# GUJARAT TECHNOLOGICAL UNIVERSITY

## MECHATRONICS (47)

FINITE ELEMENTAL METHODS
**SUBJECT CODE:** 2724710
M.E. 2ND SEMESTER

**Type of course**: Engineering Science

**Prerequisite**: NA

**Rationale**: This subject deals with fundamentals of Finite Element Methods and its applications, which are useful for Mechatronics engineers.

**Teaching and Examination Scheme:**

| Teaching Scheme | | | Credits | Examination Marks | | | | | | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|
| L | T | P | C | Theory Marks | | Practical Marks | | | | |
| | | | | ESE (E) | PA (M) | ESE (V) | | PA (I) | | |
| | | | | | | ESE | OEP | PA | RP | |
| 3 | 2# | 2 | 5 | 70 | 30 | 20 | 10 | 10 | 10 | 150 |

**Content:**

| Sr. No | Contents | Teaching Hrs | Weightage (%) |
|---|---|---|---|
| 1 | **Finite Element Method:** Basics, history and application, Comparison with other methods, Variational approach, Galerkin's Methods. | **3** | **7.5** |
| 2 | **Element and Boundary Condition:** Element shapes, interpolation function. Virtual energy principle, Rayleigh- Ritz method, stiffness matrix and properties, Boundary conditions, solution of system of equations, shape functions and characteristics, Basic equations of elasticity, strain displacement relations | **6** | **15** |
| 3 | **1-D structural problems** – axial bar element – stiffness matrix, load vector, temperature effects, Quadratic shape function. Analysis of Trusses – Plane Truss and Space Truss elements | **5** | **12.5** |
| 4 | **Analysis of beams** – Hermite shape functions – stiffness matrix – Load vector – Problems. **2-D problems** –CST, LST, force terms, Stiffness matrix, load vector, boundary conditions. | **7** | **17.5** |
| 5 | **Element types -** Isoparametric element – quadrilateral element, Shape functions – Numerical Integration – sub parametric and super parametric elements. **3-D problems** – Tetrahedral element – Jacobian matrix – Stiffness matrix. | **6** | **15** |
| 6 | **Dynamic Analysis -** Dynamic considerations, Dynamic equations – consistent mass matrix – Eigen Values, Eigen Vector, natural frequencies – mode shapes – modal analysis. Applications of numerical procedures to determine natural frequencies and mode shapes. Finite Element Method for dynamic analysis, Introduction to torsional problems | **8** | **20** |
| 7 | **Introduction to Non linearity**, Geometric Non-linearity, Material Non-linearity, Non linear dynamic problems, analytical problems | **5** | **12.5** |

**Reference Books:**


1. Introduction to finite elements in Engineering by Tirupathi K. Chandrupatla and Ashok D.Belegundu.
2. Finite Element Procedures in Engineering analysis by K.J Bathe.
3. An Introduction to Nonlinear Finite Element Analysis by J.N.Reddy, Oxford University Press.
4. The finite element methods in Engineering – S.S. Rao - Pergamon, New York.
5. An Introduction to Finite Element Methods – J. N. Reddy – McGraw Hill.
6. A Textbook of Finite Element Analysis by P. Seshu
7. The Finite Element Method in Engineering science – O.C. Zienkowicz, McGraw Hill.
8. Concepts and applications of finite element analysis – Robert Cook


**Course Outcomes:**

After learning the course the students should be able to

1. Learn the mathematical formulation of the finite element method and how to apply it to basic (linear) ordinary and partial differential equations.
2. Learn how to implement the finite element method efficiently in order to solve a particular equation.
3. Formulate simple problems into finite elements.
4. Solve structural, impact and crash problems.
5. Solve complicated 3D structural problems for stress analysis underimpact loads..
6. Appreciate the importance of ethical issues pertaining to the effective utilization of FEA.

**List of Practicals**

1. Introduction to ANSYS – Modelling and analysis
2. Solve Problems on 1-D Spring elements
3. Solve Problems on beam elements
4. Solve Problems on Truss element
5. Solve Problems on 2-D element
6. Solve problem on Bars with Constant and variable Cross-section Area, Stepped bars etc.
7. Solve problems on Bars of Tapered Cross section Area
8. To Perform Static analysis of a corner bracket
9. To Perform Modal Analysis of a Model Airplane Wing.
10. To Perform Interference Fit and Pin Pull-Out Contact Analysis.

**Tutorials:**

Tutorial classes may be arranged as per the requirements of the subject.

**Design based/open ended problem**

Student may be given a task to exhibit the knowledge of the course studied during the academic year.

**Major Equipment:**

ANSYS -14.5 - Software

**Review Presentation (RP):** The concerned faculty member shall provide the list of peer reviewed Journals and Tier-I and Tier-II Conferences relating to the subject (or relating to the area of thesis for seminar) to the students in the beginning of the semester. The same list will be uploaded on GTU website during the first two weeks of the start of the semester. Every student or a group of students shall critically study 2 papers, integrate the details and make presentation in the last two weeks of the semester. The GTU marks entry portal will allow entry of marks only after uploading of the best 3 presentations. A unique id number will be generated only after uploading the presentations. Thereafter the entry of marks will be allowed. The best 3 presentations of each college will be uploaded on GTU website.