

Practical Nonlinear Finite Element Analysis



ON-DEMAND
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#BEYONDTHE SOFTWARE
Because the Real World is Nonlinear

FEA
ACADEMY

PRACTICAL **NONLINEAR** FINITE ELEMENT ANALYSIS

15 Lectures

17 FEA Workflows

Methods & Guidelines

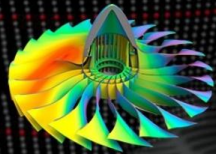
12 Hours Total

STREAMLINE
ON DEMAND

LEARN AT YOUR OWN PACE

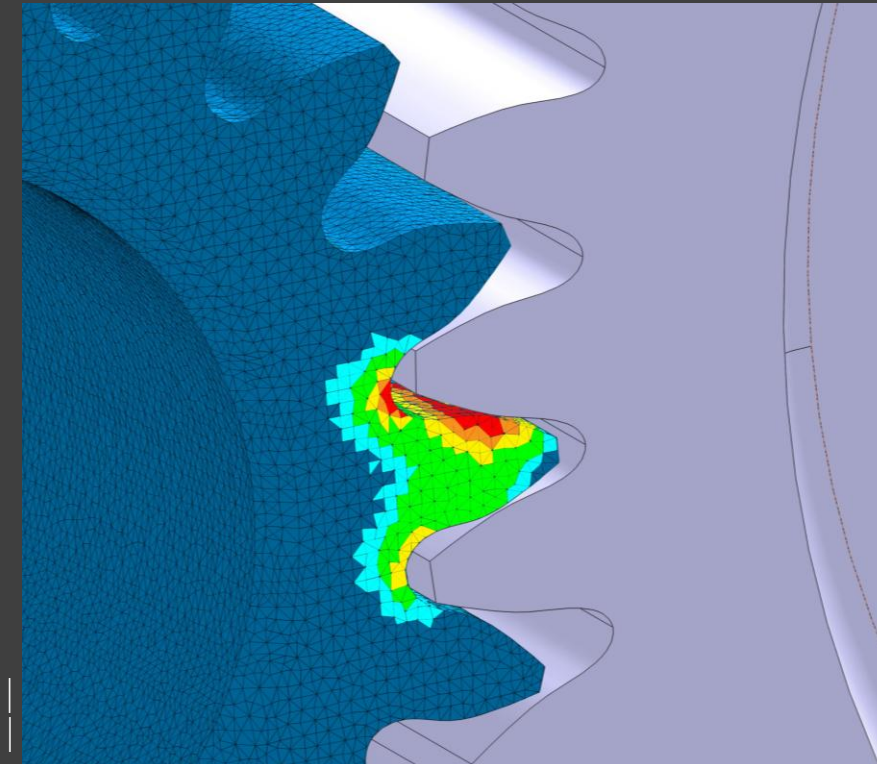
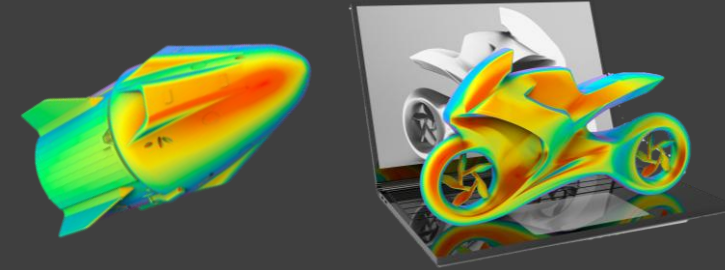


