(b)]

3 a. What is a shear center? (05 Marks)
   b. Derive the expression for shear of open section beams. (15 Marks)

4 a. Explain Bredt Batho formula for torsion. (08 Marks)
   b. Explain the method of determine shear in closed section beams. (12 Marks)

PART – B

5 a. Derive an expression for buckling stress for isotropic flat plates in compression. (08 Marks)
   b. Write the expression for the buckling stress for a sheet supported form sides, if there are ‘m’ number of waves in the buckled sheet. (06 Marks)
   c. Explain the effective width concept, in case the sheet is riveted with ‘L’ shape stringers. (06 Marks)

6 Explain the stress analysis in wings and fuselage. (20 Marks)

7 Explain the following:
   a. Safe life and fail safe concept (10 Marks)
   b. Fatigue life. (10 Marks)

8 Find the resultant force in each rivet of the connection shown in Fig.8 (20 Marks)

![Fig.8]
Sixth Semester B.E. Degree Examination, June/July 2011

Aircraft Structures - II

Time: 3 hrs. Max. Marks: 100

Note: Answer FIVE full questions selecting at least TWO questions from each part.

PART – A

1. a. Explain the concept of allowable and margin of safety based on different failure modes. (08 Marks)
   b. Discuss the loads on aircraft structural components under i) Ground loads ii) Air loads showing pressure distribution on lifting surface and fuselage iii) Loads peculiar to a/c being designed. (12 Marks)

2. a. What are the assumptions of symmetric bending? Explain the unsymmetric bending with associated equations. (08 Marks)
   b. A beam having the cross section shown in Fig. Q2 (b) is subjected to a bending moment of 1000Nm in the vertical plane. Calculate the maximum direct stress and point where it acts.

   ![Fig. Q2 (b)]

   (12 Marks)

3. a. What is shear flow? List the assumptions of shear flow analysis. (05 Marks)
   b. Explain shear centre. (04 Marks)
   c. Find shear flow distribution and shear centre of the cross section, shown in Fig. Q3 (c).

   ![Fig. Q3 (c)]

   (11 Marks)
4. a. Explain Bredt-Batho theory and derive Bredt-Batho formula.  
   b. A uniform thin walled cantilever beam of closed rectangular cross section is as shown in 
   Fig. Q4 (b). The shear modulus G of the top and bottom curves of the beam is subjected to a 
   uniformly distributed torque of 20Nm/mm along it’s length. Calculate maximum shear stress 
   according to the Bredt-Batho theory of torsin. Calculate Twist distribution along the length.

   ![Fig. Q4 (b)]

5. a. Explain buckling and crippling stress. Bring out the essential differences between them.  
   b. Define and explain the term effective skin width.  
   c. Explain the concept of Wagner beam (Tension field beam).

6. a. At a section of a fuselage the bending moment due to self weight was 9.8KNm and due to 
   symmetrical pull out tail load is 45.1KNm down. The tail load may be assumed to be acting 
   at 2m away from the section. If the stringers are 16 in number and placed as shown, with 
   areas of stringers placed symmetrical about yy axis, calculate stress in stringers.

   ![Fig. Q6 (a)]

<table>
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<tr>
<td>9</td>
<td>640</td>
<td>0</td>
<td>-540</td>
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   b. For the wing shown calculate shear force, B M and torque distribution along the span and 
   plot. Assume lift distribution to be at 0.25C and elastic axis at 0.45C.

   ![Fig. Q6 (b)]

<table>
<thead>
<tr>
<th>y(m)</th>
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<tbody>
<tr>
<td>0.6</td>
<td>1000N</td>
</tr>
<tr>
<td>1.2</td>
<td>800N</td>
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<tr>
<td>1.8</td>
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<tr>
<td>2.4</td>
<td>400N</td>
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<tr>
<td>3.0</td>
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</table>
7 a. List the design criteria specifying associated modes of failure and data to be considered for the same. (05 Marks)
   b. Derive the equation for cycle of failure $N_f$, form initial length of crack $2a_0$. Given stress intensity factor $K$ is $K = \frac{2}{\pi} \sigma \sqrt{\Pi a}$ (10 Marks)
   c. Explain 2 Bay crack criteria. (05 Marks)

8 a. Explain the joint design considerations in aircraft design. (08 Marks)
   b. Fitting details given below, Fig. Q8 (b):
      Forging: $F_t = 65000 N/mm^2$; $F_s = 39000 N/mm^2$; $F_{mb} = 98000 N/mm^2$.
      Bolt and bushing. $F_t = 125000 N/mm^2$; $F_s = 75000 N/mm^2$; $F_{mb} = 175000 N/mm^2$.
      The fitting resist limit or applied loads $15 \times 10^6 N$ compression and $12 \times 10^6 N$ Tension. A fitting factor of 1.2 and a bearing factor of 2 are used. Find MOS for all failure modes.

Fig. Q8 (b)

* * * * *
Q1(a) Explain four basic flight loading conditions that are likely to result in maximum loads in flight.
b) Draw a typical gust envelope.
c) Find out the cruise speed for which gust velocity of 15.25 m/sec would become critical for the following transport category aeroplane having a limiting load factor value $n_1$ of 2.5
Wing loading, $w = 2400$ N/m$^2$
Lift curve slope, $a = 2.5$ / radian
Effectiveness of gust, $K = 0.8$
Sea level density of air $= 1.223$ Kg/m$^3$
d) Explain functions of various structural components

Q2(a) Derive expression for direct stress for the case of unsymmetrical bending.
b) Find the position of neutral axis for the above case.
c) A beam having the cross-section shown below is subjected to pure bending moment of 1600 N m in a vertical plane. Calculate the maximum direct stress due to bending. Axis of origin is shown at a Centroid.

![Diagram of beam cross-section]

Q3 (a) Derive expression for load intensity, shear force and bending moment relationship, general case.
b) Describe parallel axis theorem for determining the second moment of area about an axis parallel to axis passing through centroid
c) Define the following:
d) Determine the second moment of area of an I-Section beam by parallel axis theorem.

e) Explain approximations for thin–walled sections. Derive expression for second moment of area $I_{xx}$ for a thin-walled channel section.

f) Determine second moment of area of a semicircular thin section.

Q4 a) Derive expression for shear of open section beams.

b) Derive expression for shear flow and Determine the shear flow distribution in the following thin-walled $Z$–section due to shear load $S_y$ applied through the shear centre of the section.

The second moments of areas of the section areas below:

$$I_{xx} = \frac{h^3 t}{3}, \ I_{yy} = \frac{h^3 t}{12}, \ I_{xy} = \frac{h^3 t}{8}$$

c) Derive expression for the second moments of areas of the thin-walled section below.
Q5(a) Explain the concept of Structural Idealization  
b) Explain the method to determine shear in open section beams 

c) What is shear center? Explain method to determine the shear center in closed section beams.  

d) The fuselage section shown in figure below is subjected to pure bending Moment of 100 KNm applied in the vertical plane of symmetry. If the section has been completely idealized into combination of direct stress carrying booms and shear stress only carrying panels, determine the direct stress in each boom. 

Each boom has an area of 150 mm$^2$ and all booms are equally spaced in the fuselage ring.

Q6a) The fuselage section shown in figure below is subjected to vertical shear load of $S_y$ equal to 10 kN. If the section has been completely idealized into combination of direct stress carrying booms and shear stress only carrying panels, determine the shear stress in each boom. 

Each boom has an area of 150 mm$^2$ and all booms are equally spaced in the fuselage ring.
b) The thin-walled single cell beam shown in figure below has been idealized into a combination of direct stress carrying booms and shear stress only carrying walls. If the section supports a vertical shear load of 10 kN acting in a vertical plane through booms 3 and 6, calculate the distribution of shear flow around the section.

Boom area: $B_1 = B_8 = 200 \text{ mm}^2$, $B_2 = B_7 = 250 \text{ mm}^2$, $B_3 = B_6 = 400 \text{ mm}^2$, $B_4 = B_5 = 100 \text{ mm}^2$.

![Beam diagram]

7a). A beam has the singly symmetrical, thin-walled cross-section shown in figure below. The thickness $t$ of the walls is constant throughout. Show that the distance of the shear centre from the web is given by:

$$\xi_s = -d \frac{\rho^2 \sin \alpha \cos \alpha}{1 + 6\rho + 2\rho^3 \sin^2 \alpha}$$

where $\rho = d / h$

![Cross-section diagram]
7b) Figure below show the regular hexagonal cross-section of a thin-walled beam of sides $a$ and constant wall thickness $t$. The beam is subjected to a transverse shear force $S$, its line of action being along a side of the hexagon, as shown. Plot the shear flow distribution around the section, with values in terms of $S$ and $a$.

Q8a) Derive expression for buckling stress for Isotropic Flat Plates in Compression

b) Explain Needham and Gerard Methods for determining crippling stresses in various shapes of structural members.

Q9(a) Explain the various types of failures in bolted or riveted joints.

b) Explain Eccentrically Loaded Connections.

c) What are design considerations for welded joints?

d) Find the resultant force in each rivet of the connection shown in figure below:

Q10a) The fuselage of a light passenger carrying aircraft has the circular cross-section as shown below. The cross-sectional area of each stringer is 100 mm$^2$ and the vertical distances given in this figure are to the mid-line of the section wall at the corresponding stringer position. If the fuselage is subjected to a bending moment of 200 kN m applied in the vertical plane of symmetry, at this section, calculate the direct stress distribution. The thickness of the shell is 0.8 mm. The skin between adjacent stringer can be considered as flat as an approximation during idealization of this structure.
b) Calculate the distribution of shear flow in the above section if the fuselage is subjected to a vertical shear of 100kN applied at a distance of 150 mm from the vertical axis of symmetry.

Q11a) Derive the following expression for twist (θ) per unit length of a box of area (A) due to shear (q) for thin wall section with thickness (t):

$$\theta = \left( \frac{1}{2AG} \right) \int q \frac{ds}{t}, \quad G = \text{shear modulus}$$

b) Explain the followings:
   i) Shear center
   ii) Flexural center
   iii) Torsion center
   iv) Elastic axis
   v) Center of twist

c) The D-cell with Two-Stringers Section with geometry and loads is as shown below; determine the shear stress in the skin ($q_n$) and in the web($q_w$), and the location of shear center for cell.

