FEA ACADEMY

ON-DEMAND ONLINE COURSE

Practical Basic Finite Element Analysis

Master the universal FEA modeling techniques with two industry specialists, at your own pace.

17 lectures | 14 FEA workflows | 20 hours | On-demand

In partnership with EVOTECH Computer-Aided Engineering Ltd

www.fea-academy.com

COURSE OBJECTIVES

What this course gives you

The best practical methods

To offer the best practical methods and guidelines for the development and validation of finite element models in solid mechanics and structural analysis.

Accurate, reliable models

To give mechanical and structural engineers the keys to developing accurate and reliable finite element models, by avoiding the most frequent errors.

Software-agnostic: the modeling techniques apply whatever FEA software you use.

WHY THIS COURSE

Learning FEA is a lot more than learning software

It is also about learning the good modeling practices and methods.

This course will deliver the real and practical knowledge that you need for your day-to-day work with FEA.

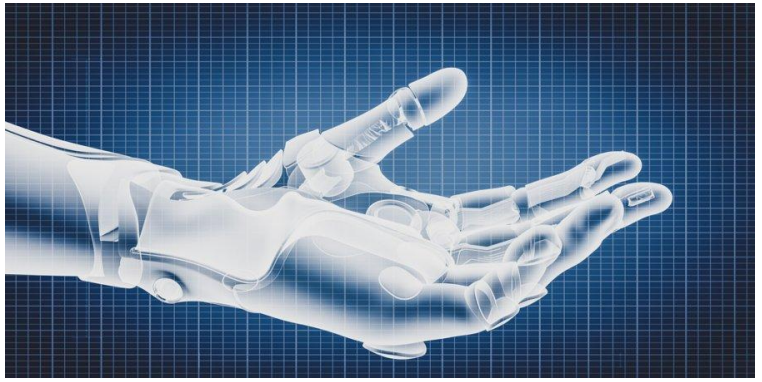
EXPAND YOUR CAREER HORIZONS

Unlock the power of FEA and excel in engineering

Gain an edge with comprehensive FEA training

Learning FEA in detail opens doors to expanded career opportunities and sets you apart.

Master good modeling practices and take your engineering skills to new heights.



Boost your versatility and conquer diverse projects

FEA is incredibly flexible: apply it in many industries and projects.

Become an engineering virtuoso, ready to navigate any challenge with confidence.

Join an inspiring community of FEA enthusiasts

Enroll in FEA Academy's courses and access a network of like-minded engineers.

Collaborate, share ideas and connect with instructors and fellow engineers.

