

Chapter 1

- 1.1. A finite element is a small body or unit interconnected to other units to model a larger structure or system.
- 1.2. Discretization means dividing the body (system) into an equivalent system of finite elements with associated nodes and elements.
- 1.3. The modern development of the finite element method began in 1941 with the work of Hrennikoff in the field of structural engineering.
- 1.4. The direct stiffness method was introduced in 1941 by Hrennikoff. However, it was not commonly known as the direct stiffness method until 1956.
- 1.5. A matrix is a rectangular array of quantities arranged in rows and columns that is often used to aid in expressing and solving a system of algebraic equations.
- 1.6. As computer developed it made possible to solve thousands of equations in a matter of minutes.
- 1.7. The following are the general steps of the finite element method.
 - Step 1
Divide the body into an equivalent system of finite elements with associated nodes and choose the most appropriate element type.
 - Step 2
Choose a displacement function within each element.
 - Step 3
Relate the stresses to the strains through the stress/strain law—generally called the constitutive law.
 - Step 4
Derive the element stiffness matrix and equations. Use the direct equilibrium method, a work or energy method, or a method of weighted residuals to relate the nodal forces to nodal displacements.
 - Step 5
Assemble the element equations to obtain the global or total equations and introduce boundary conditions.
 - Step 6
Solve for the unknown degrees of freedom (or generalized displacements).
 - Step 7
Solve for the element strains and stresses.
 - Step 8
Interpret and analyze the results for use in the design/analysis process.
- 1.8. The displacement method assumes displacements of the nodes as the unknowns of the problem. The problem is formulated such that a set of simultaneous equations is solved for nodal displacements.
- 1.9. Four common types of elements are: simple line elements, simple two-dimensional elements, simple three-dimensional elements, and simple axisymmetric elements.
- 1.10. Three common methods used to derive the element stiffness matrix and equations are
 - (1) direct equilibrium method
 - (2) work or energy methods
 - (3) methods of weighted residuals
- 1.11. The term ‘degrees of freedom’ refers to rotations and displacements that are associated with each node.

1.12. Five typical areas where the finite element is applied are as follows.

- (1) Structural/stress analysis
- (2) Heat transfer analysis
- (3) Fluid flow analysis
- (4) Electric or magnetic potential distribution analysis
- (5) Biomechanical engineering

1.13. Five advantages of the finite element method are the ability to

- (1) Model irregularly shaped bodies quite easily
- (2) Handle general load conditions without difficulty
- (3) Model bodies composed of several different materials because element equations are evaluated individually
- (4) Handle unlimited numbers and kinds of boundary conditions
- (5) Vary the size of the elements to make it possible to use small elements where necessary