I'm Your Host
Dominique Madier



Elevate your knowledge of FEA
TO THE NEXT LEVEL

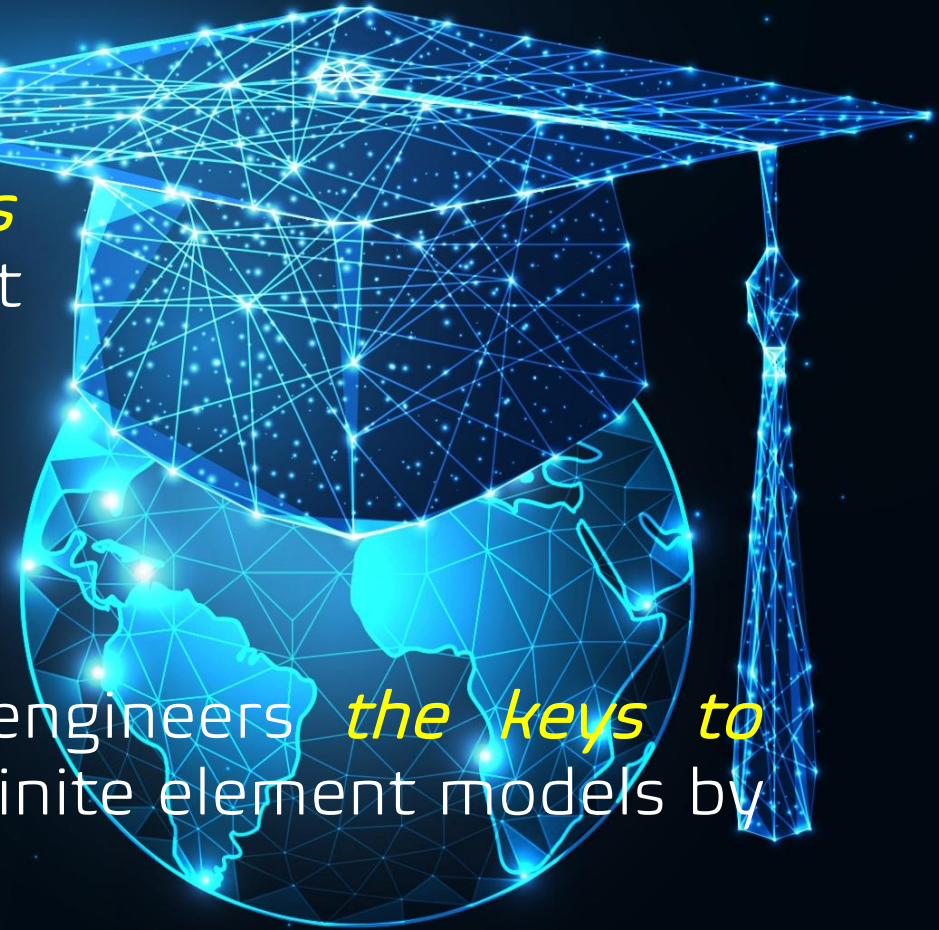
Dominique Madier
FEA Analyst

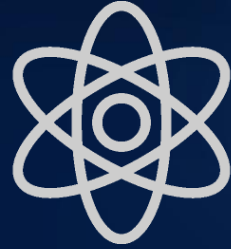


| FEA Consultant | FEA Trainer | Book Author |
| Helping Engineers and Students to Learn FEA |

Course objectives:

- To offer *the best practical methods and guidelines* for the development and validation of finite element models in solid mechanics and structural analysis *for nonlinear behaviors*.
- To give mechanical structural engineers *the keys to developing* accurate and reliable finite element models by avoiding the most frequent errors.





Because learning FEA is a lot more than just learning a software
It is also about learning the good modeling practices and methods

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



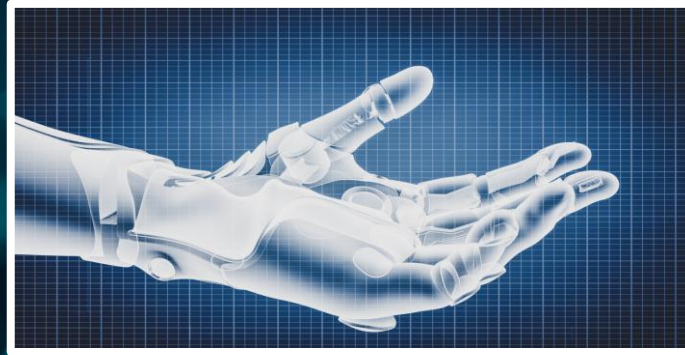
Expand Your Career Horizons: Unlock the Power of FEA to Excel in Engineering



Gain an Edge with Comprehensive FEA Training

LEARNING FEA in Detail Opens Doors to Expanded Career Opportunities and Sets You Apart from the Rest.