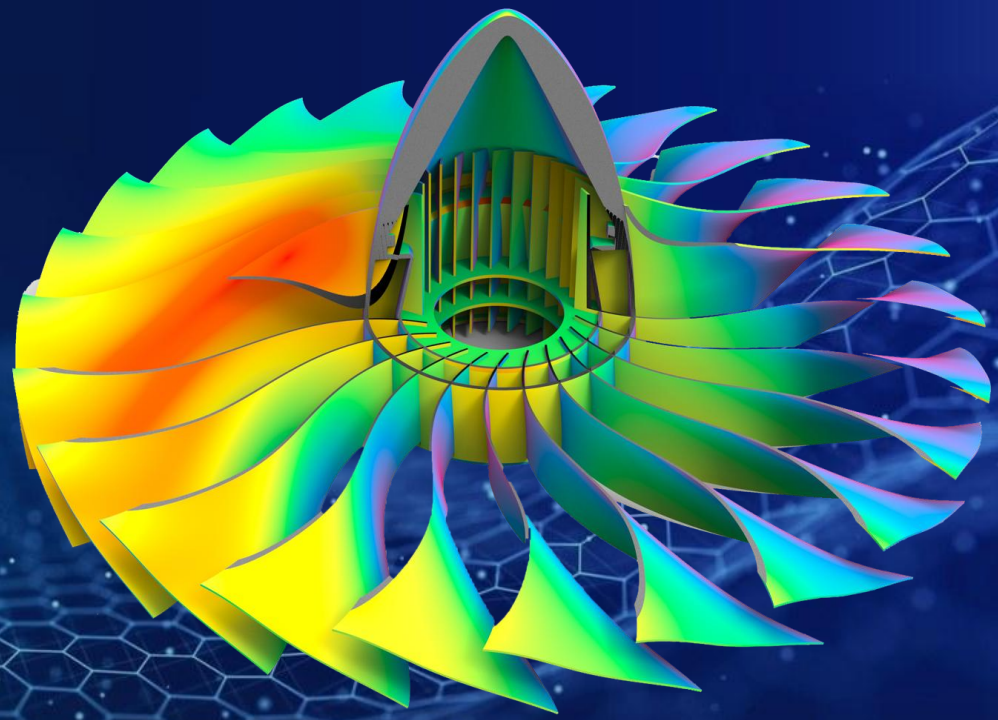
STRUCTURE OF THE COURSE

An on-demand course you follow at your own pace

31 on-demand videos

20 hours of learning

24/7 access to the virtual classroom: watch the videos at your own pace



TWO COMPLEMENTARY PARTS

The methods, then the workflows in the software

THEORY & CONCEPTS

Modeling Techniques

Methods, guidelines and examples

by Dominique Madier

17 videos **15 hours**

EXAMPLES

FEA Workflow Examples

Examples showing FEA workflows

by Dr. Steffan Evans, Evotech CAE

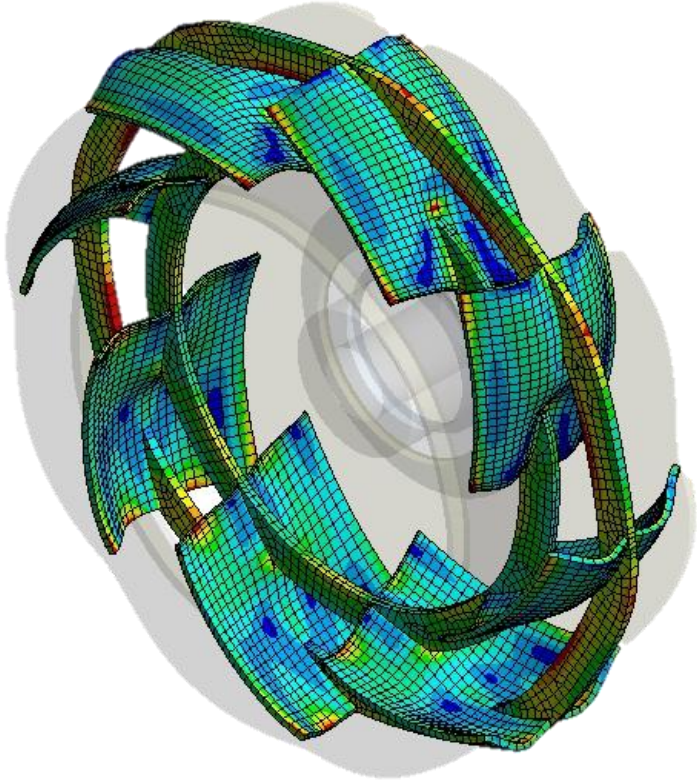
14 videos **5 hours**

PREREQUISITES

What you need before you start

- A robust general physics background.
- A review of university-level solid mechanics, statics and strength of materials is recommended.

Because learning FEA is a lot more than learning software: it is also about learning the good modeling practices and methods.

