Master’s Degree in Numerical Simulation in Engineering with ANSYS

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1. Goal

The Technical University of Madrid (UPM), in collaboration with ANSYS, organizes this online Master’s Degree focused on training experts in Fluid Mechanics and Solid Mechanics Numerical Simulation with ANSYS with a practical scope and applied to a large range of industries (energy, automotive, aeronautics, construction, civil engineering, naval, railway, industrial equipment, etc).

The master's study has a modular content that includes, among other subjects, non-linearities, implicit and explicit dynamics, aerodynamics, turbulence, combustion, meshing, optimization, multiphysic coupling, etc.

The first edition will start in October 2014 and the total duration of the Master’s Degree is between 1.5 and 2 years.
2. About UPM and ANSYS

ANSYS

ANSYS develops, markets and supports engineering simulation software used to predict how product designs will behave and how manufacturing processes will operate in real-world environments. The company continually advances simulation solutions by, first, developing or acquiring the very best technology; then integrating it into a unified and customizable simulation platform that allows engineers to efficiently perform complex simulations involving the interaction of multiple physics; and, finally, providing system services to manage simulation processes and data — all so engineers and product developers can spend more time designing and improving products and less time using software and searching for data.

Founded in 1970, ANSYS employs about 2,600 professionals, and many of them are engineers expert in fields such as finite element analysis, computational fluid dynamics, electronics and electromagnetics, and design optimization. The staff includes more master’s and Ph.D.-level engineers than any other simulation provider. ANSYS re-invests 15 percent of revenues each year into research to continually refine its software.

Technical University of Madrid (UPM)

The Technical University of Madrid (UPM) holds double recognition as a Campus of International Excellence, a distinction that refers to the quality of its research and teaching activity.

The UPM has been considered as the best technical Spanish university for the last two years by the newspaper El Mundo. It is ranked as the top university in Spain for number of projects and patents.

Its professors have wide experience in numerical simulation in technical colleges such as industrial, aeronautics, civil, naval engineering, etc.

Some data:
- 3000+ professors and researchers
- 40000+ students
- 200+ R&D groups
- 1600+ publications in JCR in 2012
- 200+ theses in 2012
- 120+ research projects
3. Structure and Content

The Master's Degree in Numerical Simulation in Engineering with ANSYS is modular and has three levels (basic, advanced, and master’s thesis) and two disciplines (fluid mechanics and solid mechanics).

Modules Listing:

<table>
<thead>
<tr>
<th>Level</th>
<th>Module</th>
<th>Discipline</th>
<th>Credits (ECTS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Modules</td>
<td>Fundamentals and Application of Finite Element Method in Mechanical Analysis</td>
<td>S</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Fundamentals and Application of Computational Fluid Dynamics</td>
<td>F</td>
<td>20</td>
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<tr>
<td>Advanced Modules</td>
<td>Dynamic Analysis</td>
<td>S</td>
<td>20</td>
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<tr>
<td></td>
<td>Thermal Analysis</td>
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<tr>
<td></td>
<td>Contact Non-Linearities</td>
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<tr>
<td></td>
<td>Advanced Non-Linearities</td>
<td>S</td>
<td>10</td>
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<td></td>
<td>Fracture and Fatigue</td>
<td>S</td>
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<td></td>
<td>Turbulence</td>
<td>F</td>
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<tr>
<td></td>
<td>Multiphase</td>
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<td>20</td>
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<td></td>
<td>Heat Transfer</td>
<td>F</td>
<td>10</td>
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<td></td>
<td>Combustion and Reactions</td>
<td>F</td>
<td>10</td>
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<td></td>
<td>Turbomachinery</td>
<td>F</td>
<td>10</td>
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<tr>
<td></td>
<td>Fluid-Structure Interaction</td>
<td>S, F</td>
<td>10</td>
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<tr>
<td>Master's Thesis</td>
<td>Optimization</td>
<td>S, F</td>
<td>10</td>
</tr>
</tbody>
</table>

F: Fluid Mechanics Discipline
S: Solid Mechanics Discipline
3. Structure and Content

The duration of each module is one semester, and the duration of the master’s thesis is between one and two semesters -- so the total duration of the master’s degree is between 1.5 and 2 years. It can be extended based on student's specific needs.