- $S_n = 15 \text{ cm (nose perimeter)}$
- $t_n = 0.1 \text{ cm (nose thickness)}$
- $t_w = 0.15 \text{ cm (web thickness)}$
- $h_w = 20 \text{ cm (web height)}$
\[ A_0 = 600 \text{ cm}^2 \]

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\[ M_y = 7000 \text{ kgcm} \]
\[ P_z = 1000 \text{ kg} \]

Q12a) Explain the followings:

a) ‘Two-Bay-Crack’ Criteria  
b) Safe life and Fail safe concept  
c) Airworthiness Requirements  
d) Shear flow redistribution due to cut-outs in fuselage
AERODYNAMICS-II

PART – A

1. INTRODUCTION TO TWO-DIMENSIONAL PANEL METHODS  06 Hrs.
Non-lifting flows over arbitrary bodies, source panel method, lifting flows over arbitrary bodies, vortex panel method, some examples

2. INCOMPRESSIBLE FLOWS OVER FINITE WINGS  08 Hrs.
Downwash, Induced drag, vortex filament, the Biot-Savart Law, Prandtl’s lifting line theory and its limitations, Elliptic lift distribution.

3. SUBSONIC LINEARIZED FLOW OVER AIRFOILS  06 Hrs.
Full velocity potential equation, linearized velocity potential equation and boundary condition, Prandtl-Glauret compressibility correction.

4. EFFECTS OF COMPRESSIBILITY  06Hrs.
Critical Mach number; Drag-divergence Mach number, Sound Barrier, Transonic area rule, Introduction to shock-free airfoils.

PART – B

5. APPLICATIONS OF FINITE WING THEORY  06 Hrs.
Simplified horse-shoe vortex model, formation flight, influence of downwash on tail plane, ground effects.

6. BODIES OF REVOLUTION  06 Hrs.
Introduction to slender body theory, cylindrical coordinates, boundary conditions, pressure coefficient, Subsonic flow past a axially symmetric body at zero incidence and solution for a slender cone.

7. SWEPT WINGS AND HIGH-LIFT SYSTEMS  06 Hrs.
Introduction to sweep effects, swept wings, pressure coefficient, typical aerodynamic characteristics, Subsonic and Supersonic leading edges. Introduction to high-lift systems, flaps, leading-edge slats and typical high - lift characteristics.
8. VISCOUS FLOWS 08 Hrs.

Derivation of Navier-Stokes equation for two-dimensional flows, boundary approximations, laminar boundary equations and boundary conditions, Blasius solution, qualitative features of boundary layer flow under pressure gradients, Integral method, aspects of transition to turbulence, turbulent boundary layer properties over a flat plate at low speeds.

TEXT BOOKS:

REFERENCE:
<table>
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</tr>
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<tbody>
<tr>
<td>1</td>
<td>INTRODUCTION TO TWO-DIMENSIONAL PANEL METHOD</td>
</tr>
<tr>
<td>2</td>
<td>Non-lifting flows over arbitrary bodies</td>
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<tr>
<td>4</td>
<td>Source panel method</td>
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<td>INCOMPRESSIBLE FLOWS OVER FINITE WINGS</td>
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<tr>
<td>9</td>
<td>Incompressible Flows Over Finite Wings</td>
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<tr>
<td>10</td>
<td>Downwash</td>
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<tr>
<td>11</td>
<td>Induced drag</td>
</tr>
<tr>
<td>12</td>
<td>Vortex filament</td>
</tr>
<tr>
<td>13</td>
<td>The Biot-Savart Law</td>
</tr>
<tr>
<td>14</td>
<td>Prandtl’s lifting line theory</td>
</tr>
<tr>
<td>15</td>
<td>Prandtl’s lifting line theory</td>
</tr>
<tr>
<td>16</td>
<td>Prandtl’s lifting line theory and its limitations</td>
</tr>
<tr>
<td>17</td>
<td>Elliptic lift distribution</td>
</tr>
<tr>
<td>18</td>
<td>SUBSONIC LINEARIZED FLOW OVER AIRFOILS</td>
</tr>
<tr>
<td>19</td>
<td>Full velocity potential equation</td>
</tr>
<tr>
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<td>Full velocity potential equation</td>
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<tr>
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<tr>
<td>25</td>
<td>Critical Mach number</td>
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<td>29</td>
<td>Transonic area rule</td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td>36</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>BODIES OF REVOLUTION: Introduction</td>
</tr>
<tr>
<td>43</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>SWEPT WINGS AND HIGH-LIFT SYSTEMS: Introduction to sweep effects,</td>
</tr>
<tr>
<td>49</td>
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</tr>
<tr>
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<td>VISCOUS FLOWS:</td>
</tr>
<tr>
<td>------</td>
<td>----------------</td>
</tr>
<tr>
<td>52</td>
<td>Derivation of Navier-Stokes equation for two-dimensional flows</td>
</tr>
<tr>
<td>53</td>
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</tr>
<tr>
<td>54</td>
<td>Boundary layer approximations</td>
</tr>
<tr>
<td>55</td>
<td>Laminar boundary equations</td>
</tr>
<tr>
<td>56</td>
<td>Boundary conditions</td>
</tr>
<tr>
<td>57</td>
<td>Blasius solution</td>
</tr>
<tr>
<td>58</td>
<td>Qualitative features of boundary layer flow under pressure gradients</td>
</tr>
<tr>
<td>59</td>
<td>Integral method,</td>
</tr>
<tr>
<td>60</td>
<td>Aspects of transition to turbulence</td>
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<td>Turbulent boundary layer properties over a flat plate at low speeds.</td>
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Sixth Semester B.E. Degree Examination, June-July 2009

Aerodynamics - II

Max. Marks: 100

Note: Answer any FIVE full questions, selecting at least TWO questions from each part.

PART - A

1. a. Briefly explain what is meant by source panel method and vortex panel method. (6 Marks)
   b. Consider non-lifting flows over arbitrary bodies and describe the procedure to calculate the pressure coefficient at the nth control point through numerical source panel method. (14 Marks)

2. a. Discuss briefly on any four of the following:
   i) Vortex filament.
   ii) Helmholtz’s vortex theorem.
   iii) Biot-Savart law.
   iv) Downwash and
   v) Induced drag.
   b. Consider a rectangular wing with an aspect ratio of b, an induced drag factor \( \delta = 0.055 \), and a zero lift angle of attack. At an angle of attack of 3.4°, the induced drag coefficient for this wing is 0.01. Calculate the induced drag coefficient for a similar wing (a rectangular wing with the same airfoil section) at the same angle of attack, but with an aspect ratio of 10. Assume that the induced factors for drag and the lift slope, \( \delta \) and \( \tau \), respectively, are equal to each other (i.e., \( \delta = \tau \)). Also, for \( AR = 10 \), \( \delta = 0.105 \). (10 Marks)

3. a. What is meant by Prandtl-Glauert Rule. (8 Marks)
   b. Derive the governing velocity potential equation for an inviscid, compressible, irrotational subsonic flow over a body immersed in a uniform stream. (12 Marks)
   c. The theoretical lift coefficient for a thin symmetric airfoil in an incompressible flow is \( C_L = 2\pi \alpha \). Calculate the lift coefficient for \( M_e = 0.7 \). (9 Marks)

4. a. Explain the following with relevant sketches:
   i) Critical Mach number and critical pressure coefficient.
   ii) Drag-Divergence Mach number and sound barrier.
   b. Describe the effect of airfoil thickness on critical Mach number and obtain the relation for critical pressure coefficient in terms of free stream Mach number \( M_e \). (10 Marks)

PART - B

5. a. What is meant by simplified horseshoe vortex model? (8 Marks)
   b. Derive an expression for lift coefficient and induced drag coefficient in terms of circulation strength \( \Gamma(y) \) for a finite wing using Prandtl’s classical lifting line theory. (15 Marks)

6. a. What are the different types of small perturbation flows? Briefly explain with relevant sketches.
   b. Describe the subsonic flow past an axially symmetric body of revolution at zero incidence. (12 Marks)

7. a. What are high lift devices? List them and explain their effects on aerodynamic characteristics.
   b. Discuss the advantages of swept wings in modern airplanes. (18 Marks)

8. a. Define laminar and turbulent boundary layer.
   b. Explain briefly those parameters which encourage the transition from laminar to turbulent flow.
   c. Define the following and also derive the relation:
      i) Displacement thickness
      ii) Momentum thickness. (20 Marks)
Sixth Semester B.E. Degree Examination, May/June 2010
Aerodynamics – II

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, selecting at least TWO questions from each part.