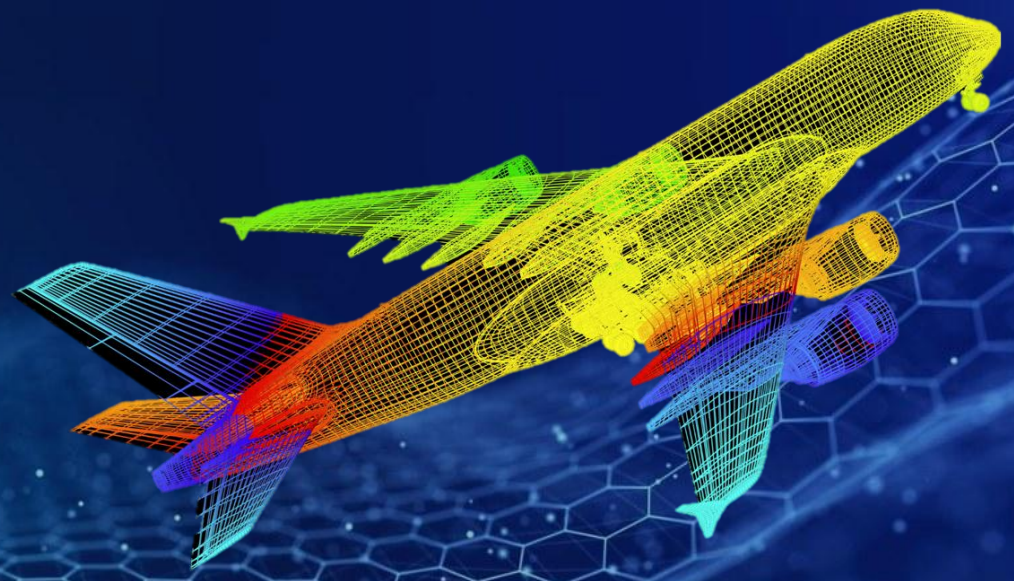


THE OUTCOME

Perform your day-to-day FEA with confidence

This course will permit you to perform your analysis for your **day-to-day work in FEA.**

You will understand FEA in detail and you will **have confidence in your results.**



THE BENEFITS

Expand your career and your versatility

Expand your career opportunities

Learning FEA in detail expands your career opportunities and gives you an edge over engineers who don't know the good modeling practices.

Improve your versatility

FEA is so flexible that it can be used in many applications. An engineer with a very good knowledge of FEA is much more versatile than one who does not know it well.

Since the modeling techniques are universal, mastering FEA lets you work in many industries and on diverse projects.

WHAT YOU GET

Everything included in the course

17 lectures (15 hours)

A complete program teaching the universal FEA modeling techniques, with the best practical methods, guidelines and examples.

14 FEA workflows (5 hours)

Software examples showing particular FEA workflows, to augment your learning experience.

Many simple examples

Every modeling technique is illustrated with simple examples, so you understand each FEA concept in detail.

On-demand course

Learn at your own pace. Access the virtual classroom 24/7 from anywhere; you only need an internet connection.

Unlimited access

Unlimited access to the FEA Academy virtual classroom, to revisit the lectures for your day-to-day work.

Keep track of your knowledge

A PDF file of 210 questions on the lectures, and a quiz after each lecture to validate your knowledge.

Download 1,000+ slides

Download the PDF slides of all 17 lectures.

Geometric and simulation files

Geometry in Parasolid, STEP and IGES formats, and the simulation files of the examples (150+ files).

Q&A with the instructors

Your instructors answer your questions during the course, to help you build a strong FEA knowledge.

COURSE CONTENT · THEORY & CONCEPTS

Modeling Techniques

Methods, guidelines and examples by Dominique Madier

17 lectures

15 hours

Dominique Madier
FEA ANALYST

FEA ACADEMY

www.fea-academy.com

LECTURE

1

20 minutes

Modeling Techniques · Concepts & Guidelines

FEA ACADEMY

LECTURE 1 OF 17

What is Finite Element Analysis (FEA)?

- Methods for Solving an Engineering Problem
- The Different Numerical Methods
- Introduction to Partial Differential Equations
- So, What is FEA?

LECTURE

2

20 minutes

Modeling Techniques · Concepts & Guidelines

LECTURE 2 OF 17

Working with FEA in Mechanical and Structural Analysis

- How Can FEA Help You?
- The FEA Process
- Capabilities of FEA Software
- How Accurate is FEA?
- Why Do FEA?
- What is Needed to Perform an FEA Simulation?

LECTURE

3

25 minutes

Modeling Techniques · Concepts & Guidelines

FEA ACADEMY

LECTURE 3 OF 17

How to Learn FEA

- The Three Stages of the FEA Learning Process
- The Main Rule of FEA Learning
- What is the Main Danger of FEA?
- What Do You Need to Learn in the FEA Field?
- My 10 Guidelines for FEA Learning
- The Five Advantages of Learning FEA

LECTURE

4

25 minutes

Modeling Techniques · Concepts & Guidelines

LECTURE 4 OF 17

Defining Your FEA Strategy

- The 10 Steps to Follow to Build an FEA Strategy
- The 14 Questions to Ask Before You Start Modeling

LECTURE

5

1 hour 15 minutes

Modeling Techniques · Concepts & Guidelines

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LECTURE 5 OF 17

The Basis of FEM Theory

- The Equilibrium Equation
- The Displacement Method
- What is a Degree of Freedom?
- What is a Shape Function?
- What is the Stiffness Matrix?
- Element Stiffness Matrices for Various Topologies
  - 1D Truss Element
  - 1D Beam Element
  - 2D Elements
  - 3D Solid Elements
- How is the Global Stiffness Matrix of the Complete Problem Assembled?
- How are the FEM Equations Solved?

