# INSTITUTE OF AERONAUTICAL ENGINEERING

**(Autonomous)**
Dundigal, Hyderabad -500 043

## CIVIL ENGINEERING

## COURSE DESCRIPTOR

| | | | | | |
|---|---|---|---|---|---|
| **Course Title** | **ADVANCED STRUCTURAL ANALYSIS** | | | | |
| **Course Code** | BSTB01 | | | | |
| **Programme** | M.Tech | | | | |
| **Semester** | I | STE | | | |
| **Course Type** | Core | | | | |
| **Regulation** | IARE - R18 | | | | |
| **Course Structure** | **Theory** | | | **Practical** | |
| | **Lectures** | **Tutorials** | **Credits** | **Laboratory** | **Credits** |
| | 3 | - | 3 | - | - |
| **Chief Coordinator** | Dr. Venu M, Professor | | | | |
| **Course Faculty** | Dr. Venu M, Professor | | | | |

## I. COURSE OVERVIEW:

This course mainly deals with matrix analysis of structures. It begins with a review of the basic concepts of structural analysis and matrix algebra, and shows how the latter provides an excellent mathematical framework for the former. This is followed by detailed descriptions, and demonstrations through many examples, of how matrix methods can be applied to linear static analysis of skeletal structures (plane and space trusses; beams and grids; plane and space frames) by the stiffness method, and also the flexibility method. Also, it is shown how simple structures can be conveniently solved using a reduced stiffness formulation, involving far less computational effort. Finally, the analysis of elastic instability and second-order response is discussed. The main objective is to enable the student to have a good grasp of all the fundamental issues in these advanced topics in structural analysis, besides enjoying the learning process, and developing analytical and intuitive skills.

## II. COURSE PRE-REQUISITES:

| Level | Course Code | Semester | Prerequisites | Credits |
|---|---|---|---|---|
| - | - | - | Strength of Materials – II | - |
| - | - | - | Structural Analysis | - |

## III. MARKSDISTRIBUTION:

| Subject | SEE Examination | CIAExamination | Total Marks |
|---|---|---|---|
| Advanced Structural Analysis | 70 Marks | 30 | 100 |

## IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ✘ | Chalk & Talk | ✘ | Quiz | ✔ | Assignments | ✘ | MOOCs |
| ✔ | LCD / PPT | ✘ | Seminars | ✘ | Mini Project | ✔ | Videos |
| ✘ | Open Ended Experiments | | | | | | |

## V. EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIE during the semester, marks are awarded by taking average of two sessional examinations.

**Semester End Examination (SEE):** The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into five modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

| | |
|---|---|
| 50 % | To test the objectiveness of the concept. |
| 50 % | To test the analytical skill of the concept OR to test the application skill of the concept. |
| 50 % | To test the application skill of the concept. |

**Continuous Internal Assessment (CIA):**

For each theory course the CIA shall be conducted by the faculty/teacher handling the course as given in Table 4. CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Technical Seminar and Term Paper.

Table 1: Assessment pattern for CIA

| Component | Theory | | Total Marks |
|---|---|---|---|
| **Type of Assessment** | CIE Exam | Technical Seminar and Term Paper | |
| **Max. CIA** | 25 | 05 | 30 |

**Continuous Internal Examination (CIE):**

Two CIE exams shall be conducted at the end of the 9th and 17th week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration, consisting of 5 one mark compulsory questions in part-A and 4 questions in part-B. The student has to answer any 4 questions out of five questions, each carrying 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

**Quiz / Alternative Assessment Tool (AAT):**

Two seminar presentations are conducted during I year I semester and II semester. For seminar, a student under the supervision of a concerned faculty member, shall identify a topic in each course and prepare the term paper with overview of topic. The evaluation of Technical seminar and term paper is for maximum of 5 marks. Marks are awarded by taking average of marks scored in two Seminar Evaluations.

## VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

| Program Outcomes (POs) | | Strength | Proficiency assessed by |
|---|---|---|---|
| PO 3 | Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields. | 2 | Assignments, Tutorials |
| PO 4 | Apply appropriate techniques, resources, modern engineering and Information Technology (IT) tools including predictions, modeling of complex structural engineering activities. | 2 | Assignments |
| PO 5 | Able to identify and analyze the impact of Structural Engineering in development projects and find a suitable solution from number of alternatives. | 2 | Assignments |
| PO 6 | Conceptualize and design civil engineering structures considering various socio-economic factors. | 2 | Presentation on realworld problems |

**3 = High; 2 = Medium; 1 = Low**

## VII. COURSE OBJECTIVES :

| The course should enable the students to: | |
|---|---|
| I | Analyze the skeleton structures using stiffness analysis code. |
| II | Use direct stiffness method understanding its limitations. |

## VIII. COURSE OUTCOMES (COs):

| COs | Course Outcome | CLOs | Course Learning Outcome |
|---|---|---|---|
| CO 1 | Know the physical significance, effects of settlements, temperature change and lack of fit, member approach and structure approach. | CLO 1 | Understand the physical significance of stiffness influence coefficients. |
| | | CLO 2 | Understand the effects of settlements of stiffness influence coefficients. |
| | | CLO 3 | Solve the problems on temperature change and lack of fit. |
| | | CLO 4 | Know the member approach and structure approach. |
| CO 2 | Understand the force method and displacement method, | CLO 5 | Understand the force method. |
| | | CLO 6 | Understand the displacement method. |

| COs | Course Outcome | CLOs | Course Learning Outcome |
|---|---|---|---|
| | degree of freedom,local coordinates and global coordinates. | CLO 7 | Know concept of degree of freedom. |
| | | CLO 8 | Understand the concept of local coordinates. |
| | | CLO 9 | Understand the concept of global coordinates. |
| CO 3 | Understand the stiffness matrix in global coordinates, boundary conditions, solution of stiffness matrix equations, calculation of reactions and member forces for beams, plane trusses, plane rigid jointed frames and grids. | CLO 10 | Develop the stiffness matrix for global coordinates and know the boundary conditions. |
| | | CLO 11 | concepts on solution of stiffness matrix equations. |
| | | CLO 12 | Know the calculation of reactions and member forces. |
| | | CLO 13 | Understand the stiffness method for beams, plane trusses and plane rigid jointed frames. |
| | | CLO 14 | Understand the formulation of grid structures. |
| | | CLO 15 | Concept of structure and member approach. |
| CO 4 | Know the boundary value problems: approximate solution of boundary value problems, modified galerkin method for one-dimensional BVP, matrix formulation of the modified galerkin method. | CLO 16 | Understand the solutions for boundary value problems. |
| | | CLO 17 | Know the modified galerkin method. |
| | | CLO 18 | Understand the modified galerkin method for one-dimensional BVP. |
| | | CLO 19 | Understand the matrix formulation of the modified galerkin method. |
| CO 5 | Understand the shape functions linear element, solution for Poisson's equation, general one dimensional equilibrium problem. | CLO 20 | Know the shape functions for linear elements. |
| | | CLO 21 | Understand the solution for Poisson's equation. |
| | | CLO 22 | Formulation of general one dimensional equilibrium problem. |
| | | CLO 23 | Solution of general one dimensional equilibrium problem. |