PART – A

1. a. What is a source sheet? Explain. Derive the velocity potential at a point P at a distance \( r \) from a source sheet of strength \( \lambda \) per unit length. (10 Marks)
   b. Consider lifting flow over an arbitrary body and derive an expression for total surface velocity induced at the \( i \) th control point employing vortex panel method and application of Kutta condition. (10 Marks)

2. a. The circulation distribution over a finite wing is of elliptic form 
   \[
   \Gamma(y) = \left[ 1 - \frac{2y}{b} \right] \sqrt{1 - \frac{4y^2}{b^2}} \]
   where \( b \) is the semispan of the wing. Obtain the closed form expression for induce angle of attack and induce drag coefficient. (12 Marks)
   b. Explain the Importance of aspect ratio of finite wing. (04 Marks)
   c. For a finite wing of aspect ratio 8, the induce drag coefficient is 0.01. Find the induce drag coefficient for a wing of aspect ratio 10. (04 Marks)

3. a. Derive an expression for pressure coefficient for an inviscid, compressible, irrotational subsonic flow using linearized velocity potential equation. (12 Marks)
   b. Explain the assumptions made to linearized velocity potential equation. (04 Marks)
   c. At a given point on the surface of an airfoil, the pressure coefficient is -0.3, at a every low speed. If the free stream Mach number is 0.6, calculate the pressure coefficient at this point. (04 Marks)

4. a. Derive the relation for critical pressure coefficient in terms of free stream Mach number. (10 Marks)
   b. Explain how to find the critical Mach number for an airfoil. (06 Marks)
   c. The critical mach number for an airfoil is 0.62. Find the critical pressure coefficient \( (\gamma = 1.4) \). (04 Marks)

PART – B

5. a. How the horse shoe vortex system for a finite wing is simplified. (08 Marks)
   b. What is Prandtl’s classical lifting line theory for finite wings? (06 Marks)
   c. Explain:
      i) Vortex filament and Biot – Savart law
      ii) Down wash and induce drag. (06 Marks)
6 a. What are cylindrical coordinates used for bodies of revolution and velocity potential in cylindrical coordinates? (06 Marks)
b. Derive linearized perturbation velocity equation for subsonic, compressible and irrotational bodies of revolution. (14 Marks)

7 a. What are swept back wings? How the performance of an airplane is improved by the application of swept back wings concept? (08 Marks)
b. Explain the requirement of high lift devices in a modern airplane. (06 Marks)
c. Describe the function of flaps and slat to improve the performance. (06 Marks)

8 a. What is the boundary layer theory? Explain laminar, turbulent boundary layer and transition over a flat plate at low speed. (08 Marks)
b. Derive an expression and explain:
   i) Displacement thickness
   ii) Momentum thickness and
   iii) Energy thickness. (06 Marks)
c. Find the displacement, momentum and energy thickness for the velocity distribution in the boundary layer given by \( \frac{u}{U} = \frac{y}{\delta} \) where \( u \) is flow velocity at a distance \( y \) from the solid boundary, \( u = U \) at \( y = \delta \), \( \delta \) is the boundary layer thickness. Also calculate the ratio of momentum thickness to displacement thickness. (06 Marks)
PART A
1. INTRODUCTION: BASIC CONCEPTS, BACKGROUND REVIEW:
   06 Hrs


2. FUNDAMENTALS OF FINITE ELEMENT METHOD:
   06 Hrs

Displacement function and natural coordinates, construction of displacement functions for 2 D truss and beam elements, applications of FEM for the analysis of truss, continuous beam and simple frame problems.

3. DISCRETE ELEMENTS:
   08 Hrs

Bar elements, uniform Bar elements, uniform section, mechanical and thermal loading, varying section, truss analysis, Frame element, Beam element, problems for various loadings and boundary conditions, Free vibration, longitudinal and lateral vibration, Use of local and natural coordinates.

4. CONTINUUM ELEMENTS:
   06 Hrs

Plane stress, Plane strain and axisymmetric problems, constant and linear strain, triangular elements, stiffness matrix, axisymmetric load vector.

PART B

5. ANALYSIS OF 2 D CONTINUUM PROBLEMS:
   08 Hrs

Elements and shape functions, Triangular, rectangular and quadrilateral elements, different types of elements, their characteristics and suitability for application, polynomial shape functions, Lagrange's and Hermitian polynomials, compatibility and convergence requirements of shape functions.
6. THEORY OF ISOPARAMETRIC ELEMENTS: 06 Hrs

Isoparametric, sub parametric and super-parametric elements, characteristics of Isoparametric quadrilateral, elements, structure of computer program for FEM analysis, description of different modules, pre and post processing.

7. FIELD PROBLEMS: 06 Hrs

Heat transfer problems, Steady' state fin problems, Derivation of element matrices for two dimensional problems, Torsion problems.

8. INTRODUCTION TO FINITE ELEMENT METHOD 06 Hrs

Construction or discrete models - sub domains and nodes - simple elements for the FEM - Simplex, complex and multiples elements Polynomial selection - illustrative examples

TEXT BOOKS:

REFERENCE:
# LESSON PLAN

**SUBJECT:** Finite Element Analysis  
**SUBJECT CODE:** 06AE64  
**NAME OF STAFF:** ***  
**JAN 2009 – MAY 2009**

<table>
<thead>
<tr>
<th>Lesson No.</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Theory of Elasticity</td>
</tr>
<tr>
<td>2</td>
<td>Matrix displacement formulation, Energy concepts</td>
</tr>
<tr>
<td>3</td>
<td>Equilibrium and energy methods for analysing structures</td>
</tr>
<tr>
<td>4</td>
<td>Rayleigh - Ritz Method</td>
</tr>
<tr>
<td>5</td>
<td>Galerkin's Method</td>
</tr>
<tr>
<td>6</td>
<td>Simple applications in structural Analysis</td>
</tr>
<tr>
<td>7</td>
<td>Simple applications in structural Analysis</td>
</tr>
<tr>
<td>8</td>
<td>FUNDAMENTALS OF FINITE ELEMENT METHOD</td>
</tr>
<tr>
<td>9</td>
<td>Displacement function and natural coordinates</td>
</tr>
<tr>
<td>10</td>
<td>Construction of displacement functions for 2D truss and beam elements</td>
</tr>
<tr>
<td>11</td>
<td>Construction of displacement functions for 2D truss and beam elements</td>
</tr>
<tr>
<td>12</td>
<td>Applications of FEM for the analysis of truss</td>
</tr>
<tr>
<td>13</td>
<td>Continuous beam and simple frame problems</td>
</tr>
<tr>
<td>14</td>
<td>Continuous beam and simple frame problems</td>
</tr>
<tr>
<td>15</td>
<td>Continuous beam and simple frame problems</td>
</tr>
<tr>
<td>16</td>
<td>DISCRETE ELEMENTS</td>
</tr>
<tr>
<td>17</td>
<td>Bar elements, uniform Bar elements</td>
</tr>
<tr>
<td>18</td>
<td>Uniform section, mechanical and thermal loading</td>
</tr>
<tr>
<td>19</td>
<td>Varying section, truss analysis</td>
</tr>
<tr>
<td>20</td>
<td>Frame element, Beam element,</td>
</tr>
<tr>
<td>21</td>
<td>Problems for various loadings and boundary conditions</td>
</tr>
<tr>
<td>22</td>
<td>Problems for various loadings and boundary conditions</td>
</tr>
<tr>
<td>23</td>
<td>Free vibration, longitudinal and lateral vibration</td>
</tr>
<tr>
<td>24</td>
<td>Use of local and natural coordinates</td>
</tr>
<tr>
<td>25</td>
<td>Use of local and natural coordinates</td>
</tr>
<tr>
<td>26</td>
<td>CONTINUUM ELEMENTS</td>
</tr>
<tr>
<td>27</td>
<td>Plane strain and axisymmetric problems</td>
</tr>
<tr>
<td>28</td>
<td>Plane strain and axisymmetric problems</td>
</tr>
<tr>
<td>29</td>
<td>Constant and linear strain</td>
</tr>
<tr>
<td>30</td>
<td>Triangular elements, stiffness matrix</td>
</tr>
<tr>
<td>31</td>
<td>Axisymmetric load vector</td>
</tr>
<tr>
<td>32</td>
<td>Axisymmetric load vector</td>
</tr>
<tr>
<td>33</td>
<td>ANALYSIS OF 2D CONTINUUM PROBLEMS</td>
</tr>
<tr>
<td>34</td>
<td>Elements and shape functions</td>
</tr>
<tr>
<td>35</td>
<td>Triangular, rectangular and quadrilateral elements</td>
</tr>
<tr>
<td>36</td>
<td>Different types of elements, their characteristics and suitability for application</td>
</tr>
<tr>
<td>37</td>
<td>Different types of elements, their characteristics and suitability for application</td>
</tr>
<tr>
<td>38</td>
<td>Polynomial shape functions,</td>
</tr>
<tr>
<td>39</td>
<td>Lagrange's and Hermitian polynomials</td>
</tr>
<tr>
<td>40</td>
<td>Compatibility and convergence requirements of shape functions.</td>
</tr>
<tr>
<td>Page</td>
<td>Content</td>
</tr>
<tr>
<td>------</td>
<td>---------</td>
</tr>
<tr>
<td>37</td>
<td>Compatibility and convergence requirements of shape functions.</td>
</tr>
<tr>
<td>38</td>
<td>Compatibility and convergence requirements of shape functions.</td>
</tr>
<tr>
<td>39</td>
<td>Isoperimetric, sub parametric and super-parametric elements</td>
</tr>
<tr>
<td>40</td>
<td>Characteristics of Isoparametric quadrilateral, elements,</td>
</tr>
<tr>
<td>41</td>
<td>Structure of computer program for FEM analysis</td>
</tr>
<tr>
<td>42</td>
<td>Description of different modules.</td>
</tr>
<tr>
<td>43</td>
<td>Pre and post processing</td>
</tr>
<tr>
<td>44</td>
<td>Pre and post processing</td>
</tr>
<tr>
<td>45</td>
<td>Pre and post processing</td>
</tr>
<tr>
<td>46</td>
<td>FIELD PROBLEMS</td>
</tr>
<tr>
<td>47</td>
<td>Heat transfer problems</td>
</tr>
<tr>
<td>48</td>
<td>Heat transfer problems</td>
</tr>
<tr>
<td>49</td>
<td>Steady state fin problems</td>
</tr>
<tr>
<td>50</td>
<td>Steady state fin problems</td>
</tr>
<tr>
<td>51</td>
<td>Derivation of element matrices for two dimensional problems</td>
</tr>
<tr>
<td>52</td>
<td>Torsion problems</td>
</tr>
<tr>
<td>53</td>
<td>Torsion problems</td>
</tr>
<tr>
<td>54</td>
<td>INTRODUCTION TO FINITE ELEMENT METHOD</td>
</tr>
<tr>
<td>55</td>
<td>Construction or discrete models - sub domains and nodes</td>
</tr>
<tr>
<td>56</td>
<td>Simple elements for the FEM - Simplex,</td>
</tr>
<tr>
<td>57</td>
<td>Simple elements for the FEM - Simplex,</td>
</tr>
<tr>
<td>58</td>
<td>Complex and multiples elements Polynomial selection</td>
</tr>
<tr>
<td>59</td>
<td>Complex and multiples elements Polynomial selection</td>
</tr>
<tr>
<td>60</td>
<td>Illustrative examples</td>
</tr>
<tr>
<td>61</td>
<td>Illustrative examples</td>
</tr>
<tr>
<td>62</td>
<td>Revision-1</td>
</tr>
<tr>
<td>63</td>
<td>Revision-2</td>
</tr>
</tbody>
</table>
Sixth Semester B.E. Degree Examination, June-July 2009

Finite Element Analysis

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, selecting at least TWO questions from each part.