MASTER Good Modeling Practices and Propel Your Engineering Skills to New Heights



Boost Your Versatility to Conquer Diverse Projects

FEA is Incredibly Flexible, Enabling Its Application in Various Industries and Projects.

BECOME an Engineering Virtuoso, Navigating Any Challenge with Confidence.



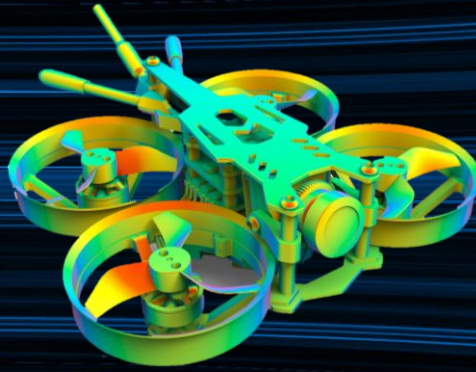
Join an Inspiring Community of FEA Enthusiasts

ENROLL in FEA Academy's Courses and Access a Vibrant Network of Like-Minded Engineers.

COLLABORATE, Share Ideas, and Forge Connections with Instructors and Fellow Students/Engineers.



Structure of the Course



32 On-Demand Videos



12 Hours



Watch the Videos at
Your Own Pace



"Examples showing FEA workflow"

by Steffan Evans
17 FEA Workflows
5 hours

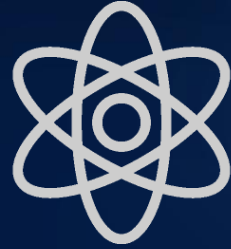
"Modeling Techniques"

Methods, Guidelines & Examples
by Dominique Madier
15 Lectures
7 hours


FEA Analyst



EVOTECH
Computer-Aided Engineering Ltd



Because learning FEA is a lot more than just learning a software
It is also about learning the good modeling practices and methods

What is the prerequisite to attend the course?

- ✓ A robust general physics background.
- ✓ A basic knowledge of FEA,
- ✓ A review of university-level in solid mechanics, statics & strength of materials is recommended.

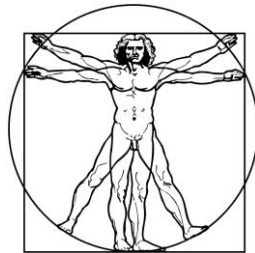
This course will permit you to perform your analysis
for your day-to-day work in FEA.

With this course, you will understand FEA in detail
and you will **have confidence in your results**.



Expand Your Career Opportunities

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



Improve Your Versatility

FEA is so flexible that it can be used in various applications.

An engineer with 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 will permit you to navigate various types of industries and work on diverse projects.

“Modeling Techniques”

Course Content

15 Lectures
7 hours

Lecture #1

INTRODUCTION TO NONLINEAR STATIC ANALYSIS

- What is a Nonlinear System?
- The Types of Nonlinearity
- Characteristics of a Nonlinear System



15 minutes

Lecture #2

THE TYPES OF NONLINEARITY

- **Geometric Nonlinearity**
 - ✓ Sources of Geometrical Nonlinearity
 - ✓ How Does Nonlinear Geometry Work?
 - ✓ The Follower Load Concept
 - ✓ Small or Large Strain?
 - ✓ Do You Really Need a Nonlinear Geometric Analysis?
 - ✓ Example of Geometric Nonlinearity



25 minutes

Lecture #3

THE TYPES OF NONLINEARITY

- **Material Nonlinearity**
 - ✓ Refresh about the Behaviors of Metallic Materials
 - ✓ Material Models
 - ✓ Engineering and True Stress-Strain Curves
 - ✓ Yield Criteria
 - ✓ Hardening Rules
 - ✓ How Does Nonlinear Material Works?
 - ✓ Define the Nonlinear Model with your FEA Software
 - ✓ Do You Really Need a Nonlinear Material Analysis?



