

## CU 7.1: MODELLING OF STRUCTURES BY FINITE ELEMENT

**Director of studies: Mourad KHELIFA**

### General CU objectives:

The aim is to introduce engineering students to structural calculation using the finite element method (theoretical aspects and applications)

We will present the finite element method, for the linear calculation of structures, in static and vibrational conditions.

The fields of structural mechanics, thermal science and acoustics will be covered. Structures consisting of bars, beams, plates/shells and 3D solids are studied.

The quality of finite element models will also be studied (meshing, convergence).

### Consists of:

- Module 1: Finite element method
- Module 2: Structural dynamics
- Module 3: Acoustics
- Module 4: Cross-cutting project

### Hourly volume

<i>In-person</i>	<i>Self-directed study</i>
<b>17.50 H Lectures</b>	<b>24.00 H</b>
<b>50.00 H Tutorials</b>	
<b>0.00 H Practicals</b>	

### Positioning of the CU in the School reference system:

after CU 6.4

### Units of skills

In accordance with the RNCP sheet

## CU 7.1: MODELLING OF STRUCTURES BY FINITE ELEMENT

Module 1: Finite element method	Coefficient 2
<b>Session leaders:</b> Mourad KHELIFA, Vincent NICOLAS	
<b>Teaching assistants:</b>	
<b>Prerequisites:</b> Mechanics of Materials, Mechanics, Materials & Design, Maths	
<b>Teaching materials:</b> Course notes – Presentation slides	
<b>Assessment methods:</b> individual Class assignment– Tutorial examination	

Learning outcomes	Description	Number of student hours (in-person)		
		Lectures	Tutorials	Practicals
<p>The main learnings of this module allow the engineering student to:</p> <ul style="list-style-type: none"> <li>– Choose the appropriate finite element model (bar, beam, shell, solid) to model a given structure;</li> <li>– Evaluate finite element results and study mesh quality and convergence</li> <li>– Make a critical analysis and interpretation of the results;</li> <li>– To propose possible changes to the models</li> </ul>	<p>Introduction to the finite element method – uniform tensile/compressive bar structures (finite element of 2-node bars and linear interpolation in displacements, transformation in 2 and 3D global reference frames, assembly, application of the principle of minimum total potential energy for static stresses, resolution of systems of equations, limit conditions, calculation flowchart, calculation of normal forces and stresses, validation of results);</p> <ul style="list-style-type: none"> <li>– plane beams in flexural behaviour– Euler-Bernoulli model (flexural stiffness matrix, equivalent load vector). Membrane–flexural superposition for plane beams;</li> <li>– 3D beams in membrane, flexural and torsion (2-node finite element with 6 degrees of freedom per node)</li> <li>– finite elements for planar problems (triangles, quadrilaterals). Reference elements, shape functions, detailed study of the triangular element with 3 nodes;</li> <li>– finite elements for 3D solids (tetrahedra, hexahedra, prisms). Detailed study of the hexahedral element with 8 nodes.</li> <li>– practical aspects (meshes, convergence, quality of results)</li> </ul>	8.75	10.00	
		8.75	10.00	0.00

## CU 7.1: MODELLING OF STRUCTURES BY FINITE ELEMENT

Module 2: Structural dynamics	Coefficient 2
<b>Session leaders:</b> Mourad KHELIFA	
<b>Teaching assistants:</b>	
<b>Prerequisites:</b> Mechanics of Materials, Maths	
<b>Teaching materials:</b> Course notes – Presentation slides – Project	
<b>Assessment methods:</b> individual Report - Tutorial examination	

Learning outcomes	Description	Number of student hours (in-person)		
		Lectures	Tutorials	Practicals
<p>At the end of this module, students will be able to:</p> <ul style="list-style-type: none"> <li>– model and study the vibrational response of a structure (building type)</li> <li>– determine the dynamic characteristics (frequencies and natural modes of vibration) of a structure</li> <li>– process the cases of periodic and aperiodic loading.</li> </ul>	<p>Introduction to the linear dynamics of structures</p> <ul style="list-style-type: none"> <li>– Reminders of mathematics, rheological models and differential equations</li> <li>– Calculation of the vibratory response of systems with only 1 degree of freedom (1 ddl)</li> <li>– Calculation of the vibratory response of systems with 2 degrees of freedom (highlighting the coupling)</li> <li>– Generalisation to N ddl systems</li> <li>– Practical aspects and modelling assumptions of building structures– applications</li> <li>– Modal analysis (determination of dynamic characteristics of structures)</li> <li>– Vibratory insulation: limitation of the vibrations transmitted by the equipment to the structures (floors), limitation of the vibrations of the equipment transmitted by the vibrations of the structures</li> <li>– Study of short-term stresses, such as impacts, shock, impulse.</li> </ul>	8.75	10.00	
		<b>8.75</b>	<b>10.00</b>	<b>0.00</b>

## CU 7.1: MODELLING OF STRUCTURES BY FINITE ELEMENT

Module 3: Acoustics	Coefficient 1
<b>Session leaders:</b> Sébastien AUCHET	
<b>Teaching assistants:</b>	
<b>Prerequisites:</b>	
<b>Teaching materials:</b> Course notes – Presentation slides – Project	
<b>Assessment methods:</b> individual Class assignment	

Learning outcomes	Description	Number of student hours (in-person)		
		Lecture s	Tutorial s	Practical s
At the end of the module, engineering students will be able to factor sound insulation into the design of timber buildings.	Determine the sound insulation of each wall of a dwelling using the New Acoustic Regulation (NRA).			
	Calculate the sound insulation index $R'$ of a composite wall from the indices of the different elements making up the wall.		6.00	
	Estimate the reverberation time of a room from the Sabine reverberation coefficients ( $\alpha$ ) of the different reverberation surfaces of the room.			
		0.00	6.00	0.00

## CU 7.1: MODELLING OF STRUCTURES BY FINITE ELEMENT

Module 4: Cross-cutting project	Coefficient 2
<b>Session leaders:</b> Mourad KHELIFA, Sébastien AUCHET	
<b>Teaching assistants:</b>	
<b>Prerequisites:</b>	
<b>Teaching materials:</b>	
<b>Assessment methods:</b> Individual Report	

Learning outcomes	Description	Number of student hours (in-person)		
		Lectures	Tutorials	Practicals
Examine and carry out a structural and acoustic design/calculation approach and then carry out analysis and expertise work based on the knowledge acquired during CU lectures and tutorials.	<p>The project topics will be initiated by personal proposals from the students, in direct relation with the company taking on the apprentice, and then validated with the academic tutor responsible for the CU.</p> <p>The objective of the projects is to support apprentices in their approach to the design/calculation of structures so that they can carry out analytical and expert work based on their knowledge, on the following themes:</p> <ul style="list-style-type: none"> <li>– Calculation and verification of the performance of a product (structure, joinery, furniture, etc.) made by the company</li> <li>– Qualification of the acoustic insulation of a company building.</li> </ul> <p>Expected deliverables: 10-15 page report</p>		24.00	
		0.00	24.00	0.00