PART – A

1. a. Derive an expression for Potential Energy of a general elastic 3D solid. (10 Marks)
b. Explain:
   i) Plane Stress
   ii) Plane strain problems. (10 Marks)

2. a. Solve for displacements at the point of application of point load P in a rod shown in Fig. Q.2(a). (10 Marks)

![Fig. Q.2(a)](image)

b. Discuss Galerkin's approach to 3-D elasticity. (10 Marks)

3. a. Derive the following with respect to CST Element
   i) [ J ]
   ii) [ B ]
   iii) [ K ]

   b. Explain local coordinates and natural coordinates. (15 Marks)

4. a. Calculate
   i) Direction Cosines of Element
   ii) Stiffness matrices of Element
   iii) Combined stiffness matrix

   For the member Truss shown in Fig. Q.4(a).

   ![Fig. Q.4(a)](image)

   Assume
   \[ A_1 = 1000 \text{mm}^2 \]
   \[ A_2 = 1500 \text{mm}^2 \]
   \[ E_1 = E_2 = 210 \text{ GPa} \]

   (12 Marks)

b. Using two beam Elements determine the deflection at Centre of a simply supported beam carrying a point load P at its centre. Assume the beam span to be L with E being the material modulus. (12 Marks)
PART - B

5. Derive the shape function for
   i) 8 nodded Quadrilateral
   ii) CST Elements. (15 Marks)
   b. Explain Pascal’s Triangle for 2-D formulations. (8 Marks)

6. a. Define Hermite shape functions. Derive Hermits shape functions for 2 nodded Beam Element. (10 Marks)
   b. Explain the various modules in any Commercially available FEA software package. (10 Marks)

7. a. Explain:
   i) ISO
   ii) Sub
   iii) Super parametric Element. (6 Marks)
   b. Derive an expression for the thermal conductivity matrix for 1-D Two nodded heat Element. (8 Marks)
   c. Derive shape functions for 1-D, Three nodded element using Lagrange’s polynomial. (6 Marks)

8. Using penalty approach solve for Temperature distribution in the composite wall shown in Fig.Q.8. (20 Marks)

\[ T_1 = 25 \text{W/m}^2^\circ C \]
\[ T_2 = 30 \text{W/m}^2^\circ C \]
\[ T_3 = 50 \text{W/m}^2^\circ C \]
\[ h = 25 \text{W/m}^2^\circ C \]
\[ T_w = 800^\circ C \]
\[ T_e = 20^\circ C \] specified.

Fig.Q.8

*****

2 of 2
Sixth Semester B.E. Degree Examination, May/June 2010

Finite Element Analysis

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, selecting at least TWO questions from each part.

PART – A

1. a. Explain the theorem of minimum potential energy and derive an expression for total potential energy of a elastic body subjected to body forces, surface forces and concentrated forces in 3 - dimensions. (10 Marks)
   b. A uniform cross sectioned rod fixed at one end is subjected to a uniform axial load q_a. Find the expression for the stresses in any point using Rayleigh Ritz method. (10 Marks)

2. a. Derive the stiffness matrix for a plane truss element using displacement functions. (10 Marks)
   b. Derive Hermite shape functions for a beam problem and sketch the variation of shape functions over function. (10 Marks)

3. a. Using Galerkin’s method derive the stiffness matrix for one dimensional bar element in global coordinate system. (10 Marks)
   b. Using direct stiffness method, calculate nodal displacements strain and stresses in each element. (10 Marks)

Fig. 3(a)  \[ \begin{align*}
A_1 &= 1000 \, \text{mm}^2 \\
A_2 &= 750 \, \text{mm}^2 \\
E_1 &= 100 \, \text{GPa} \\
E_2 &= 50 \, \text{GPa} \\
F_1 &= 1 \, \text{kN} \\
F_2 &= 2 \, \text{kN}
\end{align*} \]

4. a. A three nodded triangular element is formed with nodes at (20, 40), (60, 20) and (80, 60). Determine the shape functions at point (40, 40) and show that the sum of shape functions is one. (10 Marks)
   b. Using shape function, derive displacement – strain matrix for CST element. (10 Marks)

PART – B

5. a. Derive shape functions for nine nodded – 2 dimensional rectangular plane stress element and sketch the variation of shape functions of the element. (10 Marks)
   b. Explain the convergence criteria of displacement and compatibility requirements of elements. (10 Marks)

6. a. Explain ISO – parametric and super parametric elements using a 2-D element. Also discuss merits and demerits of each element. (10 Marks)
   b. Explain different steps of finite element procedure for solving a problem. In general discuss the pre and post processing steps in FEM in a computer software package. (10 Marks)

7. a. Derive the stiffness matrix for a composite wall made with two different materials with thermal gradient considering heat conduction. (10 Marks)
   b. Derive the element characteristic equations for torsion problems. (10 Marks)

8. a. Sketch and explain various elements in fem. Discuss merits of each type of element. (10 Marks)
   b. Explain any one method of auto – meshing scheme in finite element analysis. (10 Marks)

****
THEORY OF VIBRATION

Sub Code: 06AE65  IA Marks: 25
Hrs/ Week: 04  Exam Hours: 03
Total Hours: 52  Exam Marks: 100

PART A

1. INTRODUCTION  06 Hrs

2. UNDAMPED FREE VIBRATIONS  07 Hrs
Single degree of freedom systems. Undamped free vibration, natural frequency of free vibration, Spring and Mass elements, effect of mass of spring, Compound Pendulum.

3. DAMPED FREE VIBRATIONS  07 Hrs
Single degree of freedom systems, different types of damping, concept of critical damping and its importance, study of response of viscous damped systems for cases of under damping, critical and over damping, Logarithmic decrement.

4. FORCED VIBRATION.  06 Hrs
Single degree of freedom systems, steady state solution with viscous damping due to harmonic force. Solution by Complex algebra, reciprocating and rotating unbalance, vibration isolation, transmissibility ratio. due to harmonic exitation and support motion.

PART B

5. VIBRATION MEASURING INSTRUMENTS & WHIRLING OF SHAFTS  06 Hrs
Vibrometer meter and accelerometer. Whirling of shafts with and without air damping. Discussion of speeds above and below critical speeds.
6. SYSTEMS WITH TWO DEGREES OF FREEDOM  08 Hrs


Applications:
a) Vehicle suspension.
b) Dynamic vibration absorber.
c) Dynamics of reciprocating Engines.

7. CONTINUOUS SYSTEMS  06 Hrs

Introduction, vibration of string, longitudinal vibration of rods, Torsional vibration of rods, Euler’s equation for beams.