50 minutes

Lecture #4

THE TYPES OF NONLINEARITY

- **Boundary Nonlinearity**
 - ✓ Loads and/or constraints variation
 - ✓ Introduction to contact conditions



5 minutes

Lecture #5

SHOULD YOU RUN A LINEAR OR A NONLINEAR SOLUTION?

- 6 Questions to answer before to run a nonlinear solution



5 minutes

Lecture #6

HOW DO FEA SOLVERS COMPUTE NONLINEAR PROBLEMS?

- Formulation of a Nonlinear Problem
- Newton-Raphson Methods
- Computational Methods
- Equilibrium Path and Critical Points
- Stiffness Matrix Update Strategies
- Convergence Criteria
- Choosing the Incremental Load Step
- Arc-Length Methods
- How to Select the Right Iterative Solution Scheme?



1 hour

Lecture #7

SUMMARY OF THE NONLINEAR SOLUTION STRATEGY

- Basic Operations
- Iterative Process
- Stiffness Matrix Updates
- Adaptive Load Increment



5 minutes

Lecture #8

STRATEGIES TO AVOID AND SOLVE CONVERGENCE ISSUES

- Non-Convergence Issues
- Tools to Solve the Non-Convergence



10 minutes

Lecture #9

MODELING CONTACTS #1

- **What is a Contact?**
 - ✓ Contact Definition
 - ✓ Contact Strategy
 - ✓ Contact Force
 - ✓ Friction Force
 - ✓ Linear Vs Nonlinear
- **Types of Contact**
 - ✓ Contact Definition
 - ✓ Types of Interaction
 - ✓ Types of Contact Body



25 minutes

Lecture #10

MODELING CONTACTS #2

- **Contact Analysis Procedure**
 - ✓ The Master-Slave Concept
 - ✓ Contact Detection
 - ✓ Contact Tolerance
 - ✓ Detection Algorithms
 - ✓ Influence of the Load Increment on Contact Detection
- **Guidelines for Defining Contact**
- **Do you Really Need to Represent Contact in your Simulations?**



45 minutes

Lecture #11

MODELING CONTACTS #3

- **Examples**
 - ✓ Glued Contact
 - ✓ Touching Contact
 - ✓ Contact between Deformable Bodies
 - ✓ Deformable-Rigid Contact



25 minutes

Lecture #12

EXAMPLES OF NONLINEAR STATIC ANALYSIS

- Geometric Nonlinearity & History Path
- Cumulative Effect of a Nonlinear Analysis
- Influence of the Incremental Load Step on Results
- Material Nonlinearity: The Elastoplastic Plate
- Highly Nonlinear Problem: Metal Forming (Geometric, Material & Contact)



50 minutes

Lecture #13

GENERAL RECOMMENDATIONS FOR NONLINEAR ANALYSIS

- 9 Key Points to Succeed with Nonlinear Analysis



20 minutes

Lecture #14

COMMON MISTAKES IN NONLINEAR ANALYSIS

- The 8 most common mistakes made during nonlinear analyzes



10 minutes

Lecture #15

INTRODUCTION TO NONLINEAR BUCKLING ANALYSIS

- Why Perform a Nonlinear Buckling Analysis?
- The History Path and the Converged Analysis
- Essential Steps in Nonlinear Buckling Analysis
- Examples of Nonlinear Buckling Analysis
 - ✓ Buckling of a Curved Panel
 - ✓ Snap-Through: Newton-Raphson Vs Arc-Length



25 minutes

Supporting Files

Download from the Virtual Classroom

PDF FILES



LECTURES SLIDES ~600 SLIDES

MODELING FILES

- The MSC Nastran Model Files for All the Examples (convertible in any FEA package format)
- Geometric Files to Replicate all the Examples (Lectures and FEA Workflows):
 - ✓ Parasolid (.xmt)
 - ✓ Step (.stp)
 - ✓ IGES (.igs)

