SNS COLLEGE OF TECHNOLOGY

Coimbatore-35

(An Autonomous Institution)

Accredited by NBA – AICTE and Accredited by NAAC – UGC with ‘A+’ Grade

Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF MECHANICAL ENGINEERING

Finite Element Analysis

IV Year VII Sem

Unit I Introduction

Topic – Advantages, limitations and applications of FEA

SNS *Design Thinkers*

Dr.M.SUBRAMANIAN, ***Professor /Mechanical Engineering***

Advantages, limitations and applications of FEA

Engineering Applications of the Finite Element Method

Area of Study	Equilibrium Problems	Eigenvalue Problems	Propagation Problems
1. Civil engineering structures	Static analysis of trusses, frames, folded plates, shell roofs, shear walls, bridges, and prestressed concrete structures	Natural frequencies and modes of structures; stability of structures	Propagation of stress waves; response of structures to aperiodic loads
2. Aircraft structures	Static analysis of aircraft wings, fuselages, fins, rockets, spacecraft, and missile structures	Natural frequencies, flutter, and stability of aircraft, rocket, spacecraft, and missile structures	Response of aircraft structures to random loads, and dynamic response of aircraft and spacecraft to aperiodic loads
3. Heat conduction	Steady-state temperature distribution in solids and fluids	—	Transient heat flow in rocket nozzles, internal combustion engines, turbine blades, fins, and building structures
4. Geomechanics	Analysis of excavations, retaining walls, underground openings, rock joints, and soil—structure interaction problems; stress analysis in soils, dams, layered piles, and machine foundations	Natural frequencies and modes of dam—reservoir systems and soil—structure interaction problems	Time-dependent soil—structure interaction problems; transient seepage in soils and rocks; stress wave propagation in soils and rocks

Engineering Applications of the Finite Element Method

Area of Study	Equilibrium Problems	Eigenvalue Problems	Propagation Problems
5. Hydraulic and water resources engineering; hydrodynamics	Analysis of potential flows, free surface flows, boundary layer flows, viscous flows, transonic aerodynamic problems; analysis of hydraulic structures and dams	Natural periods and modes of shallow basins, lakes, and harbors; sloshing of liquids in rigid and flexible containers	Analysis of unsteady fluid flow and wave propagation problems; transient seepage in aquifers and porous media; rarefied gas dynamics; magnetohydrodynamic flows
6. Nuclear engineering	Analysis of nuclear pressure vessels and containment structures; steady-state temperature distribution in reactor components	Natural frequencies and stability of containment structures; neutron flux distribution	Response of reactor containment structures to dynamic loads; unsteady temperature distribution in reactor components; thermal and viscoelastic analysis of reactor structures
7. Biomedical engineering	Stress analysis of eyeballs, bones, and teeth; load-bearing capacity of implant and prosthetic systems; mechanics of heart valves	—	Impact analysis of skull; dynamics of anatomical structures

Advantages, limitations and applications of FEA

Engineering Applications of the Finite Element Method

Area of Study	Equilibrium Problems	Eigenvalue Problems	Propagation Problems
8. Mechanical design	Stress concentration problems; stress analysis of pressure vessels, pistons, composite materials, linkages, and gears	Natural frequencies and stability of linkages, gears, and machine tools	Crack and fracture problems under dynamic loads
9. Electrical machines and electromagnetics	Steady-state analysis of synchronous and induction machines, eddy current, and core losses in electric machines, magnetostatics	—	Transient behavior of electromechanical devices such as motors and actuators, magnetodynamics

Advantages of the FEM

Can readily handle very complex geometry:
- The heart and power of the FEM

Can handle a wide variety of engineering problems
- Solid mechanics
- Dynamics
- Heat problems
- Fluids
- Electrostatic problems

Can handle complex restraints
- Indeterminate structures can be solved.

Can handle complex loading
- Nodal load (point loads)
- Element load (pressure, thermal, inertial forces)
- Time or frequency dependent loading

Advantages of the FEM

- Irregular Boundaries
- General Loads
- Different Materials
- Boundary Conditions
- Variable Element Size
- Easy Modification
- Dynamics
- Nonlinear Problems (Geometric or Material)