8. NUMERICAL METHODS FOR MULTI-DEGREE FREEDOM SYSTEMS  08Hrs


TEXT BOOKS

REFERENCE:
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LESSON PLAN</strong></td>
<td></td>
</tr>
<tr>
<td><strong>SUBJECT:</strong> THEORY OF VIBRATION</td>
<td></td>
</tr>
<tr>
<td><strong>SUBJECT CODE:</strong> 06AE65</td>
<td></td>
</tr>
<tr>
<td><strong>NAME OF STAFF:</strong> ***</td>
<td>JAN 2009 –MAY 2009</td>
</tr>
<tr>
<td><strong>INTRODUCTION</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Types of vibrations,</td>
</tr>
<tr>
<td>2</td>
<td>S.H.M,</td>
</tr>
<tr>
<td>3</td>
<td>Principle of super position applied to Simple Harmonic Motions.</td>
</tr>
<tr>
<td>4</td>
<td>Beats, Fourier theorem and simple problems</td>
</tr>
<tr>
<td>5</td>
<td>Beats, Fourier theorem and simple problems</td>
</tr>
<tr>
<td>6</td>
<td>Beats, Fourier theorem and simple problems</td>
</tr>
<tr>
<td>7</td>
<td>Beats, Fourier theorem and simple problems</td>
</tr>
<tr>
<td><strong>UNDAMPED FREE VIBRATIONS</strong></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Single degree of freedom systems.</td>
</tr>
<tr>
<td>9</td>
<td>Undamped free vibration</td>
</tr>
<tr>
<td>10</td>
<td>Natural frequency of free vibration,</td>
</tr>
<tr>
<td>11</td>
<td>Spring and Mass elements</td>
</tr>
<tr>
<td>12</td>
<td>Effect of mass of spring,</td>
</tr>
<tr>
<td>13</td>
<td>Effect of mass of spring,</td>
</tr>
<tr>
<td>14</td>
<td>Compound Pendulum</td>
</tr>
<tr>
<td>15</td>
<td>Compound Pendulum</td>
</tr>
<tr>
<td><strong>DAMPED FREE VIBRATIONS</strong></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Single degree of freedom systems,</td>
</tr>
<tr>
<td>17</td>
<td>Different types of damping,</td>
</tr>
<tr>
<td>18</td>
<td>Concept of critical damping and its importance</td>
</tr>
<tr>
<td>19</td>
<td>Study of response of viscous damped systems for cases of under damping,</td>
</tr>
<tr>
<td>20</td>
<td>Critical and over damping,</td>
</tr>
<tr>
<td>21</td>
<td>Logarithmic decrement</td>
</tr>
<tr>
<td>22</td>
<td>Logarithmic decrement</td>
</tr>
<tr>
<td><strong>FORCED VIBRATION.</strong></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Single degree of freedom systems,</td>
</tr>
<tr>
<td>24</td>
<td>Steady state solution with viscous damping due to harmonic force.</td>
</tr>
<tr>
<td>25</td>
<td>Solution by Complex algebra, reciprocating and rotating unbalance,</td>
</tr>
<tr>
<td>26</td>
<td>Vibration isolation</td>
</tr>
<tr>
<td>27</td>
<td>Transmissibility ratio due to harmonic excitation and support motion</td>
</tr>
<tr>
<td>28</td>
<td>Transmissibility ratio due to harmonic excitation and support motion</td>
</tr>
<tr>
<td>29</td>
<td>Transmissibility ratio due to harmonic excitation and support motion</td>
</tr>
<tr>
<td><strong>VIBRATION MEASURING INSTRUMENTS &amp; WHIRLING OF SHAFTS</strong></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Vibrometer meter and accelerometer.</td>
</tr>
<tr>
<td>31</td>
<td>Vibrometer meter and accelerometer.</td>
</tr>
<tr>
<td>32</td>
<td>Whirling of shafts with and without air damping.</td>
</tr>
<tr>
<td>33</td>
<td>Whirling of shafts with and without air damping.</td>
</tr>
<tr>
<td>34</td>
<td>Discussion of speeds above and below critical speeds.</td>
</tr>
<tr>
<td>35</td>
<td>Discussion of speeds above and below critical speeds.</td>
</tr>
<tr>
<td>36</td>
<td>Discussion of speeds above and below critical speeds.</td>
</tr>
<tr>
<td>Systems with Two Degrees of Freedom</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------</td>
<td></td>
</tr>
<tr>
<td>37 Introduction,</td>
<td></td>
</tr>
<tr>
<td>38 Principle modes and Normal modes of vibration,</td>
<td></td>
</tr>
<tr>
<td>39 Co-ordinate coupling,</td>
<td></td>
</tr>
<tr>
<td>40 Generalized and principal co-ordinates,</td>
<td></td>
</tr>
<tr>
<td>41 Free vibration in terms of initial conditions.</td>
<td></td>
</tr>
<tr>
<td>42 Geared systems. Forced Oscillations-Harmonic excitation.</td>
<td></td>
</tr>
<tr>
<td>44 c) Dynamics of reciprocating Engines</td>
<td></td>
</tr>
<tr>
<td>45 c) Dynamics of reciprocating Engines</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Continuous Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>46 Introduction,</td>
</tr>
<tr>
<td>47 Vibration of string,</td>
</tr>
<tr>
<td>48 Longitudinal vibration of rods,</td>
</tr>
<tr>
<td>49 Torsional vibration of rods,</td>
</tr>
<tr>
<td>50 Euler’s equation for beams.</td>
</tr>
<tr>
<td>51 Euler’s equation for beams</td>
</tr>
<tr>
<td>52 Euler’s equation for beams</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Numerical Methods for Multi-Degree Freedom Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>53 Introduction, Influence coefficients, Maxwell reciprocal theorem,</td>
</tr>
<tr>
<td>54 Dunkerley’s equation.</td>
</tr>
<tr>
<td>55 Orthogonality of principal modes,</td>
</tr>
<tr>
<td>56 Method of matrix iteration-Method of determination of all the natural frequencies using sweeping matrix and Orthogonality principle.</td>
</tr>
<tr>
<td>57 Method of matrix iteration-Method of determination of all the natural frequencies using sweeping matrix and Orthogonality principle.</td>
</tr>
<tr>
<td>58 Method of matrix iteration-Method of determination of all the natural frequencies using sweeping matrix and Orthogonality principle.</td>
</tr>
<tr>
<td>59 Holzer’s method, Stodola method</td>
</tr>
<tr>
<td>60 Holzer’s method, Stodola method</td>
</tr>
<tr>
<td>61 Revision</td>
</tr>
<tr>
<td>62 Revision</td>
</tr>
</tbody>
</table>
Sixth Semester B.E. Degree Examination, June-July 2009
Theory of Vibrations

Max. Marks: 100

Note: Answer any FIVE full questions, selecting at least TWO questions from each part.

PART - A

1. a. Explain three types of vibrations with neat sketches.
   b. A periodic motion observed on the oscilloscope is illustrated in Fig. Q.1(b). Represent this motion by harmonic series.

   Fig. Q.1(b).

   Fig. Q.2(b).

   Fig. Q.3(a).

   c. Express the resultant in the form \( X = A \sin(\omega t + \phi) \) for the following two harmonic motions:
      \( x_1 = 1 \sin(\omega t + 30^\circ) \)
      \( x_2 = 2 \cos(\omega t - 15^\circ) \).

   (04 Marks)

2. a. Determine the natural frequency of the spring-mass system, taking mass of the spring into account.
   b. Determine the natural frequency of the system shown in Fig. Q.2(b).
   c. An unknown mass 'm' kg attached to the end of an unknown spring 'k' has natural frequency 94 cpm. When a 0.453 kg mass is added to 'm', the natural frequency is lowered to 76.7 cpm. Determine the unknown mass 'm' kg and the spring constant K N/m.

   (04 Marks)

3. a. Set up the differential equation of motion for the system shown in Fig. Q.3(a). Determine the natural frequency of damped oscillation and the critical damping coefficient.
   b. A mass of 5 kg is suspended on a spring and set oscillating. It is observed that the amplitude reduces to 5% of its initial value after 2 oscillations. It takes 0.5 seconds to do this. Calculate:
      i) The damping ratio; ii) The natural frequency; iii) The actual frequency; iv) The spring stiffness; v) The critical damping coefficient; vi) The actual damping coefficient.

   (08 Marks)

4. a. Obtain an expression and find natural frequency of vibration of the system shown in Fig. Q.4(a) for small displacement making necessary approximation.

   b. A reciprocating machine of mass 75 kg is mounted on spring of stiffness 11.76 x 10^5 N/m and a damper of damping factor 0.2. The slider of mass 2 kg slides within the machine has a
reciprocating motion with a stroke of 0.08m. The speed is 3000 rpm. Assuming the motion of the piston to be harmonic, find:

1) Amplitude of vibration of the machine; ii) Transmissibility ratio; iii) Force transmitted to the foundation and iv) Is vibration isolation achieved? If so how?

c. A refrigerator of mass 55 kgs operating at 480 rpm is supported on 3 springs. If only 10% of the shaking force is to be transmitted to the foundation, what should be the value of K?

**PART - B**

5. a. A seismic instrument is fitted to measure the vibration of a machine running at 120 rpm. If the natural frequency of the instrument is 2Hz and if it shows 0.004cm, determine displacement, velocity and acceleration assuming no damping.

b. A vertical shaft 1.25 cm in diameter rotates in long bearings and a disc of mass 15 kgs is attached to the mid span of the shaft as shown in the Fig.Q.5(b). The span of the shaft between bearings is 50cm. The mass center of the disc is 0.05 cm from the geometric axis of the shaft. Neglecting the mass of the shaft and taking the deflection as for beam fixed at both ends, determine the critical speed of rotation. Also determine the range of speed over which the stress in the shaft due to bending will exceed 0.125 GN/m². Take E = 200 GN/m².

6. a. Determine the natural frequency and draw mode shapes of the system shown in Fig.Q.6(a).

b. A torsional gear system is shown in Fig.Q.6(b). Determine stiffness of equivalent shaft and torsional frequency.

7. a. A flexible cable supported at the upper end and free to oscillate under the influence of gravity as shown in the Fig.Q7(a). Show that the equation of lateral motion is

\[ \ddot{y} = g \left( \frac{d^2y}{ds^2} + \frac{dy}{dx} \right) \]

b. A cord of length 'l' and mass per unit length 'm' is under tension with left end fixed and right end attached to a spring mass system as shown in Fig.Q7(b). Determine the equations for the natural frequencies. Determine three natural frequencies of the spring mass system shown in the Fig.Q.8 using Holzer method. Assuming the initial displacement \( x_i = 1 \) and natural frequencies \( \omega_n = \sqrt{ \frac{k}{m} } \) are 0.50, 0.75, 1.0, 1.25, 1.50, 1.75 and 2.0.

+++

2 of 2
Sixth Semester B.E. Degree Examination, May/June 2010
Theory of Vibrations

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, selecting at least TWO questions from each part.

PART – A

1. a. Name and explain the causes of vibration. (06 Marks)
   b. Define the terms: Periodic motion, free vibrations, forced vibration, degree of freedom. (04 Marks)
   c. The motion of a particle is represented by the equation: \(10 \sin \omega t\). Show the relative positions and magnitude of the displacement, velocity and acceleration vector at time \(t = 0\), for the case when i) \(\omega = 2.0 \text{ rad/sec}\) and ii) \(\omega = 0.5 \text{ rad/sec}\). (10 Marks)

2. a. Derive the relationship between the undamped natural frequency and the static deflection of the system. (06 Marks)
   b. A U-tube, open to atmosphere at both the ends contains a column length \(l\) of a certain liquid. Find the natural period of oscillation of the liquid column. (06 Marks)
   c. A cylinder of mass \(M\) and radius \(r\) rolls without slipping on a cylindrical surface of radius \(R\). Find the natural frequency for small oscillations about the lowest point. (08 Marks)

3. a. Derive from first principles, a relation for the displacement of an overdamped spring mass system subjected to free vibration. (10 Marks)
   b. A gun barrel of mass 600 kg has a recoil spring of stiffness 2,94,000 N/m. If the barrel recoils 1.3 m on firing, determine:
      i) The initial recoil velocity of the barrel
      ii) The critical damping coefficient of the dashpot, which is engaged at the end of the recoil stroke.
      iii) The time required for the barrel to return to a position 50 mm from the initial position. (10 Marks)

4. a. Derive an expression for steady state amplitude and phase lag of single degree of freedom system subjected to forced vibration. (10 Marks)
   b. A machine part having a mass of 2.5 kg vibrates in a viscous medium. A harmonic force of 30 N acts on the part and causes a resonant amplitude of 14 mm with a period of 0.22 second. Find the damping coefficient. If the frequency of the exciting force is changed to 4Hz, determine the increase in the amplitude of the forced vibrations upon the removal of the damper. (10 Marks)

PART – B

5. a. Sketch and explain the construction of vibration measurement of accelerometer. (08 Marks)
   b. A shaft of diameter 14 mm and length 1.2 m is held between two bearings. A circular disc of 16 kg is mounted at mid position of shafts and the centre of mass of disc has an eccentricity of 0.4 mm from the centre of the rotor. Determine the critical speed of the shaft and the range of speed over which it is unsafe to run the shaft. Take: the \(E_{\text{shaft}} = 200 \text{ GPa}\) and permissible stress of the shaft material = 70 MPa. (12 Marks)
6. a. Derive and explain the principal mode and normal mode vibration of an undamped two degree of freedom systems.

