Centurion University of Technology and Management PKD campus

Workshop on Simulation Techniques for FEM/FVM cases

RESOURCE PERSON

Rakesh Kumar Sharma

Co Founder - Perfectice Eduventure Pvt. Ltd.

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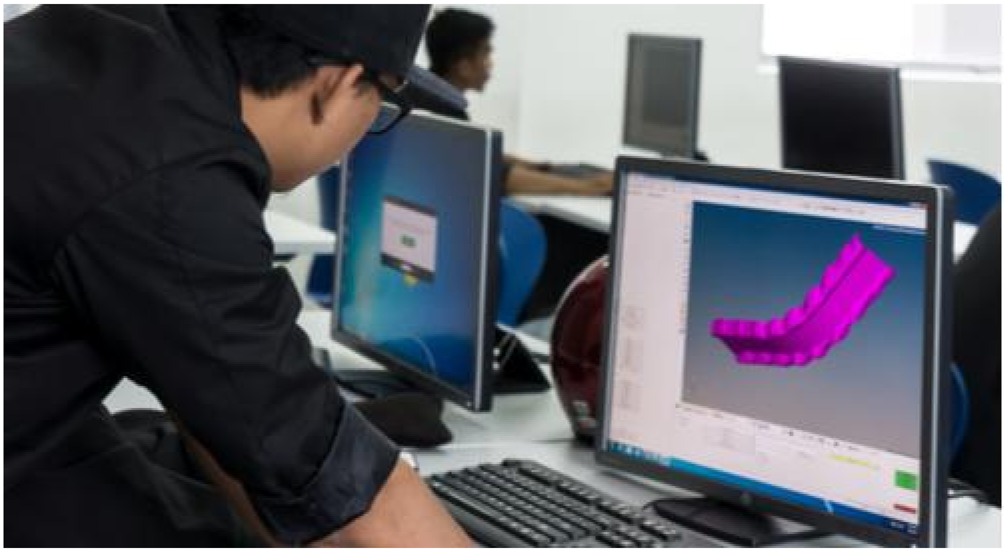
The finite element method (FEM) is a systematic numerical method for solving problems of engineering and mathematical physics, more specifically PDEs. The FEM generally addresses issues in heat transfer, structural analysis, fluid flow, electromagnetic potential, and mass transport. Also, the analytical nature of the solutions of these issues typically requires the solution to boundary value problems for PDEs.

Furthermore, the FEM formulation of the problem will result in a system of algebraic equations. The FEM also appraises the unknown function over the domain. Thus, to solve the problem, it subdivides a large system into smaller, simpler parts that are called finite elements. After which, these simple equations that model the finite elements are then compiled into a larger system of equations that models the entire problem. The FEM will then use variational methods from the calculus of variations to estimate a solution by minimizing a related error function.

Lately, the FEM is in use in applications for simulating quantum effects in low dimensional systems like carbon nanotubes, metallic nanoparticles, quantum wells, quantum dots, monolayer transition metal dichalcogenides, and artificial molecules.



What is the Finite Volume Method (FVM)?

The Finite volume method (FVM) is a widely used numerical technique. The fundamental conservation property of the FVM makes it the preferable method in comparison to the other methods, i.e., FEM, and finite difference method (FDM). Also, the FVM's approach is comparable to the known numerical methods like FEM and FDM, which means that its evaluation of volumes is at discrete places over a meshed geometry.

Furthermore, the FVM transforms the set of partial differential equations into a system of linear algebraic equations. Although the discrete approximation procedure in use in the FVM is distinctive, it also utilizes two basic steps. Firstly, it transforms and integrates the PDEs into balance equations over an element. The process incorporates the changing of the surface and volume integrals into discrete algebraic relations over elements as well as their surfaces using an integration quadrature of a specified order of accuracy. This will result in a set of semi-discrete equations.

Secondly, in this next step, the interpolation profiles are chosen to estimate the variation of the variables within the element and relate the surface values of the variables to their cell values and thus transform the algebraic relations into algebraic equations. In regards to the two steps in the FVM process, your approximation selection affects the overall accuracy of the subsequent numeric.

The Finite Element Method (FEM) vs. Finite Volume Method (FVM)

With FEM and FVM, both methods share some similarities, since they both represent a systematic numerical method for solving PDEs. However, one crucial difference is the ease of implementation. Among the majority of engineers, the prevailing opinion is that the FDM is the easiest to implement, while FEM is the most difficult, leaving FVM somewhere in the middle.

Finite Element Method

The finite element method (FEM) involves basically four steps:

(1) Discretize the solution region into a finite number of subregions or elements

(2) Derive the governing equations for each element based on either a variational approach or Galerkin's method

(3) Assemble all the elements together in the solution space.

(4) Solve the resulting system of equations

Finite Element Method

- Introduction
- General Principle
- Variational formulation
- Discretization
- Algorithm
- Examples

LIST OF PARTICIPANTS

1	Dr. Ashish Ranjan Dash	AOLPD8281M	Associate Professor
2	Ms. N. Jeebaratnam	AGMPN7728E	Assistant Professor
3	Mr. Sandipan Pine	BGGPP7516K	Associate Professor
4	Mr. Satyanarayan Padhy	ATUPP6339E	Assistant Professor
5	Mr. Rajesh Kumar Mishra	BAYPM4301H	Assistant Professor
6	Mr. Prabhat Kumar Patnaik	ARMPP6020C	Assistant Professor
7	Dr. Prafulla Kumar Panda	BBEPP6505R	Assistant Professor
8	Dr. Rajib Kumar Majhi	BZGPM8163G	Assistant Professor
9	Mr. Vishal Kumar Singh	EBOPS1024K	Assistant Professor
10	Dr. P. Srinivasa Rao	AHHPP2279E	Professor
11	Mr. Mir Sadat Ali	ALJPA3780D	Associate Professor
12	Dr. Vijay. Miditana	BCUPM8886R	Associate Professor
13	Dr. N. B. Karthik Babu	CRDPK2350K	Assistant Professor
14	Dr. Nagesh Kolagani	AGCPK7520P	Professor
15	Ms. A. Abhilasha	AQPPA2713B	Assistant Professor

Prof. KVD Prakash
Dean - IIE & HRD

Dr. Prasanta Ku. Mohanty
Dean Academic