## IX. COURSE LEARNING OUTCOMES (CLOs):

| CLO Code | CLO's | At the end of the course, the student will have the ability to: | PO's Mapped | Strength of Mapping |
|---|---|---|---|---|
| BSTB01.01 | CLO 1 | Understand the physical significance of stiffness influence coefficients. | PO 3 | 2 |
| BSTB01.02 | CLO 2 | Understand the effects of settlements of stiffness influence coefficients. | PO 3 | 2 |
| BSTB01.03 | CLO 3 | Solve the problems on temperature change and lack of fit. | PO 3, PO 4 | 1 |
| BSTB01.04 | CLO 4 | Know the member approach and structure approach. | PO 3 | 2 |
| BSTB01.05 | CLO 5 | Understand the force method. | PO 3 | 2 |
| BSTB01.06 | CLO 6 | Understand the displacement method. | PO 5, PO 6 | 1 |
| BSTB01.07 | CLO 7 | Know concept of degree of freedom. | PO 3 | 1 |
| BSTB01.08 | CLO 8 | Understand the concept of local coordinates. | PO 3, PO 4 | 2 |
| BSTB01.09 | CLO 9 | Understand the concept of global coordinates. | PO 3 | 1 |
| BSTB01.10 | CLO 10 | Develop the stiffness matrix for global coordinates and know the boundary conditions. | PO 3, PO 4 | 1 |
| BSTB01.11 | CLO 11 | Concepts on solution of stiffness matrix equations. | PO 3, PO 4, PO 5 | 2 |
| BSTB01.12 | CLO 12 | Know the calculation of reactions and member forces. | PO 3, PO 4, PO 6 | 1 |

| CLO Code | CLO's | At the end of the course, the student will have the ability to: | PO's Mapped | Strength of Mapping |
|---|---|---|---|---|
| BSTB01.13 | CLO 13 | Understand the stiffness method for beams, plane trusses and plane rigid jointed frames. | PO 3, PO 6 | 2 |
| BSTB01.14 | CLO 14 | Understand the formulation of grid structures. | PO 3, PO 4 | 2 |
| BSTB01.15 | CLO 15 | Concept of structure and member approach. | PO 3 | 2 |
| BSTB01.16 | CLO 16 | Understand the solutions for boundary value problems. | PO 3 | 2 |
| BSTB01.17 | CLO 17 | Know the modified galerkin method. | PO 3, PO 4 PO 5, PO 6 | 1 |
| BSTB01.18 | CLO 18 | Understand the modified galerkin method for one-dimensionalBVP. | PO 3, PO 6 | 2 |
| BSTB01.19 | CLO 19 | Understand the matrix formulation of the modified galerkin method. | PO 3, PO 5 | 2 |
| BSTB01.20 | CLO 20 | Know the shape functions for linear elements. | PO 3, PO 4 PO 5, PO 6 | 2 |
| BSTB01.21 | CLO 21 | Understand the solution for Poisson's equation. | PO 3, PO 4 | 1 |
| BSTB01.22 | CLO 22 | Formulation of general one dimensional equilibrium problem. | PO 3, PO 4, PO 6 | 2 |
| BSTB01.23 | CLO 23 | Solution of general one dimensional equilibrium problem. | PO 3, PO 5, PO 6 | 2 |

**3= High; 2 = Medium; 1 = Low**

## X. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

| Course Outcomes (COs) | Program Outcomes (POs) | | | |
|---|---|---|---|---|
| | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 1 | 2 | 1 | | |
| CO 2 | 2 | 2 | 2 | 1 |
| CO 3 | 2 | 2 | 2 | 1 |
| CO 4 | 2 | 1 | 2 | 1 |
| CO 5 | 2 | 2 | 1 | 2 |

**3 = High; 2 = Medium; 1 = Low**

## XI. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

| (CLOs) | Program Outcomes (POs) | | | | | | |
|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 |
| CLO 1 | | | 2 | | | | |
| CLO 2 | | | 2 | | | | |
| CLO 3 | | | 2 | 1 | | | |
| CLO 4 | | | 2 | | | | |

