NATIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF MECHANICAL ENGINEERING

MECHANICAL ENGINEERING PROGRAM

MC516 – FINITE ELEMENTS

I. GENERAL INFORMATION

CODE	:	MC516 Finite Elements
SEMESTER	:	7
CREDITS	:	3
HOURS PER WEEK	:	4 (Theory–Practice)
PREREQUISITES	:	MB165 Linear Algebra MC325 Strength of Materials II
CONDITION	:	Compulsory
DEPARTMENT	:	Mechanical Engineering

II. COURSE DESCRIPTION

The course prepares students for the analysis and application of finite element methods to solve engineering problems. Students apply potential elastic energy concepts to solve one-dimensional and two-dimensional design problems. Trusses, beams and frames are analyzed, as well as structures with non-articulated nodes. Specialized software is used.

III. COURSE OUTCOMES

At the end of the course, students:

1. Understand basic concepts and criteria of strength of materials used in the field of finite element analysis.
2. Explain the importance of applying finite elements methods to solve engineering problems.
3. Understand and apply the theorems of Castigliano, Maxwell, Green and Betti, for analyzing the mechanical behavior of materials.
4. Know about other engineering sciences where finite elements methods could be applied to obtain better, faster and easier results.

IV. LEARNING UNITS

1. ELASTIC ENERGY

Density of energy / Elastic energy / External work / Potential energy / Theorems: Principle of virtual work / First and second theorem of Castigliano / Maxwell theorem. / Theorems of Betti, identity of Green / Elastic displacement / Deformations and efforts / Constant of Larne / Equations of Larne / Equilibrium in an oriented point of material / Procedures of Ritz-Galerkin / Variational calculus (notions) / Ritz-Galerkin equation / Accordance with the principle of virtual works / Uniaxial effective stress (Von Mises).

2. MATRICES

General considerations / Order of a matrix / Array of components / Matrix operations / Coordinate systems / Coordinate rotation / Arbitrary vector / Rotation of a matrix (dyadic) / Hooke's law and Poisson rate.

3. PROBLEMS IN ONE DIMENSION

Introduction / Real body and model / Connectivity of the model / Degrees of freedom / Modal connectivity / Overall and local coordinates / Internal displacements of a finite element / Interpolation functions / Deformations in finite elements / Stresses / Nodal loads / Elastic energy (simple traction) / Stiffness matrix / Equation of rigidity / Effect of temperature.

4. **TRUSSES**
   Introduction / Trusses in two dimensions / Nodal degrees of freedom / Systems of coordinates and directors cosines / Transformations of rotation / Matrix of rigidity / Stresses on single members of truss / Trusses in three dimensions / Nodal degrees of freedom / Systems of coordinates and a directors cosines / Transformations of rotation / Matrix of rigidity / Stresses on single members of a truss / Effect of temperature / Application problems.

5. **BEAMS**
   General considerations / Elastic energy / Modeling of beam / Interpretation of nodal degrees of freedom / Hermite functions / Transformation of the gradient / Deformation in a finite element / Deformed model / Stiffness matrix / Equation of rigidity / Distributed loads on a beam / Nodal loads in the model / Shearing force and bending torque / Normal and shearing stresses in a beam / Application problems.

6. **STRUCTURES WITH NON-ARTICULATED NODES**
   Introduction / Nodal degrees of freedom / Systems of coordinates and director cosines / Transformation of rotation / Effects overlaying (traction and bending) / Stiffness matrix / Overall matrix of rigidity / Load vector / Equation of rigidity / Stress in structure components / Application problems.

V. PRACTICAL EXPERIENCE

Practice 1: Solving problems of forces, external displacements, deformation and stresses.
Practice 2: Traction in one dimension.
Practice 3: Traction with thermal deformation.
Practice 4: Trusses in two dimensions.
Practice 5: Trusses in three dimensions.
Practice 6: Beams.
Practice 7: Structures with non-articulated nodes.

VI. METHODOLOGY

The course takes place in theory and practice sessions. In theory sessions faculty presents the theory, concepts and methods. In practice sessions, students apply finite element analysis to real engineering problems using specialized simulation software as SolidWorks and ANSYS, also use numerical calculation software as MATLAB. At the end of the course, students submit and defend a final report. Student active participation is promoted throughout the course.

VII. GRADING FORMULA

The Final Grade PF is calculated as follow:

PF = (EP + EF + 2*PP) / 4

EP: Mid-term Exam EF: Final Exam
PP: Average of practice grades.

VIII. BIBLIOGRAPHY

1. CHANDRUPATLA, T.
   Introduction to the Study of the Finite Elements for Engineering, Prentice Hall, 2009.