LECTURE

6

1 hour 45 minutes

Modeling Techniques · Concepts & Guidelines

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LECTURE 6 OF 17

The Library of Elements

- Types of Elements Used in FEA
  - The Basic Building Blocks
  - The 1D Truss Element
  - The 1D Beam Element
  - The 1D Spring Element
  - The 2D Shell Element
  - The 3D Solid Elements
  - Special Elements
- Geometry, Size and Shape
- Linear vs Quadratic Elements
- Element Selection Criteria
- How to Choose the Right Element
- Integration Schemes
- Shear Locking: What is it and How to Prevent it?

LECTURE

7

1 hour 40 minutes

Modeling Techniques · Concepts & Guidelines

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LECTURE 7 OF 17

Meshing

- Plan the Meshing
- Define the Element Size
- Mesh Refinement (Why and How)
  - Why Refine the Mesh
  - The Mesh Refinement Process
  - Advantages and Disadvantages
  - Mesh Refinement Techniques
  - Convergence Study Methodology
- 1D Meshing Rules
- 2D Meshing Rules
- 3D Meshing Rules
- Physical Interfaces and Mesh Transition
- Various Recommendations for Meshing

LECTURE

8

1 hour 20 minutes

Modeling Techniques · Concepts & Guidelines

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LECTURE 8 OF 17

Defining Loads and Boundary Conditions

- What is a Boundary Condition?
- Why Do You Need Boundary Conditions?
- The Different Types of Boundary Conditions
- How to Constrain a Model
- Influence of Boundary Conditions
- Strategy to Define Boundary Conditions
- How to Create Isostatic Restraints
- Over-Stiffening and Under-Stiffening Problems
- About Singularities
- Types of Loading

LECTURE

9

1 hour

Modeling Techniques · Concepts & Guidelines

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LECTURE 9 OF 17

Rigid Body Elements and Multi-Point Constraints

- Terminology
- Why Use Rigid Elements
- Rigid Body Elements (RBE)
- Constraint Elements (MPC)
- Examples of RBE and MPC Usage

LECTURE

10

1 hour 15 minutes

Modeling Techniques · Concepts & Guidelines

LECTURE 10 OF 17

Modeling Bolted Joints

- Bolt Behaviors
- Do You Really Need to Model the Bolts?
- Fasteners Modeled with Rigid Elements
- Fasteners Modeled with 1D Spring Elements
- Fasteners Modeled with Beam Elements
- Fastener Stiffness Calculation
- How to Connect the Fasteners to the Surrounding Mesh?
- How to Capture the Prying Effect with 1D Spring Elements?
- Modeling the Bolt Preload

LECTURE

11

20 minutes

Modeling Techniques · Concepts & Guidelines

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LECTURE 11 OF 17

Submodeling

- What is Submodeling?
- Why Do Submodeling?
- How to Do Submodeling
  - Submodel a Global FEM
  - Extract a Part of the Global FEM
  - Examples
- Tips and Hints for Submodeling

LECTURE

12

1 hour

Modeling Techniques · Concepts & Guidelines

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LECTURE 12 OF 17

Verify and Validate Your FEA

- What is Verification and Validation?
- Accuracy Checks
- Mathematical Checks
- Examples
- Correlation
- My Checklist

LECTURE

13

1 hour 30 minutes

Modeling Techniques · Concepts & Guidelines

FEA ACADEMY

LECTURE 13 OF 17

Understanding FEM Outputs

- Standard Outputs
  - Deformations
  - Element Forces
  - Free-Body Diagram
  - Stresses
- The Basic Rules of Post-Processing
- How to Deal with Singularities in Stress Models