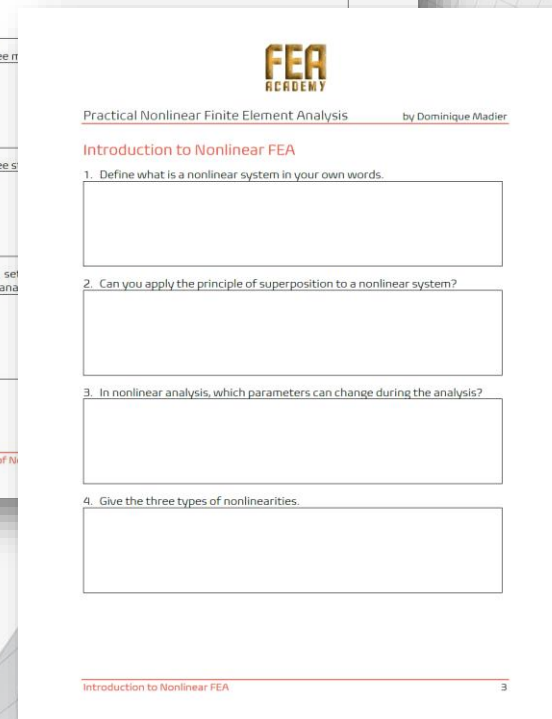
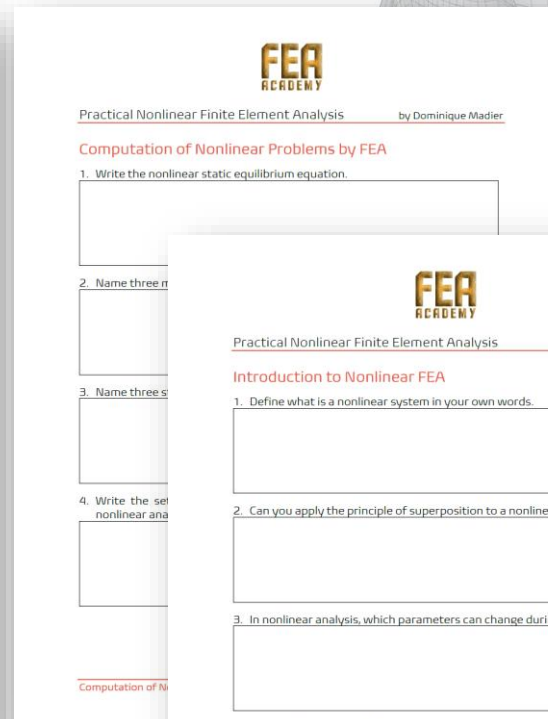
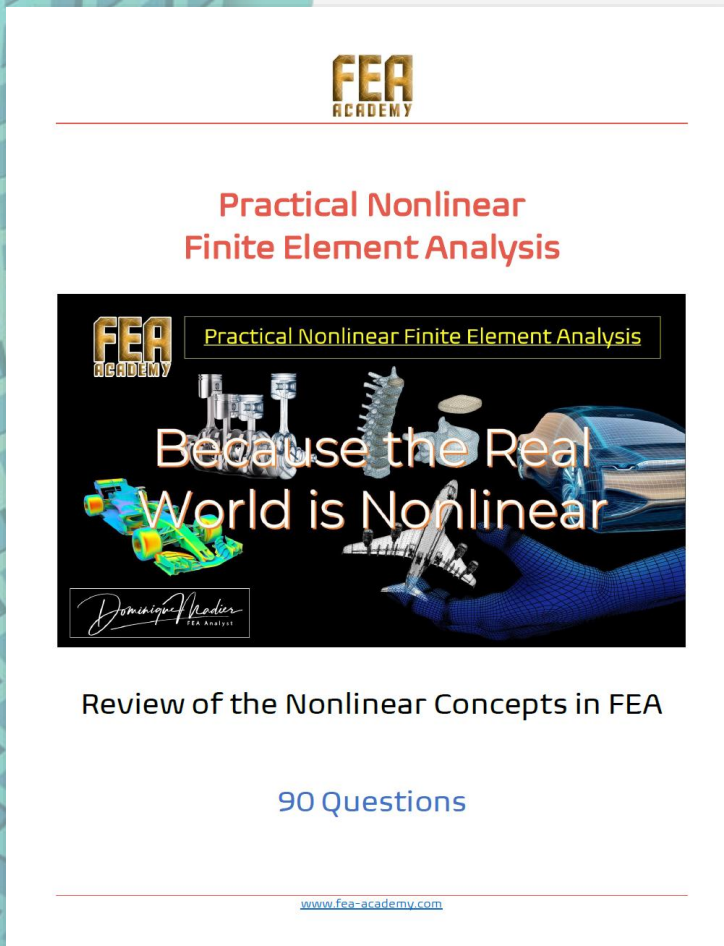
Steffan Evans