(12 Marks)

b. A pump is coupled to an engine flywheel through a pair of gears. The shaft which connects the engine flywheel to the driving gear has 48 mm diameter and is 800 mm long. The shaft from the driven gear to the pump has 32 mm diameter and is 280 mm long. The pump speed is four times the engine speed. Take $I_{\text{flywheel}} = 1000 \text{ kg m}^2$, $I_{\text{driving gear}} = 14 \text{ kg m}^2$, $I_{\text{driven gear}} = 5 \text{ kg m}^2$ and $I_{\text{pump}} = 18 \text{ kg m}^2$. Find the natural frequency of oscillations of the system. $G = 80 \text{ GPa}$.

(08 Marks)

7. a. What are the continuous systems? Explain their vibration analysis.

(05 Marks)

b. A uniform string of length $l$ and a large initial tension $T$, stretched between two supports is displaced laterally through a distance $a_0$ at the centre and is released at time $t = 0$. Find the equation of motion for the string.

(15 Marks)

8. a. Explain Maxwell’s reciprocal theorem.

(05 Marks)

b. For a three degree of system shown in Fig. Q8(b), find the lowest natural frequency by Stodola’s method.

(15 Marks)

Fig. Q8(b)
Electives: 06AE66x

- Elective - I: (Group A)

<table>
<thead>
<tr>
<th>Sub Code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>06AE661</td>
<td>Numerical Methods</td>
</tr>
<tr>
<td>06AE662</td>
<td>Aircraft Materials</td>
</tr>
<tr>
<td>06AE663</td>
<td>Combustion</td>
</tr>
<tr>
<td>06AE664</td>
<td>Reliability Engineering</td>
</tr>
<tr>
<td>06AE665</td>
<td>Industrial Management</td>
</tr>
</tbody>
</table>
Numerical Methods

Sub Code: 06AE661  IA Marks: 25
Hrs/ Week: 04      Exam Hours: 03
Total Hours: 52    Exam Marks: 100

PART A

1. NUMERICAL COMPUTATION: 06 Hrs
   Motivation and Objectives/ Number Representation/ Machine Precision/
   Roundof - Error/ Truncation Error/ Random Number Generation.

2. LINEAR ALGEBRAIC SYSTEMS: 06 Hrs
   Motivation and Objectives/ Gauss-Jordan Elimination/ Gaussian Elimination/

3. INTERPOLATION AND APPROXIMATION: 06 Hrs
   Lagrangian Polynomials - Divided differences Interpolating with a cubic
   spline - Newton's forward and backward difference formulas.

4. EIGEN VALUES AND EIGENVECTORS: 08 Hrs
   Motivation and Objectives/ The characteristics Polynominal/ Power Methods /
   Jacobi’s Method/ Householder Transformation/ QR Method/ Danilevsky’s Method/ Polynominal Roots.

PART B

5. NUMERICAL DIFFERENTIATION AND INTEGRATION: 08 Hrs
   Derivative from difference tables - Divided differences and finite
   differences - Numerical integration by trapezoidal and Simpson's 1/3 and
   3/8 rules - Two and Three point Gaussian quadrature formulas -integrals using
   trapezoidal and Simpson's rules.
6. CURVE FITTING: 06 Hrs

Motivation and objectives/ Interpolation/ Newton’s Difference Formula/ Cubic Splines/ Least Square/ Two-Dimensional Interpolation.

7. ROOT FINDING: 06 Hrs

Motivation and Objectives/ Bracketing methods/ Contraction Mapping Method/Se cant Method/ Muller’s Method/ Newton’s Method/ Polynomial Roots/Nonlinear Systems of Equations.

8. OPTIMIZATION: 06 Hrs

Motivation and Objectives/ Local and Global Minima / Line Searches / Steepest Descent Method / Conjugate-Gradient Method / Quasi-Newton Methods / Penalty Functions / Simulated Annealing.

TEXT BOOKS:

REFERENCE:
Sixth Semester B.E. Degree Examination, June-July 2009
Numerical Methods

Time: 3 hrs. Max. Marks: 100
Note: Answer any FIVE full questions, selecting at least TWO questions from each part.

PART - A

1. a. Write minimum of ten objectives of studying numerical computation. (10 Marks)
   b. Expressing the Taylor’s series expansion of \( e^x \) about the point \( x = 0 \), truncated to \( n = 5 \) find the relative truncated error, \( r_5 \), at \( x = 1 \) and also upperbound for \( r_5 \). (10 Marks)

2. a. If \( x = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} \) then solve the linear system \( \begin{bmatrix} 1 & 0 & 2 \\ 2 & -1 & 3 \\ 4 & 1 & 8 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 1 \\ -1 \\ 2 \end{bmatrix} \) by Gaussian elimination methods. (10 Marks)
   b. Find the LU factorization of \( A = \begin{bmatrix} 3 & -1 & 2 \\ 1 & 2 & 3 \\ 2 & -2 & -1 \end{bmatrix} \). (10 Marks)

3. a. For the following table find \( f(3.0) \) using Lagrange’s interpolation method. (10 Marks)
   
   \[
x & 3.2 & 2.7 & 1.0 & 4.8 \\
   f(x) & 22.0 & 17.8 & 14.2 & 38.3
   \]
   b. Using appropriate interpolation formula evaluate \( f(2) \) and \( f(8) \) if \( x = 0, 3, 6, 9 \) and \( f(x) = 4, 9, 14, 20 \). (19 Marks)

4. a. Using Jacobi’s method find all the eigenvalues of the matrix \( A = \begin{bmatrix} 1 & \sqrt{2} & 2 \\ \sqrt{2} & 3 & \sqrt{2} \\ 2 & \sqrt{2} & 1 \end{bmatrix} \). (12 Marks)
   b. Using Householder’s transformation reduce the matrix \( A = \begin{bmatrix} 2 & 1 & 1 \\ 1 & 0 & 1 \end{bmatrix} \) into a tridiagonal form. (08 Marks)

PART - B

5. a. If \( f(x) = x^2 - x + 1 \), tabulate \( f(x) \) for \( x = 0, 2, 3, 5, 6 \) Hence find derivative of \( f(x) \) at \( x = 4.1 \) using divided difference table. (10 Marks)
   b. Evaluate the integral \( I = \int_{0}^{2} \int_{x}^{2} dxdy \) using the simpson’s rule with \( h = 0.5 \) along \( x - y \) axis and \( y = 0.25 \) along \( y - x \) axis. (10 Marks)

6. a. Find the spline functions passing through the points \( D = \{ (0, 2), (1, 3), (2, 1) \} \). (10 Marks)
   b. Fit a straight line passing through point set \( \{ (0, 2.1), (1, 2.85), (2, 1.1), (3, 3.2), (4, 3.9) \} \). (10 Marks)

7. a. Find a real root of \( f(x) = e^x - x - 2 = 0 \) by contraction mapping method, in \( [0, 1] \). (10 Marks)
   b. Explain Newton’s method of finding a real root of a function \( f(x) = 0 \). Also find a real root of \( (x^2 e^{-x^2}) - 1 = 0 \) with \( x_0 = 1 \). (10 Marks)

8. a. Explain steepest Descent method. (10 Marks)
   b. Explain simulate Annealing. (10 Marks)
Sixth Semester B.E. Degree Examination, May/June 2010

Numerical Methods

Time: 3 hrs.

Note: Answer any FIVE full questions,
selecting at least TWO questions from each part.

PART – A

1. a. Convert the following:
   (42.375)_{10} into binary
   (51D4)_{16} into decimal
   (234)_{8} into hexadecimal.
   b. Explain the machine precision.
   c. If the value of π is rounded off to 4 significant figures, determine the absolute and relative error.
   d. Explain a method to generate random numbers.

2. a. What are the pitfalls of Gauss elimination method? What are the techniques for improving the solution?
   b. Solve the system of equations by LU decomposition method
      \[9x_1 + 2x_2 + 4x_3 = 20\]
      \[x_1 + 10x_2 + 4x_3 = 6\]
      \[2x_1 - 4x_2 + 10x_3 = -15.\]

3. a. Explain Lagrangian interpolation method. List their advantages.
   b. The following table gives the values of y for five values of x.

   \[
   \begin{array}{c|c|c|c|c|c}
   X & 0 & 1 & 2 & 3 & 4 \\
   \hline
   Y & 4 & 12 & 32 & 76 & 156 \\
   \end{array}
   \]

   Obtain linear, quadratic and cubic polynomial by Newton’s forward difference formula and hence determine the values of y(0.5) in each case.

4. a. Write an algorithm to determine the dominant eigenvalue and its eigen vector by power method.
   b. Determine the eigenvalues and eigen vectors of a matrix \( A \) by Jacobi’s method.

\[
A = \begin{bmatrix}
-1 & 2 \\
2 & 2 \\
\end{bmatrix}
\]
PART – B

5. a. Using the forward difference for numerical differentiation, determine the value of sec 31° from the following table.

<table>
<thead>
<tr>
<th>θ°</th>
<th>31</th>
<th>32</th>
<th>33</th>
<th>34</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tan θ</td>
<td>0.6008606</td>
<td>0.6248693</td>
<td>0.6494075</td>
<td>0.6745085</td>
</tr>
</tbody>
</table>

(10 Marks)

b. Evaluate the integral

\[ \int_0^1 \frac{dx}{x^3 + 3^2} \]

by three point Gaussian quadrature formula and verify your answer with actual integration.