Examples of Duration:

<table>
<thead>
<tr>
<th>Semester</th>
<th>Example 1</th>
<th>Example 2</th>
<th>Example 3</th>
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<tr>
<td>1</td>
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<tr>
<td>2</td>
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<td>Advanced Module 3</td>
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</table>
3. Structure and Content

Based on the student’s area of interest, he can focus on three itineraries:

• Students interested in **Solid Mechanics** should take:
  – Solid basic module (Fundamentals and Application of Finite Element Method in Mechanical Analysis)
  – One or several Solid advanced modules (Dynamic Analysis, Thermal Analysis, Contact Non-linearities, Advanced Non-linearities, Fracture and Fatigue, Fluid-Structure Interaction, Optimization)
  – Master’s thesis

• Students interested in **Fluid Mechanics** should take:
  – Fluid basic module (Fundamentals and Application of Finite Element Method in Mechanical Analysis)
  – One or several Fluid advanced modules (Turbulence, Multiphase, Heat Transfer, Combustion and Reactions, Turbomachinery, Fluid-Structure Interaction, Optimization)
  – Master’s thesis

• Students interested in **Fluid-Structure Interaction** should take:
  – Two basic modules (Fundamentals and Application of Finite Element Method in Mechanical Analysis and Fundamentals and Application of Computational Fluid Dynamics)
  – The advanced module of Fluid-Structure Interaction
  – Master's thesis

In the following pages you can find the description of each module.
Fundamentals and Application of Finite Element Method in Mechanical Analysis

The objective of this module is to provide the adequate theoretical and practical background to analyze *mechanical* problems through numerical simulations based on the finite element method (FEM) with ANSYS Mechanical.

- 20 credits
- **Topics**
  - Fundamental Concepts of FEM: 1D Problems
  - 2D and 3D Elastostatics
  - Isoparametric Elements
  - Geometry Preparation and Meshing Techniques
  - Definition of Boundary Conditions and Loads
  - Plate and Beam Modelling
  - Potential Problems
  - Linear Buckling Analysis
  - Introduction to Modal Analysis
  - Nonlinear Analysis
  - Industrial Applications
Fundamentals and Application of Computational Fluid Dynamics

The objective of this module is to provide the adequate theoretical and practical background to analyze fluid mechanics problems through numerical simulations based on the finite volume method (FVM) with ANSYS CFD.

- 20 credits
- Topics
  - Fundamentals of CFD
  - CFD pre-processing : Geometry, Mesh
  - Incompressible/Compressible flows
  - Introduction to turbulence modelling
  - Numerical performance optimization
  - Industrial applications
Dynamic Analysis

The objective of this module is to provide the adequate theoretical and practical background to analyze dynamic problems through numerical simulations based on the finite element method (FEM) with ANSYS Mechanical.

- **20 credits**
- **Topics**
  - Introduction to Dynamic Analysis
  - Modal Analysis
  - Response to Harmonic Loading
  - Spectrum&PSD Analysis
  - Response to General Dynamic Loading
    - Implicit Methods
    - Explicit Methods
The objective of this module is to provide the adequate theoretical and practical background to analyze thermal problems through numerical simulations based on the finite element method (FEM) with ANSYS Mechanical.

- **10 credits**
- **Topics**
  - Basic concepts of Heat Transfer: Conduction, Convection & Radiation
  - Steady-State and Transient thermal analysis
  - Phase change and Fluid thermal simulation
  - Thermo-Mechanical analysis: weak and strong coupling
  - Thermo-Electrical analysis
Contact Non-Linearities

This module is intended to provide a theoretical and practical background in Computational Contact Mechanics. Types of connections like gasket joints and prestressed bolts will be also addressed.

- 10 credits
- Topics
  - Basic concepts
  - Types of contact
  - Normal and tangential contact methodologies
  - Contact detection methods
  - Finite element implementation of contact interaction
  - Contact post processing
  - General Joints
  - Bolt pretensions
  - Gasket joints
Advanced Non-Linearities

The aim of this module is to provide the adequate theoretical and practical background to perform advance structural nonlinear analyses with ANSYS Mechanical. Geometric and Material non-linearities will be covered.