**"FEA Workflow
Examples"****17 Videos
5 hours**

Stiffened Panel Nonlinear Analysis	 50 minutes (4 videos)
Generalities: Model Build and Analysis Set-Up	 23 minutes
Multiple Load Case and Step Analysis	 20 minutes
Linear Vs Nonlinear	 10 minutes
Structural Collapse, Shell Column Structure	 15 minutes
Panel Instability and Load Redistribution	 15 minutes
Fuselage Skin Instability (Load Incrementation Scheme & Load Redistribution)	 25 minutes
Nonlinear Material Behavior	 30 minutes
Plasticity & Permanent Deformation	 15 minutes
Hydroforming/Spring back – Punch Forming	 20 minutes
Shock Absorber	 20 minutes
Involute Gear	 25 minutes
3D Bolt Joint with Preload	 10 minutes
3D Interference Fit	 15 minutes

Keep Track of Your Knowledge

- Download our pdf document with **90 questions** to review your knowledge.
- Download our pdf document with **all the answers** to the 90 questions.
- Test yourself by answering the quizzes after each lecture in the FEA Academy learning platform.



Your instructor for "Modeling Techniques"



Dominique Madier

| FEA Analyst | FEA Trainer | Book Author | Speaker |
| Founder & Director of FEA Academy & FEA Experts |
dominique.madier@fea-academy.com

👉 Senior FEA consultant, trainer and coach with 25+ years of experience in FEA.

👉 He has an advanced expertise in Finite Element Analysis (FEA) of static and dynamic problems for linear and nonlinear structural behaviors on aerospace metallic and composite structures such as aircraft fuselage, wing, empennage, nacelle, engine pylon and systems.

👉 Dominique conducted detailed finite element analyses for aerospace companies in Europe and in North America: Airbus, Dassault Aviation, Safran, Bell Helicopter, Bombardier Aerospace, Pratt & Whitney Canada, Beta Technologies, and their subcontractors.

👉 He is the author of the books **"Practical Finite Element Analysis for Mechanical Engineer"** and **"Harness the Power of FEA"**, which provide practical methods and guidelines for engineers and students in developing and validating finite element models. Additionally, these books offer valuable insights for technical managers on building and managing effective FEA teams.

👉 Dominique is the founder & director of FEA Academy and FEA Experts, companies offering FEA Consulting Services as well as FEA Training, Coaching and Mentoring Services.

Your instructor for "FEA Workflows"



Steffan Evans

| FEA Analyst & Trainer | Director of Evotech CAE Ltd. |
info@evotechcae.com

- 👉 Doctor of Engineering, 'Multi-Parameter Structural Optimisation'.
- 👉 Steff is a Chartered Mechanical Engineer in UK.
- 👉 He obtained the NAFEMS Certification Professional Simulation Engineer at Advanced Level.
- 👉 Steff spent 20 Years in Airbus/BAE Systems Supply Chain involved in Strategic FEA Development, Analysis and Verification.
- 👉 Since the last 5 years, he is running Evotech CAE Ltd, an engineered product consultancy company in CAE, FEA and Design Optimisation, partnered with MSC Software for training and technical resales.
- 👉 Steff is known as "The Apex Guy" on LinkedIn.

Ask your questions in
the **"Discussion"**
sections available with
each lecture in the
FEA Academy virtual
classroom

Dominique Nadier
FEA Analyst

| FEA Consultant | Book Author | FEA Trainer | Speaker |
| Helping Engineers and Students to Learn FEA |



« *Practical Finite Element Analysis for Mechanical Engineers* »

650 PAGES OF FEA BEST PRACTICAL METHODS & GUIDELINES – 100+ EXAMPLES

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