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Disadvantages of the FEM

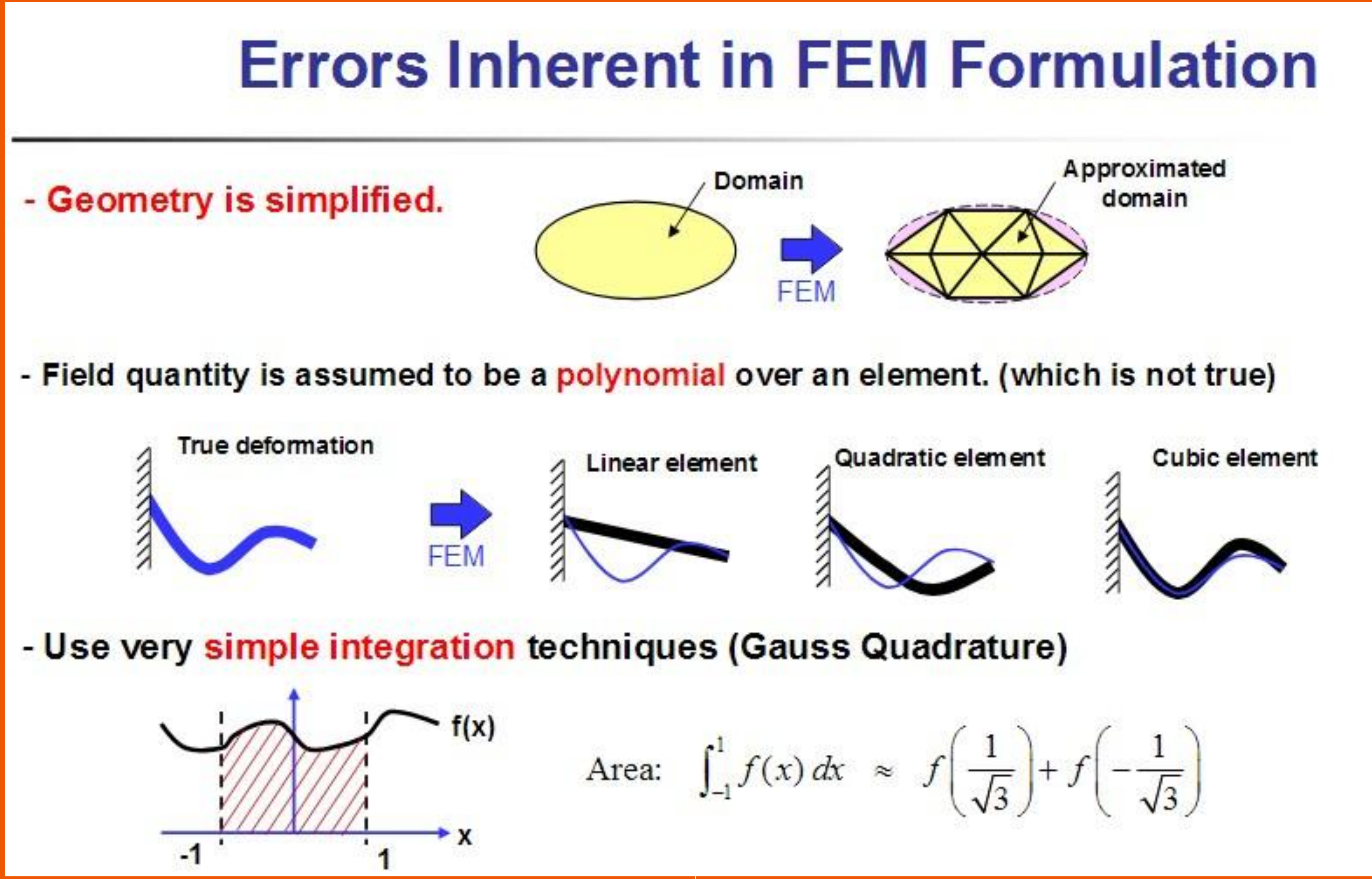
A general closed-form solution, which would permit one to examine system response to changes in various parameters, is not produced.

The FEM obtains only "approximate" solutions.

The FEM has "inherent" errors.

Mistakes by users can be fatal.