(10 Marks)

6. Fit natural cubic splines to the following data and estimate the values of y at x = 2, 4 and 7.

<table>
<thead>
<tr>
<th>X</th>
<th>1</th>
<th>3</th>
<th>6</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>4</td>
<td>5.5</td>
<td>7</td>
<td>9.5</td>
</tr>
</tbody>
</table>

(20 Marks)

7. a. Using Newton’s method, find the root of the equation. \(2(x - 3) = \log_{10} x\), correct to six decimal places. It has a real root at about \(x = 3\).

(10 Marks)

b. Use secant method to obtain a root of the equation: \(x \log_{10} x = 1.2\) correct to six decimal places.

(10 Marks)

8. Explain the following:

a. Quasi – Newton method
b. Penalty functions
c. Steepest descent techniques.

(20 Marks)
Aircraft Materials

Sub Code: 06AE662       IA Marks: 25
Hrs / Week: 04        Exam Hours: 03
Total Hours: 52       Exam Marks: 100

PART A

1. INTRODUCTION TO AIRCRAFT MATERIALS  06 Hrs

General properties of materials, Definition of terms, Requirements of aircraft materials, Testing of aircraft materials, Inspection methods, Application and trends in usage in aircraft structures and engines, Introduction to smart materials and nanomaterials; Selection of materials for use in aircraft

2. AIRCRAFT METAL ALLOYS AND SUPERALLOYS  08 Hrs

Aluminum alloys, Magnesium alloys, Titanium alloys, Plain carbon and Low carbon Steels, Corrosion and Heat resistant steels, Maraging steels, Copper alloys, Producibility and Surface treatments aspects for each of the above; General introduction to superalloys, Nickel based superalloys, Cobalt based superalloys, and Iron based superalloys, manufacturing processes associated with superalloys, Heat treatment and surface treatment of superalloys

3. COMPOSITE MATERIALS     06 Hrs

Definition and comparison of composites with conventional monolithic materials, Reinforcing fibers and Matrix materials, Fabrication of composites and quality control aspects, Carbon -Carbon Composites production, properties and applications, inter metallic matrix composites, ablative composites based on polymers, ceramic matrix, metal matrix composites based on aluminum, magnesium, titanium and nickel based composites for engines

4. POLYMERS, POLYMERIC MATERIALS & PLASTICS AND CERAMICS & GLASS:      06 Hrs

Knowledge and identification of physical characteristics of commonly used polymeric material: plastics and its categories, properties and applications; commonly used ceramic, glass and transparent plastics, properties and applications, adhesives and sealants and their applications in aircraft
PART B

5. ABLATIVE AND SUPER CONDUCTING MATERIALS:  06 Hrs
Ablation process, ablative materials and applications in aerospace; Phenomenon of super conduction, super conducting materials and applications in aerospace

6. AIRCRAFT WOOD, RUBBER, FABRICS & DOPE AND PAINT  07 Hrs
Classification and properties of wood, Seasoning of wood, Aircraft woods, their properties and applications, Joining processes for wood, Plywood; Characteristics and definition of terminologies pertaining to aircraft fabrics and their applications, Purpose of doping and commonly used dopes; Purpose of painting, Types of aircraft paints, Aircraft painting process

7. CORROSION AND ITS PREVENTION  06 Hrs
Knowledge of the various methods used for removal of corrosion from common aircraft metals and methods employed to prevent corrosion.

8. HIGH ENERGY MATERIALS  07 Hrs
Materials for rockets and missiles. Types of propellants and its general and desirable properties, Insulating materials for cryogenic engines. Types of solid propellants: Mechanical characterization of solid propellants using uni-axial, strip-biaxial and tubular tests.

TEXT BOOKS:
1. C G Krishnadas Nair, Handbook of Aircraft materials Interline publishers, Bangalore, 1993

REFERENCE:
2. Balram Gupta, Aerospace material Vol. 1,2,3 ARDB, S Chand & Co 1996
5. AIAA Journal of Propulsion and Power, 2001
Combustion

Sub Code: 06AE663       IA Marks: 25
Hrs/ Week: 04        Exam Hours: 03
Total Hours: 52    Exam Marks: 100

PART A

1. REVIEW OF BASIC CONCEPTS:      06 Hrs

Laws of thermodynamics, Multi-component mixtures, simple thermo chemical
equations and heat of combustion, properties of real gases, transport
phenomena, Rankine-Hugoniot curves, ideas of deflagration and detonation

2. CHEMICAL EQUILIBRIUM AND KINETICS: 06 Hrs

Concept of chemical equilibrium in multicomponent mixtures, Elements of
adiabatic flame temperature calculation, Chemical kinetics – rates and order of
reactions, Reaction mechanism and chain reactions

3. DIFFUSION FLAMES:      06 Hrs

Differences between premixed and diffusion flames, gas diffusion flames in
parallel flow – jet flames and Burke Schumann flames, Liquid droplet
combustion.

4. PREMIXED FLAMES:       08 Hrs

Mechanistic description of premixed flames, Burning velocity and parametric
dependences, Experimental methods of measuring burning velocity, Simple
onedimensional thermal theory of flame, concepts of minimum ignition energy,
quenching distance, stability limits and flame stabilization

PART B

5. COMBUSTION IN PISTON     06 Hrs

Review of operation of reciprocating engines, Description of the combustion
process in piston engines, Combustion efficiency and factors affecting it,
detonation in reciprocating engines and preventive methods
6. COMBUSTION IN GAS-TURBINE ENGINES: 07 Hrs

Description of different types of combustion chambers in gas-turbine engines, primary requirements of the combustor, Flow structure, recirculation and flame stabilization in main combustion chamber, afterburners.

7. COMBUSTION IN ROCKET ENGINES: 07 Hrs

Combustion of carbon particle, boundary layer combustion, basic principles of combustion solid propellants, extension of droplet combustion to liquid propellant rockets

8. EMISSIONS 06 Hrs

Flame radiation, pollutants - unburnt hydrocarbons, oxides of nitrogen and carbon monoxide, methods of reducing pollutants, Principle of exhaust gas analysis

TEXT BOOKS:
1. Introduction to Combustion by Stephen Turn.
2. Combustion fundamentals by Roger Strehlow

REFERENCE:
1. Industrial Combustion by Charles E. Baukal.
2. Heat Transfer in Industrial Combustion by CE Baukal Jr
Sixth Semester B.E. Degree Examination, May/June 2010

Combustion

Max. Marks: 100

Note: Answer any FIVE full questions, selecting at least TWO questions from each part.

PART - A

1. a. Write short notes on ‘heat of combustion’ and ‘heating values’. (08 Marks)
   
   b. Define deflagration and detonation and explain the Rankine – Hugoniot curve and derive its governing equation. (12 Marks)

2. a. Derive an expression for equilibrium constant ‘Kp’ using Gibb’s function. (10 Marks)
   
   b. Define the following: i) Adiabatic flame temperature ii) Enthalpy of formation. (04 Marks)
   
   c. Estimate the constant pressure adiabatic flame temperature for the combustion of a stoichiometric CH₄ – air mixture. The pressure is 1 atm and the initial reactant temperature is 298K. Use the following assumptions and data:
   
   i) Complete combustion (no dissociation) i.e. the product mixture consists only of CO₂, H₂O and N₂.
   
   ii) The product mixture enthalpy is estimated using constant specific heat evaluated at 1200K.
   
   Data: \( h^{f,e}_{\text{CH}_4} \) (kJ/Kmol) @ 298 \( \rightarrow \) CH₄ = -74831 ; CO₂ = -393549 ; H₂O = -241845 ; N₂, O₂ = 0.
   
   \( \bar{C}_p \) (kJ/K mol (-k)) @ 1200 K \( \rightarrow \) CO₂ = 56.21 ; H₂O = 43.87 ; N₂ = 33.71 ; CH₄, O \( \rightarrow \) no value. (06 Marks)

3. a. Briefly explain the flame structure of laminar gaseous jet diffusion flame. (08 Marks)
   
   b. List the assumptions made in the analysis of 2D diffusion flame. (05 Marks)
   
   c. A laminar butane gas jet, issued from a tube into the air, has a flame height of 10cm. Determine volumetric fuel flow rate and heat release rate. If the fuel – tube diameter is increased by 25% and velocity if increased by 25%, what will be the flame height? Assume heat of combustion of butane gas is 45000 kJ/kg, Tad = 2300K. (07 Marks)

4. a. Derive the expression for the quenching distance of a pre-mixed laminar flame. (08 Marks)
   
   b. State the William’s I and II criterion and derive an expression for minimum ignition energy of a pre-mixed laminar flame. (12 Marks)

PART - B

5. a. Explain in brief the phases of combustion in spark ignition and compression ignition engines. (14 Marks)
   
   b. Briefly explain detonation in an IC engine and bring out its effects and preventive methods. (06 Marks)

6. a. What is the classification of gas turbine engine combustion chamber? Briefly explain its operation. (10 Marks)
   
   b. What are the primary requirements of a gas turbine engine combustor? (05 Marks)
   
   c. What is an after burner? How the flame is stabilized during its operation? (05 Marks)

7. a. Derive an expression for the burning rate of carbon particle using one – film analysis. (12 Marks)
   
   b. Derive the expression for droplet burning time using D³ law. (08 Marks)