| (CLOs) | Program Outcomes (POs) | | | | | | |
|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 |
| CLO 5 | | | 2 | | | | |
| CLO 6 | | | | | 2 | 1 | |
| CLO 7 | | | 1 | | | | |
| CLO 8 | | | 2 | 2 | | | |
| CLO 9 | | | 1 | | | | |
| CLO 10 | | | 2 | 1 | | | |
| CLO 11 | | | 2 | 2 | 2 | | |
| CLO 12 | | | 1 | 2 | | 1 | |
| CLO 13 | | | 2 | | | 2 | |
| CLO 14 | | | 2 | 2 | | | |
| CLO 15 | | | 2 | | | | |
| CLO 16 | | | 2 | | | | |
| CLO 17 | | | 2 | 1 | 2 | 1 | |
| CLO 18 | | | 2 | | | 2 | |
| CLO 19 | | | 2 | | 2 | | |
| CLO 20 | | | 2 | 2 | 1 | 2 | |
| CLO 21 | | | 1 | 2 | | | |
| CLO 22 | | | 2 | 2 | | 2 | |
| CLO 23 | | | 2 | | 2 | 2 | |

**3 = High; 2 = Medium; 1 = Low**

## XII. ASSESSMENT METHODOLOGIES–DIRECT:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CIE Exams | PO3, PO4, PO5,PO6 | SEE Exams | PO3, PO4, PO5, PO6 | Assignments | PO3, PO4, PO5, PO6 | Seminars | - |
| Laboratory Practices | - | Student Viva | - | Mini Project | - | Certification | - |
| Term Paper | - | | | | | | |

## XIII. ASSESSMENT METHODOLOGIES–INDIRECT:

| | | | |
|---|---|---|---|
| ✔ | Early Semester Feedback | ✔ | End Semester OBE Feedback |
| ✘ | Assessment of Mini Projects by Experts | | |

## XIV. SYLLABUS

| UNIT-I | INFLUENCE COEFFICIENTS |
|---|---|
| Physical Significance, Effects of Settlements, Temperature Change and Lack of Fit, Member Approach and Structure Approach. | |
| **UNIT-II** | **STIFFNESS METHOD APPLIED TO LARGE FRAMES** |
| Force method and displacement method, Degree of Freedom,Local Coordinates and Global Coordinates. | |
| **UNIT-III** | **STIFFNESS MATRIX ASSEMBLY OF STRUCTURES AND APPLICATION TO SIMPLE PROBLEMS** |
| Stiffness Matrix in Global Coordinates, Boundary Conditions, Solution of Stiffness Matrix Equations, Calculation of Reactions and Member Forces.<br><br>Beams, Plane Trusses, Plane Rigid Jointed Frames and Grids by Structure Approach and Member Approach. | |
| **UNIT-IV** | **BOUNDARY VALUE PROBLEMS (BVP)** |
| Boundary Value Problems: Approximate Solution of Boundary Value Problems, Modified Galerkin Method for One-Dimensional BVP, Matrix Formulation of the Modified Galerkin Method. | |
| **UNIT-V** | **LINEAR ELEMENT** |
| Linear Element: Shape Functions, Solution for Poisson's Equation, General One Dimensional Equilibrium Problem. | |
| **Text Books:** | |
| 1. G. S. Pandit and S.P. Gupta, "Structural Analysis – A Matrix Approach", McGraw Hill Education. 2nd Edition, 2008.<br>2. C.S. Reddy, "Basic Structural Analysis", 3rd Edition, McGraw Hill Education.<br>3. Ashok. K. Jain, "Advanced Structural Analysis", Nem Chand & Bros. 3rd Edition, 2010.<br>4. J. Meek, "Matrix Methods of Structural Analysis", McGraw Hill Education.1st Edition, 2011.<br>5. S SBhavikatti, "Finite Element Analysis", New Age International Pvt. Ltd., Publishers.1st Edition, 2009. | |
| **Reference Books:** | |
| 1. Todd, J.D., "Structural theory and analysis", The Mac Million Press Ltd., New York.<br>2. Menon, D., "Advanced structural analysis", Narosa Publishing House, New Delhi.<br>3. McCarmac, J. and Elling, R. E., "Structural Analysis: A Classical and Matrix A Approach", Harper and Row Publishers. | |
| **Web References:** | |
| 1. nptel.ac.in/courses/Webcourse-contents/.../Structural%20Analysis/pdf/m2l7.pdf.<br>2. https://nptel.ac.in/reviewed_pdfs/105106050/lec1.pdf<br>3. http://web.iitd.ac.in/~sbhalla/rc717.pdf | |
| **E-Text Books:** | |
| 1. https://phindia.com/.../matrix_methods_of_structural_analysis_theory_and_problems<br>2. http://www.uomisan.edu.iq/library/admin/book/91314849583.pdf<br>3. http://priodeep.weebly.com/uploads/6/5/4/9/65495087/w._j._spencer__auth._- | |