Disadvantages of the FEM



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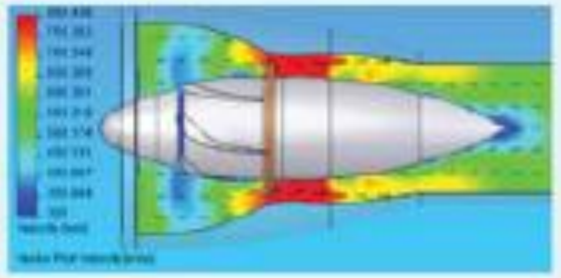
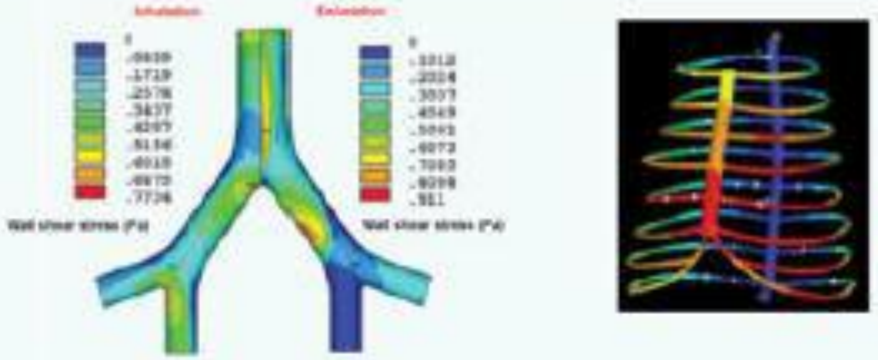
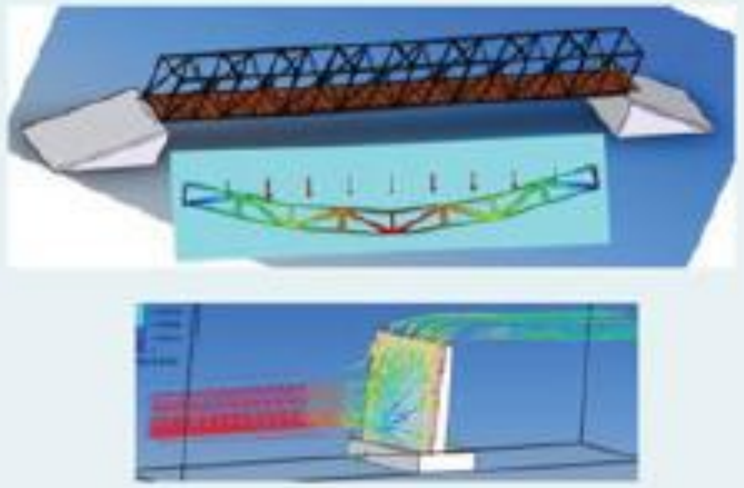
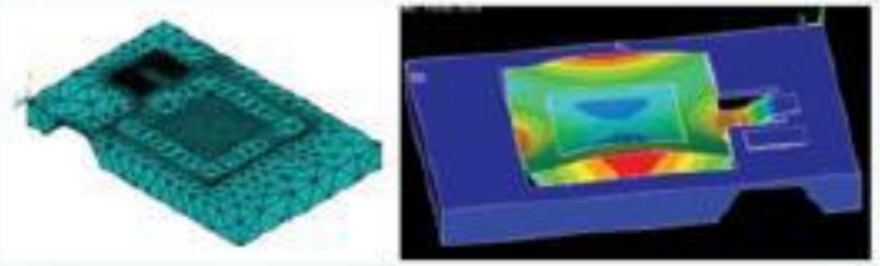
Advantages, limitations and applications of FEA

Discipline	Example
Aerospace Engineering	
Biomedical Engineering	
Civil Engineering	
Mechanical/Electrical Engineering	

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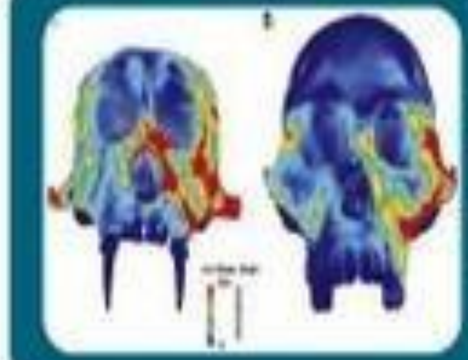
Areas of applications

Engineering

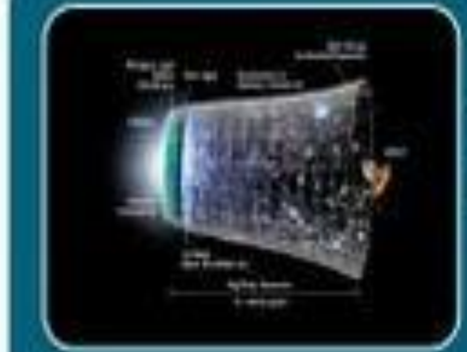
- Fluid mechanics
- Thermodynamics
- Metal Forming etc

Biological Sciences



- Botany
- Zoology
- Archeological Anthropology
- Paleontology

General application



- Geology
- Astrophysics

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Advantages, limitations and applications of FEA

Finite element solution errors

Error	Error occurrence in
Discretization	Use of finite element interpolations for geometry and solution variables
Numerical integration in space	Evaluation of finite element matrices using numerical integration
Evaluation of constitutive relations	Use of nonlinear material models
Solution of dynamic equilibrium equations	Direct time integration, mode superposition
Solution of finite element equations by iteration	Gauss-Seidel, conjugate gradient, Newton-Raphson, quasi-Newton methods, eigensolutions
Round-off	Setting up equations and their solution

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Check Google classroom for a Lecture material

Thank you

SOURCE: CENTERS FOR DISEASE CONTROL AND PREVENTION