Course Code	ME 324
Course Title	Finite Element Analysis for Mechanical Design
No. of Credits	3
Pre-requisites	CE 201, ME 222
Compulsory/Optional	Compulsory for Design track, Energy Systems track, and Mechanical Engineering with Business track under Mechanical Engineering stream /Optional for others.

Aim(s):

To impart the theory and practice of the finite element method and its connection to computer aided design, and design optimization so that all students will be able to model, and analyze the behavior of complicated mechanical engineering systems and structures.

Intended Learning Outcomes:

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

- apply finite the element method for mechanical engineering problems of different application areas such as structural, thermal and fluids,
- develop special-purpose finite element programs in a procedural programming platform,
- solve problems in the areas of structural, thermal and fluids using professional-level Finite Element Analysis software packages,
- evaluate the accuracy and reliability of finite element solutions and solve problems arising from errors in a given finite element analysis,
- apply design optimization techniques in mechanical engineering design applications using software tools.

Time Allocation (Hours) : Lectures 25 , Tutorials 02 , Assignments 36
(Notional Hours: 150)

- **Introduction to Finite Element Methods**: Discrete systems and origin of finite element method, General steps and applications, Advantages and disadvantages, Practical considerations in modeling and interpreting results, Computer programs.
- **Displacement based finite element method**: Derivation of stiffness matrix for a spring element, Assembling of total stiffness matrix using direct Stiffness matrix, Applying boundary condition, Solution techniques, Transformation matrix for a spring in 2-dimension and 3-dimension spaces and derivation of stiffness matrix for truss element in 2D and 3D, Computer implementation of the process using a programming language,
- **Development of beam equations**: Derivation of stiffness matrix for beam element based on Euler-Bernoulli beam theory and Timoshenko beam theory, Assembling the element stiffness matrices using direct stiffness method and applying boundary conditions, Equivalent nodal forces, Computer implementation of the process using a programming language
- **Development of plane stress and plane strain stiffness equations:** Derivation of constant strain triangular (CST) element stiffness matrix and linear strain triangular (LST) element stiffness matrix assembling the element stiffness matrices using direct stiffness method and applying boundary conditions, Equivalent nodal forces
- **Isoperimetric formulations**: Isoperimetric formulation for 4-node quadrilateral element; Gauss points and Gauss quadrature numerical integration; Equivalent

nodal forces , Higher order elements.

- **Three dimensional stress analysis**: 3-D stress and strains, Tetrahedral element formulation.
- **Thermal system analysis**: Formulation of thermal stress problems and 2-D finite element formulation.
- **Structural dynamics**: Lumped-mass matrix and consistent-mass matrix, Derivation of bar element equations, Numerical integration in time, Natural frequencies of a one-dimensional bar, Time dependent one-dimensional bar analysis.
- **Computer aided design:** Design of mechanical components and assemblies of complex geometries and loading conditions using software tools.

Recommended Texts (if any) :

- Logan, D. (2007). *First Course in Finite Element Method*, (4th Edition). Nelson Engineering, Florida, USA.
- Desai, C. (2005). *Introduction to the Finite Element Method*, (1st Edition), CBS Publications, New Delhi, India.
- Budynas−Nisbett (2008). *Shigley's Mechanical Engineering Design* (8th Edition). McGraw Hill, New York, USA.
- Hassan, M.H. (2016). *Systems Engineering Innovation and Design* (1st Edition). CreateSpace Independent Publishing Platform, North Charleston, South Carolina, USA.
- Singhose, W. and Donnell, J. (2012). *Introductory Mechanical Design Tools (*1st Edition). Lulu Press, Inc, Morrisville, North Carolina.

Assessment	**Percentage Mark**
In-course Tutorials/Assignments/Quizzes/Practicals Mid Semester Examination:	 40 -
End-semester: Written examination	60