• 10 credits
• Topics
  – Non linear solution diagnostic
  – Geometric non-linearities: structural buckling
  – Non linear material models:
    • Plasticity
    • Viscoplasticity
    • Creep
    • Hiperelasticity
    • Viscoelasticity
    • Advanced Models
Fracture and Fatigue Analysis

The objective of this module is to provide the adequate theoretical and practical background to analyze fracture and fatigue problems through numerical simulations based on the finite element method (FEM) with ANSYS Mechanical and ANSYS nCode.

- 10 credits
- Topics
  - Introduction to Fracture Analysis
    - Stress Intensity Factor (SIFs)
    - J-Integral
    - Energy Release Rate (G)
  - Definition of Fracture Analysis
    - Fracture Tool (Crack, Premeshed crack, Postprocessing)
  - Introduction to Fatigue Analysis
  - Definition of Fatigue Analysis Analysis
    - Stress Life Analysis
    - Strain Life Analysis
Turbulence

The objective of this module is to detail advanced turbulence modelizations and allows the attendee to be able to accurately simulate all turbulent engineering flows with ANSYS CFD.

• 10 credits
• Topics
  – Fundamentals of Turbulence
  – Turbulent eddies and boundary layers
  – Advanced RANS models (RSM, transition,...)
  – Scale Resolving models (LES, DES, SAS,...)
  – Models evaluation / Best practices
The objective of this module is to present all models available in ANSYS CFD focusing on capabilities and setup for Multiphase modelling.

- 20 credits
- Topics
  - Particulate Flows
    - Sprays, Chemical Reactions, Particle Size Distribution,...
  - Eulerian Flows
    - All flow regimes
    - Gas/Liq, Gas/Solid, Liq/Gas and Liq/Solid
  - Eulerian Wall Film
  - Free Surface Flows
  - Phase Interaction
    - Drag, Lift,...
    - Condensation, Evaporation, Boiling
The objective of this module is to present all modes of heat transfer and allows the attendee to be able to set up and solve them with ANSYS CFD.

- 10 credits
- Topics
  - Conduction
  - Convection (forced and natural)
  - Fluid-solid conjugate heat-transfer
  - Radiation
  - Interphase energy source
  - Heat exchangers
Combustion and Reactions

The objective of this module is to provide detailed background on reacting flow models allowing the attendee to be able to accurately simulate reacting flows in steady and unsteady analysis in ANSYS CFD.

- 10 credits
- Topics
  - Species Transport
  - Non-Premixed, Premixed & Partially Premixed Flames
  - Discrete Phase Reaction Modelling
  - Detailed Chemistry & Chemistry Acceleration
  - Surface Reactions
The objective of this module is to present various levels of modeling of turbomachinery from 2D blade models to full rotor unsteady simulations with ANSYS CFD.

- 10 credits
- Topics
  - Fundamentals of rotating machines
  - Simplified blade to blade and through flow models
  - Modelizations of Turbines and Compressors
  - Steady CFD approach (MRF)
  - Transient CFD approach (Sliding Mesh)
The aim of this module is to be able to set up different simulations scheme between CFD and FEM codes to study phenomena arising from fluid structure interaction and provide coupled results for both fields.

• 10 credits
• Topics
  – 1-Way and 2-Way Fluid Structure Interaction
  – Structural FSI
  – Thermal FSI
  – Thermo-Structural FSI
  – Moving and deforming Meshes
Optimization

The goal of this module is to obtain both the theoretical and practical knowledge related to optimization in Fluid Mechanics or Solid Mechanics with ANSYS.

- 10 credits
- Topics
  - Parametric optimization with DesignXplorer
    • Parameters correlation
    • Design of experiments
    • Response surface
    • Goal Driven Optimization
    • Robust design and Six Sigma analysis
  - Fluids Topological and Shape Optimization
    • in ANSYS FLUENT with Adjoint Solver and Mesh Morpher Optimizer
  - Solids Topological and Shape Optimization
    • in GENESIS Topology for ANSYS Mechanical
4. Degrees

Students enrolling in this master's degree have access to the following Technical University of Madrid private degrees:

- **Expert's degree** (20 ECTS-credits): by taking a basic module
- **Specialist's degree** (at least 30 ECTS-credits): by taking both a basic module and an advanced module
- **Master's degree** (at least 70 ECTS-credits): by taking a basic module, at least 30 credits in advance modules, and the master's thesis

In the next pages there are some examples of the degrees obtained based on the modules taken.
4. Degrees

Examples of Expert’s Degrees:

<table>
<thead>
<tr>
<th>Example 1</th>
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<tbody>
<tr>
<td><strong>Modules</strong></td>
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<tr>
<td><strong>Degree</strong></td>
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<tr>
<td><strong>Credits</strong></td>
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<th>Example 2</th>
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<tr>
<td><strong>Modules</strong></td>
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<tr>
<td><strong>Degree</strong></td>
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<tr>
<td><strong>Credits</strong></td>
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</tbody>
</table>
4. Degrees

Examples of Specialist’s Degrees:

Example 3

**Modules**
Fundamentals and Application of Finite Element Method in Mechanical Analysis
Thermal Analysis

**Degree**
Specialist in Numerical Simulation in Engineering with ANSYS (Thermal Analysis majoring)

**Credits**
30 ECTS

Example 4

**Modules**
Fundamentals and Application of Computational Fluid Dynamics
Multiphase

**Degree**
Specialist in Numerical Simulation in Engineering with ANSYS (Multiphase majoring)

**Credits**
40 ECTS

Example 5

**Modules**
Fundamentals and Application of Computational Fluid Dynamics
Multiphase
Turbulence

**Degree**
Specialist in Numerical Simulation in Engineering with ANSYS (Multiphase and Turbulence majoring)

**Credits**
50 ECTS
## 4. Degrees

### Examples of Master’s Degrees:

<table>
<thead>
<tr>
<th>Example 6</th>
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<tbody>
<tr>
<td><strong>Modules</strong></td>
</tr>
<tr>
<td>Fundamentals and Application of Finite Element Method in Mechanical Analysis</td>
</tr>
<tr>
<td>Thermal Analysis</td>
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<tr>
<td>Dynamic Analysis</td>
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<tr>
<td>Master’s Thesis</td>
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<tr>
<td><strong>Degree</strong></td>
</tr>
<tr>
<td>Master’s Degree in Numerical Simulation in Engineering with ANSYS (Solid Mechanics majoring)</td>
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<tr>
<td><strong>Credits</strong></td>
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<tr>
<td>70 ECTS</td>
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<th>Example 7</th>
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<tr>
<td><strong>Modules</strong></td>
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<tr>
<td>Fundamentals and Application of Computational Fluid Dynamics</td>
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<tr>
<td>Multiphase</td>
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<tr>
<td>Turbulence</td>
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<tr>
<td>Optimization</td>
</tr>
<tr>
<td>Master's thesis</td>
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<tr>
<td><strong>Degree</strong></td>
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<tr>
<td>Master’s Degree in Numerical Simulation in Engineering with ANSYS (Fluid Mechanics majoring)</td>
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<tr>
<td><strong>Credits</strong></td>
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<tr>
<td>80 ECTS</td>
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<th>Example 8</th>
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<tbody>
<tr>
<td><strong>Modules</strong></td>
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<tr>
<td>Fundamentals and Application of Finite Element Method in Mechanical Analysis</td>
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<tr>
<td>Fundamentals and Application of Computational Fluid Dynamics</td>
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<tr>
<td>Fluid-Structure Interaction</td>
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<tr>
<td>Master's thesis</td>
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<tr>
<td><strong>Degree</strong></td>
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<tr>
<td>Master’s Degree in Numerical Simulation in Engineering with ANSYS (Fluid-Structure Interaction majoring)</td>
</tr>
<tr>
<td><strong>Credits</strong></td>
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<tr>
<td>70 ECTS</td>
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</tbody>
</table>
5. Learning Method

The master's degree learning methodology is entirely online and includes documentation, exercises, tutorials, online evaluation, tutoring sessions, forum and exams.

The student has access to all learning materials through the virtual classroom.