## XV. COURSE PLAN:

| Lecture No. | Topics to be covered | Course Learning Outcomes (CLOs) | Reference |
|---|---|---|---|
| 1-2 | Physical significance of stiffness influence coefficients. | CLO 1 | T1:133–142 |
| 3-5 | Effects of settlements of stiffness influence coefficients. | CLO 2 | T1:133–142 |

| Lecture No. | Topics to be covered | Course Learning Outcomes (CLOs) | Reference |
|---|---|---|---|
| 6-8 | Problems on temperature change and lack of fit. | CLO 3 | T1:140–170 |
| 9 | Member approach and structure approach. | CLO 4 | T1:140–170 |
| 10 | Introduction to the force method. | CLO 5 | T1:185 |
| 11 | Introduction to the displacement method. | CLO 6 | T1:199 |
| 12-13 | Degree of freedom. | CLO 7 | T1:1 – 25 |
| 14-15 | Concept of local coordinates. | CLO 8 | T5:33 – 38 |
| 16-17 | Global coordinates. | CLO 9 | T5:39 – 53 |
| 18-20 | Stiffness matrix for global coordinates and know the boundary conditions. | CLO 10 | T1:185–221 |
| 21 | Solution of stiffness matrix equations | CLO 11 | T1:185–221 |
| 22-24 | Calculation of reactions and member forces. | CLO 12 | T1:185–221 |
| 25-26 | Stiffness method for beams, plane trusses and plane rigid jointed frames. | CLO 13 | T1:227–252 |
| 27-28 | Formulation of grid structures. | CLO 14 | T1:253–300 |
| 29 | Concept of structure and member approach. | CLO 15 | T1:318–337 |
| 30 | Solutions for boundary value problems. | CLO 16 | T5:338–345 |
| 31 | Modified galerkin method. | CLO 17 | T5:118–119 |
| 32-33 | Modified galerkin method for one-dimensionalBVP. | CLO 18 | T5:118–119 |
| 34-35 | Matrix formulation of the modified galerkin method. | CLO 19 | T5:118–119 |
| 36-39 | Shape functions for linear elements. | CLO 20 | T5:55 – 80 |
| 40-41 | Solution for Poisson's equation. | CLO 21 | T5:82 – 95 |
| 42-45 | General one dimensional equilibrium problems | CLO 22 | T5:96 – 98 |

## XVI. GAPS IN THE SYLLABUS-TO MEET INDUSTRY / PROFESSION REQUIREMENTS:

| S.No. | Description | Proposed Actions | Relevance with POs |
|---|---|---|---|
| 1 | Experimental analysis of Structure and the behaviour under loads | Seminars / Guest Lectures / NPTEL | PO 3, PO 4, PO 5, PO 6 |
| 2 | Advanced Structural Analysis of using Software packages | Seminars / Guest Lectures / NPTEL | PO 5, PO 6 |
| 3 | Thermal analysis of a structures using FEM | Assignments / Laboratory Practices | PO 3, PO 6 |

**Prepared by:**

Dr.Venu M, Professor

**HOD, CE**