LECTURE

14

30 minutes

Modeling Techniques · Concepts & Guidelines

BASIC FEA SOLUTIONS IN SOLID MECHANICS

Linear Static Analysis

- What is Linear Static Analysis?
- How to Solve a Linear Static Problem?
- Characteristics of a Linear Static Analysis
- Examples

LECTURE

15

45 minutes

Modeling Techniques · Concepts & Guidelines

FEA ACADEMY

BASIC FEA SOLUTIONS IN SOLID MECHANICS

Linear Buckling Analysis

- What is Linear Buckling Analysis?
- Assumptions and Limitations of LBA
- The LBA Outcomes
- How Does an FE Solver Compute LBA Problems?
- Linear Buckling Strategy
- Examples

LECTURE

16

45 minutes

Modeling Techniques · Concepts & Guidelines

BASIC FEA SOLUTIONS IN SOLID MECHANICS

Normal Mode Analysis

- Introduction to Modal Analysis
- The Eigen Equation
- Numerical Methods for Solving the Eigen Equation
- What a Mode is and What a Mode is Not
- How are Natural Frequencies and Mode Shapes Influenced?
- Why Compute a Modal Analysis?
- Influence of Pre-Stiffness on the Natural Frequencies
- Examples

LECTURE

17

10 minutes

Modeling Techniques · Concepts & Guidelines

How to Choose the Right Solution?

- Should I Run a Static or a Dynamic Solution?
- Should I Run a Linear or a Nonlinear Solution?
- Should I Run a Buckling Solution?
- Should I Run a Normal Mode Solution?

COURSE CONTENT · EXAMPLES

FEA Workflow Examples

by Dr. Steffan Evans

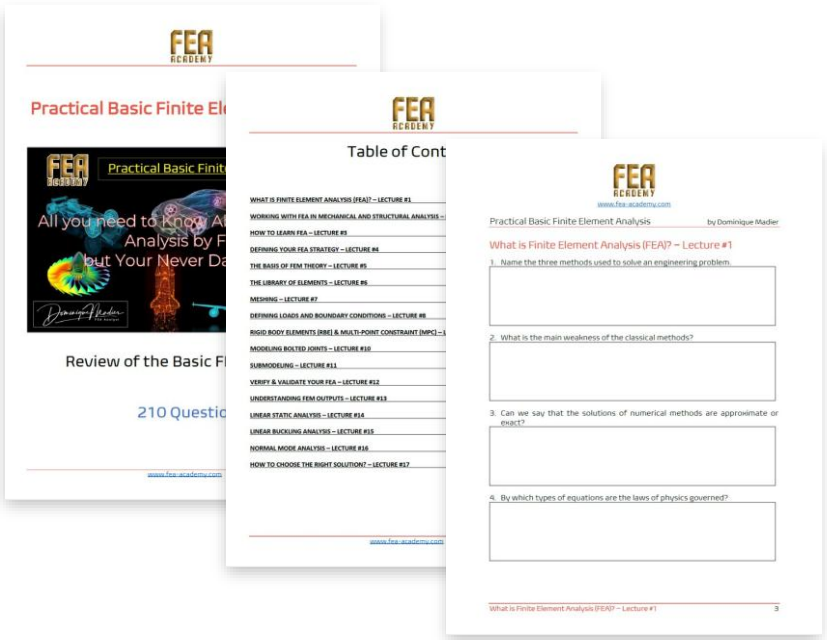
Evotech CAE Ltd.

14 videos **5 hours**

Topic	Workflow videos	Duration
Meshing	1D, 2D, 3D Meshing, Refinement, Convergence	**1 h 30**
Loads and Boundary Conditions	Boundary Conditions, Loading	**50 min**
RBEs and MPCs	RBEs Application	**10 min**
Modeling Bolted Joints	Joints Example	**25 min**
Submodeling	Submodeling Application	**35 min**
Understanding FEM Outputs	Typical Post-Processing	**40 min**
Linear Static Analysis	Modeling a Stiffened Panel	**30 min**
Linear Buckling Analysis	A Complete Linear Buckling Workflow	**10 min**
Normal Mode Analysis	Capturing Natural Frequencies	**10 min**

KEEP TRACK OF YOUR KNOWLEDGE

Review, test and validate what you learn



210 review questions

Download our PDF document with 210 questions to review your knowledge of each lecture.

