PHYS 780

Nonlinear Finite Element Modeling and Simulation

Syllabus

Tuesdays 4:30 PM to 7:10 PM,
Exploratory Hall - Room 1004

Instructor: Professor Dhafer Marzougui
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Office Hours: Tuesdays 1:00 PM – 3:00 PM, or by appointment

COURSE DESCRIPTION AND OBJECTIVES:

Introduction to the use of non-linear finite element codes for impact dynamics and crash safety applications. Methods and techniques to model, simulate, and analyze different material behaviors, connections, boundary conditions, and contacts during impacts will be introduced. The course focuses on the application of LS-DYNA (an explicit finite element code) to address these topics. This course will equip students with necessary details to be a successful LS-DYNA FEA practitioner.

COURSE REQUIREMENTS (Including class attendance and participation, if required):

Recommended but not required: Background in the finite element method and continuum mechanics
Reference: LS-DYNA user manuals

Reference Textbook (recommended but not required):

1. Nonlinear Finite Elements for Continua and Structures, Ted Belytschko, Wing Kam Liu, Brian Moran

BASIS ON WHICH FINAL GRADES ARE DETERMINED:

Homework Assignments, Mid-Term, and Final Project.

		Suggested Reading:
Week 1	• Course Introduction and Outline • General FEA Process • LS-DYNA Background • Input Format (keyword) • Example of an Input Deck • Computer Session	Book 1: Chapter 1
Week 2	• Detailed Capabilities of Keyword Format • Explicit FEM Theory • Computer Session	Book 1: Chapter 2 Equilibrium conditions, Explicit time integration
Week 3	• Initial Conditions • Boundary Conditions • Loads • Rigid Walls • Constrains • Computer Session	Book 1: Chapter 3 Continuum mechanics
Week 4	• Time Integration • Time Step • Computer session	Book 1: Chapter 6 Solution methods & stability
Week 5	• Contacts Algorithms Types Guidelines • Computer Session	Book 1: Chapter 10 Contact-impact
Week 6	• Element Formulation Solid, Shell, Beam, Discrete • Hourglass Control • Computer Session	Book 1: Chapter 8 Element technology Chapter 9 Beams & Shells Appendix 3
Week 7	• Material Models Metals, Rubber, Foam • Rigid Bodies • Computer Session	Book 1: Chapter 5 Constitutive Models
Week 8	• Analysis Tools • Output Options • Quasi-static Analysis • Dynamic Relaxation • Damping • Restart	

Week 9	Introduction to Vehicle Crashworthiness • Vehicle safety standards • The automotive body Introduction to Pre-Processing (Part 1) • Basic functions of HyperMesh • Geometry cleanup to prepare for meshing • Mesh generation tools Finite Element Model • Commonly used material models • Frame rail (car and truck) • Mechanical Components • Bumpers and doors	
Week 10	Mesh Quality • Meshing and quality of FE mesh • Structure fasteners (spot weld, joints, door hinges, etc.) • Element selection • Time step control techniques, energy calculation and time history • Material models • Metals, Foam, Honeycomb, special materials (interior trim, door trim, etc.) Introduction to Pre-Processing (Part 2) • Solver specific operations (control cards, time history output, etc.) • Defining element and material properties • Defining Boundary conditions	
Week 11	Advanced Pre-Processing • Applying boundary conditions • Exporting and importing LS-DYNA input files • Combining FE models	
Week 12	Finite Element Model • FE model setup for data analysis • Data collection techniques Advanced Pre-Processing • Front impact model setup • Side impact model setup • Rear impact model setup	
Week 13	Data Analysis • Understanding full-scale test data • Analyzing full-scale test data Post Processing (HyperGraph) • Video data for full-scale test and simulation • Time history plot for full-scale test and simulation • Data manipulation	