8. a. Explain in brief the preventive methods of Nox by combustion modification method and post combustion modification method. (12 Marks)
   
   b. Write short notes on the following pollutants: i) CO₂ ii) CO iii) SO₂. (08 Marks)
<table>
<thead>
<tr>
<th>S.No</th>
<th>Topics to be covered</th>
</tr>
</thead>
</table>
| 1.   | **Unit 1: Review of Basic Concepts**  
|      | Laws of Thermodynamics, Multi Component Mixtures |
| 2.   | Simple thermo chemical Equations |
| 3.   | Heat of combustion |
| 4.   | Properties of real gases |
| 5.   | Transport Phenomena |
| 6.   | Rankine-Hugoniot curves |
| 7.   | Ideas of deflagration and detonation |
| 8.   | **Unit 2: Chemical Equilibrium and Kinetics**  
|      | Concept of chemical Equilibrium in multicomponent mixtures |
| 9.   | Elements of adiabatic flame temperature calculation |
| 10.  | Elements of adiabatic flame temperature calculation |
| 11.  | Chemical Kinetics-Rates and Order of Reactions |
| 12.  | Chemical Kinetics-Rates and Order of Reactions |
| 13.  | Reaction Mechanism and Chain reaction |
| 14.  | Reaction Mechanism and Chain reaction |
| 15.  | **Unit 3: Diffusion Flames**  
|      | Difference between premixed and diffusion flames |
| 16.  | Difference between premixed and diffusion flames |
| 17.  | Gas diffusion flames in parallel flow- Jet flame and Burke Schumann flames |
| 18.  | Gas diffusion flames in parallel flow- Jet flame and Burke Schumann flames |
| 19.  | Gas diffusion flames in parallel flow- Jet flame and Burke Schumann flames |
| 20.  | Liquid droplet combustion |
| 21.  | Liquid droplet combustion |
| 22.  | **Unit 4: Premixed Flames**  
<p>|      | Mechanistic description of premixed flames |
| 23.  | Burning velocity and parametric dependences |
| 24.  | Experimental Methods of measuring burning velocity |
| 25.  | Simple one-dimensional thermal theory of flame |
| 26.  | Simple one-dimensional thermal theory of flame |
| 27.  | Concepts of minimum ignition Energy |
| 28.  | Quenching distance |
| 29.  | Stability limits and flame stabilization |
| 30.  | Stability limits and flame stabilization |</p>
<table>
<thead>
<tr>
<th></th>
<th>Unit 5: Combustion in Piston Engines</th>
</tr>
</thead>
<tbody>
<tr>
<td>31.</td>
<td>Review of operation of reciprocating engines</td>
</tr>
<tr>
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</tr>
<tr>
<td>33.</td>
<td>Description of the combustion process in piston engines</td>
</tr>
<tr>
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</tr>
<tr>
<td>35.</td>
<td>Combustion efficiency and factors affecting it</td>
</tr>
<tr>
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</tr>
<tr>
<td>37.</td>
<td>Detonation in reciprocating engines and preventive methods</td>
</tr>
<tr>
<td>38.</td>
<td>Unit 6: Combustion in gas turbine Engines</td>
</tr>
<tr>
<td></td>
<td>Description of different types of combustion chambers in gas turbine engines</td>
</tr>
<tr>
<td>39.</td>
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</tr>
<tr>
<td>40.</td>
<td>Primary requirements of the combustors</td>
</tr>
<tr>
<td>41.</td>
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</tr>
<tr>
<td>42.</td>
<td>Flow structure, recirculation</td>
</tr>
<tr>
<td>43.</td>
<td>Flame stabilization in main combustion chamber</td>
</tr>
<tr>
<td>44.</td>
<td>Flame stabilization in main combustion chamber</td>
</tr>
<tr>
<td>45.</td>
<td>Afterburners</td>
</tr>
<tr>
<td>46.</td>
<td>Unit 7: Combustion in Rocket Engines</td>
</tr>
<tr>
<td></td>
<td>Combustion of carbon particle</td>
</tr>
<tr>
<td>47.</td>
<td>Combustion of carbon particle</td>
</tr>
<tr>
<td>48.</td>
<td>Boundary Layer Combustion</td>
</tr>
<tr>
<td>49.</td>
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</tr>
<tr>
<td>50.</td>
<td>Basic Principles of combustion solid propellants</td>
</tr>
<tr>
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</tr>
<tr>
<td>52.</td>
<td>Extension of droplet combustion to liquid rocket</td>
</tr>
<tr>
<td>53.</td>
<td>Extension of droplet combustion to liquid rocket</td>
</tr>
<tr>
<td>54.</td>
<td>Unit 8: Emissions: Flame Radiation</td>
</tr>
<tr>
<td>55.</td>
<td>Pollutants-unburnt hydrocarbons</td>
</tr>
<tr>
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<td>Pollutants-unburnt hydrocarbons</td>
</tr>
<tr>
<td>57.</td>
<td>Oxides of nitrogen and carbon monoxide</td>
</tr>
<tr>
<td>58.</td>
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</tr>
<tr>
<td>59.</td>
<td>Methods of reducing pollutants</td>
</tr>
<tr>
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<td>Methods of reducing pollutants</td>
</tr>
<tr>
<td>61.</td>
<td>Principle of Exhaust gas Analysis</td>
</tr>
<tr>
<td>62.</td>
<td>Principle of Exhaust gas Analysis</td>
</tr>
</tbody>
</table>
Reliability Engineering

Sub Code: 06AE664       IA Marks: 25
Hrs/ Week: 04        Exam Hours: 03
Total Hours: 52        Exam Marks: 100

PART A

1. Introduction        07 Hrs
Reliability concepts and definitions, probability distribution functions and their application in
reliability Evaluation, Reliability Evaluation in Engineering systems using Markov Models

2. Failure analysis     07 Hrs
Causes of failure, concept of hazard failure models, Bath Tub curve, MTTF, MTBF

3. Reliability Modeling 06 Hrs
System reliability for various configurations and combinational aspects, Weibull analysis on
reliability

4. Reliability Studies
Reliability improvement, redundancy, reliability-cost trade-off.

PART B

5. Maintainability and Availability concepts 06 Hrs
System Safety analysis

6. Maintenance concepts 07 Hrs
Types of Maintenance, Modern trends in Maintenance Philosophy like BITE, IRAN, HUM,
TPM etc.

7. Failure Investigation Process and Methodologies like FTA, FMEA 06 Hrs

8. Reliability and Quality Improvement techniques like, Bench Marking, JIT Quality Circles, Quality Audit, TQM, Kaizan etc. 07 Hrs

TEXT BOOKS:
REFERENCE:
1. K.S. Trivedi, Probability and statistics with Reliability, Queuing and Computer Science Applications, PHI.
Industrial Management

Sub Code: 06AE665       IA Marks: 25
Hrs/ Week: 04        Exam Hours: 03
Total Hours: 52       Exam Marks: 100

PART – A
UNIT 1: Introduction:
Historical perspective, contribution of Taylor, Henry Fayol, Gilbert, Charles Babbage, HL Gantt and others to the evolution of management science in the Indian context. Ownership of Industries Proprietorship, partnership, joint stock companies, public and private undertakings, co-operative organizations

(6 Hours)

UNIT 2: Management Functions:
Planning: corporate objectives, policies, strategies need for planning, responsibilities and types of plans, modern toll of planning, selection of alternatives and process of decision making, case studies. Organization: Basic requirement, types, structures and merits, Departmentation, vertical and horizontal growth, span of control, authority and responsibility, centralization and decentralization, formal and informal organizations, case studies

(7 Hours)

UNIT 3: Staffing:
Appraisal of needs, executive development schemes, performance appraisal and managerial mobility. Directing: Types of instructions and characteristics of good order, communication follow of instructions motivation and leadership. Controlling: process of control, requirements of effective controlling, controlling techniques.

(7 Hours)

UNIT 4: Work study, incentives, Health and safety:
Method study and time study, Foundations of work-study, Job evaluation systems, Multi skilling, Incentive schemes, Training and Development, Safety Regulations and safe practices.

(6 Hours)

PART – B

Unit 5: Management and Behavioral Approach:
Contribution of Elton Mayo and skinner and others to behavior sciences. Skills of a manager at various levels in an organization and inter-related systems, understanding past behavior, predicting future behavior, directing, changing and controlling behavior.

(6 Hours)
UNIT 6: Motivation and Behavior:
Maslow’s hierarchy of needs, pretence of needs and satisfaction of needs, goal oriented behavior, integration of organizational goals and needs of employee. Hawthorn’s studies and its findings theory X and theory Y, immaturity theory, motivation hygiene theory.

(6 Hours)

UNIT 7: Process Management:
Definition of process management. Major process decisions-process choice, vertical integration, resource flexibility, customer involvement, capital intensity, relationships between decisions, service operation relationships between decisions, service operation relationships, economics of scope and gaining focus. Designing process-process rearranging and process improvement

(7 Hours)

UNIT 8: Management of Technology:

(7 Hours)

TEXT BOOKS:
2. Production and operations Management, S.N Chery, TATA McGraw Hill

REFERENCE BOOKS:
AERODYNAMICS LABORATORY

Sub Code: 06AEL67
Hrs / Week: 03
Total Hours: 42
IA Marks: 25
Exam Hours: 03
Exam Marks: 50

LIST OF EXPERIMENTS

1. Calibration of a subsonic wind tunnel: test section static pressure and total head
2. Smoke flow visualization studies on a two-dimensional circular cylinder at low speeds.
3. Smoke flow visualization studies on a two dimensional airfoil at different angles of incidence at low speeds
4. Tuft flow visualization on a wing model at different angles of incidence at low speeds: identify zones of attached and separated flows.
5. Surface pressure distributions on a two-dimensional circular cylinder at low speeds and calculation of pressure drag.
6. Surface pressure distributions on a two-dimensional symmetric airfoil at zero incidences at low speeds.
7. Surface pressure distributions on a two-dimensional cambered airfoil at different angles of incidence and calculation of lift and pressure drag.
9. Calculation of total drag of a two-dimensional cambered airfoil at low speeds at incidence using pitot-static probe wake survey.
10. Measurement of a typical boundary layer velocity profile on the tunnel wall (at low speeds) using a pitot probe and calculation of boundary layer displacement and momentum thickness.
PROPULSION LABORATORY

Sub Code: 06AEL68       IA Marks: 25
Hrs / Week:               03 Exam Hours: 03
Total Hours: 42              Exam Marks: 50

LIST OF EXPERIMENTS

1. Study of an aircraft piston engine. (Includes study of assembly of sub systems, various components, their functions and operating principles)
2. Study of an aircraft jet engine (Includes study of assembly of sub systems, various components, their functions and operating principles)
3. Study of forced convective heat transfer over a flat plate.
4. Cascade testing of a model of axial compressor blade row.
5. Study of performance of a propeller.
7. Study of free jet
9. Fuel-injection characteristics