All the answers

Download the PDF document with all the answers, to check yourself.

A quiz after each lecture

Test yourself by answering the quiz after each lecture in the FEA Academy learning platform.

SUPPORTING FILES

Download everything from the virtual classroom

17

PDF files of the lectures

1,000+

lecture slides

150+

modeling files

Nastran model files of the lecture examples (convertible to any FEA package format).

Geometric files to replicate the lecture and FEA workflow examples, in three formats:

- **Parasolid (.x_t)**
- **STEP (.stp)**
- **IGES (.igs)**

YOUR INSTRUCTOR FOR “MODELING TECHNIQUES”

Dominique Madier

FEA Analyst · Trainer · Book Author · Speaker

Founder and Director of FEA Academy and Simulation Experts

dominique.madier@fea-academy.com

- Senior FEA consultant, trainer and coach with 25+ years of experience in FEA.
- Advanced expertise in static and dynamic FEA of linear and nonlinear structural behaviors, on aerospace metallic and composite structures: fuselage, wing, empennage, nacelle, engine pylon and systems.
- Detailed finite element analyses for aerospace companies in Europe and North America: Airbus, Dassault Aviation, Safran, Latécoère, Bell Helicopter, Bombardier Aerospace, Pratt & Whitney Canada, Beta Technologies and their engineering partners.
- Author of “Practical Finite Element Analysis for Mechanical Engineers” and “Harness the Power of FEA”.

YOUR INSTRUCTOR FOR “FEA WORKFLOWS”

Dr. Steffan Evans

FEA Analyst and Trainer · “The Apex Guy”
Director of Evotech CAE Ltd.

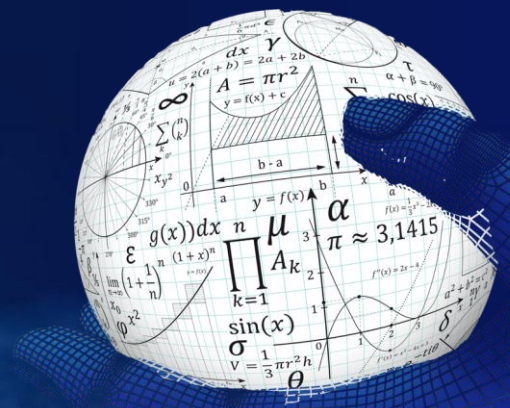
info@evotechcae.com

- Doctor of Engineering in Multi-Parameter Structural Optimization.
- Chartered Mechanical Engineer (UK) and NAFEMS Certified Professional Simulation Engineer at Advanced Level.
- 20 years in the Airbus / BAE Systems supply chain, in strategic FEA development, analysis and verification.
- Runs Evotech CAE Ltd., an engineered product consultancy in CAE, FEA and design optimization, partnered with MSC Software for training and technical resales.

QUESTIONS AND ANSWERS

Ask your questions, get answers from the instructors

Ask your questions in the **Discussion** section available with each lecture in the FEA Academy virtual classroom.

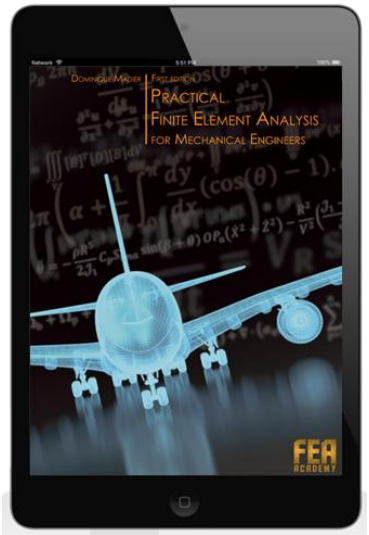


Dominique Madier
FEA ANALYST

FEA Consultant · Book Author · FEA Trainer · Speaker
Helping engineers and students to learn FEA

THE BOOK BEHIND THE COURSE

Practical Finite Element Analysis for Mechanical Engineers



650+ pages
of FEA best practical methods and guidelines

100+ examples
illustrating every modeling concept

Hardcover and eBook
available in the FEA Academy Book Store

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