All written material of these modules is in English. The curriculum combines theory (between 30 percent and 50 percent of the modules) with application (50 percent to 70 percent). The goal of this content is to train the student in all theoretical fundamentals and concepts needed to solve fluid and/or solid mechanics problems by means of numerical simulation and its practical application to real-life problems with ANSYS software, one of the most comprehensive engineering simulation tools worldwide.

All instructional material has been created by the Technical University of Madrid and ANSYS.

Student has access to the ANSYS software and licenses needed to perform exercises, tutorials, exams and the master’s thesis.
5. Learning Method

Contact with the professors is conducted through the virtual classroom, tutor sessions or forum (also available at the virtual classroom). Communication between student and professor can be done in English or in Spanish.

Student evaluation is carried out via an exam for each module and an evaluation of the master's thesis.

The exams take place online and consist of theory and application parts (resolution of a simulation exercise).

All modules are available at the beginning of the semester of each course, starting in October and February.

Additionally, there are two pre-enrollment and enrollment periods: one ending in October and another one ending in February.
6. Teaching Staff

Teaching is conducted by recognized professors from several technical colleges from the Technical University of Madrid (industrial, aeronautics, civil, and naval engineering) in collaboration with the ANSYS technical team:

### Directors

<table>
<thead>
<tr>
<th>Director - UPM</th>
<th>Director - ANSYS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juan José Moreno Navarro</td>
<td>Carlos García Blázquez</td>
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</tbody>
</table>

### Coordinators

<table>
<thead>
<tr>
<th>Coordinator Solid - UPM</th>
<th>Coordinator Solid - ANSYS</th>
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<tbody>
<tr>
<td>Ricardo Perera Velamazán</td>
<td>Jorge Dopico Lagoa</td>
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<table>
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<tr>
<th>Coordinator Fluids - UPM</th>
<th>Coordinator Fluids - ANSYS</th>
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<tr>
<td>Benigno Lázaro Gómez</td>
<td>Benjamin Lehugeur</td>
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### Collaborators

<table>
<thead>
<tr>
<th>Collaborator - UPM</th>
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<tbody>
<tr>
<td>Jorge Muñoz Paniagua</td>
<td>José Manuel Vega de Prada</td>
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<tr>
<td>José Miguel Atienza Riera</td>
<td>Juan Ángel Martín</td>
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<tr>
<td>Juan Manuel Tizón Pulido</td>
<td>Leo González Gutiérrez</td>
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<tr>
<td>Lutz Hermanns</td>
<td>Manuel Rodríguez Fernández</td>
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<tr>
<td>Marcos Chimeno</td>
<td>Mariano Morales Marcos</td>
</tr>
<tr>
<td>Miguel Hermmans</td>
<td>Pablo García-Fogeda Núñez</td>
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<tr>
<td>Pedro Afonso</td>
<td>Yuu Arrieta Aoki</td>
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<tr>
<td>Rafael Rebollo Gómez</td>
<td>Santiago Terrón Fraile</td>
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7. Access Requirements

This master's degree is intended for engineers, architects, and mathematical, physical or chemical sciences graduates, either working in the industry or recent graduates.

To enroll in this master's degree, the student should own an official university degree from the European Higher Education Area:

- Degree in exact, physics or chemistry sciences
- Engineering
- Architecture

Alternatively, the student should hold a degree that recognizes a training or competences level similar to those stated here and that gives access to a post-graduate course in the student's country of origin.

To participate, the student needs a PC with at least 4Gb RAM memory, internet connection and one of the platforms supported by ANSYS: [www.ansys.com/Support/Platform+Support](http://www.ansys.com/Support/Platform+Support)
8. More Information

You can find more information in:

• **Master’s Degree Website**: [www.ansys.com/mastersdegree](http://www.ansys.com/mastersdegree)
• Pre-Enrollment: [www.upm.es/atenea/login.upm](http://www.upm.es/atenea/login.upm)
• Technical University of Madrid (UPM): [www.upm.es/internacional](http://www.upm.es/internacional)
• ANSYS: [www.ansys.com](http://www.ansys.com)
• Linkedin: [www.linkedin.com/groups?home=&gid=7430975&trk=anet_ug_hm](http://www.linkedin.com/groups?home=&gid=7430975&trk=anet_ug_hm)

For any question, please contact us:

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• Telephone: +34 913363021
www.ansys.com/mastersdegree

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