SYLLABUS

Course	
Name	Structural Analysis
Code	AIM14
Degree	Grado en Ingeniería Electromecánica
Year	4º
Semester	1º
ECTS credits	6 ECTS
Character	Basic
Department	Mechanical Engineering
Area	Continuum Mechanics
Universidad	Pontificia Comillas
Schedule	
Instructors	Jesús R. Jiménez Octavio Alberto Carnicero López
Descriptor	

Instructors	
Professor	
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COURSE SPECIFICS

Context of the course

Contribution to the professional profile

This course provides the basic principles of structural analysis and its application to solving problems in the field of engineering.

When completing the course, students will understand the calculation of problems related to truss and framed structures and will be familiarized with certain building standards. The acquired concepts here are the basis for subjects that will be explored in next future as Industrial Building and even this course may be a brief introduction to the Finite Element Method.

In addition, this course covers both theoretical and practical aspects of structural analysis. To the theoretical part a practical approach is added, therefore conceptual problems are enriched with more realistic ones according to the validation against the mandatory specific standards.

Pre-requisites

There are no prerequisites that formally prevent this course. However, by being immersed in a graduate program, it is based on concepts that have been studied before in previous courses:

- Linear Algebra
- Calculus I
- Material Mechanics

Competences – Goals

Generic competences

CG1.	Ability to write, sign and development of projects in the field of industrial engineering aimed, according to the knowledge acquired as provided in paragraph 5 of the order of 9 February CIN/351/2009, to building, repair, maintenance, demolition, manufacturing, installation, assembly or operation of: structures, mechanical equipment, energy facilities, electrical and electronic installations and industrial plants and manufacturing and automation processes.
CG3.	Knowledge of basic and technological subjects, which enables students to learn new methods and theories, and gives them versatility to adapt to new environments.
CG4.	Ability to solve problems with initiative, decision, creativity, and critical reasoning; and to communicate and transfer knowledge, abilities and skills in the field of Engineering.
CG6.	Ability to handle specifications, regulations and mandatory standards.

Specific Competences and Learning Results[1]
CE1. To know the basics of structural analysis
RA1. To understand structural analysis objectives, its history and applications
RA2. To identify the type of the component elements in real life applications
RA3. To understand the fundamental hypothesis assumed in this subject, all of them based on the general knowledge on material mechanics
CE2. To know and to understand the analysis and characteristics of truss and framed structures
RA4. To identify statically determinate trusses (SDT) and frames (SDF)
RA5. To know how to calculate member forces of SDT by means of equilibrium equations
RA6. To understand the Principle of Virtual Work (PVW) applied to SDT and SDF
RA7. To know how to calculate deflections of SDT and SDF by means of PVW
RA8. To identify statically indeterminate trusses (SIT) and frames (SIF)
RA9. To be able to identify the source and degree of indetermination in SIT and SIF
RA10. To understand the PVW applied to SIT and SIF
RA11. To know how to turn SIT and SIF into SDT and SDF by means of PVW
CE3. To understand the necessity and to know systematic structural analysis methods
RA12. To understand the Stiffness Method (SM) for coplanar structures
RA13. To identify the degrees of freedom and boundary conditions in any truss or framed structure
RA14. To know how to build the stiffness matrix and the load vector in any truss or framed structure and to express such structure in a matrix system
RA15. To know how to calculate deflections in any truss or framed structure by means of SM theoretically and computer assisted
RA16. To know how to calculate the forces on the members in any truss or framed structure by means of SM
RA17. To understand the systematized mode of arranging the physical information of SF and to realize the robustness and flexibility of this method to be extrapolated to more complex applications
CE4. To understand the necessity and to know the application of mandatory standards for steel structures
RA18. To know the codes of practice and normalization
RA19. To understand the basis of design
RA20. To know how to identify a critical load combinations according to the standards
RA21. To know how to a apply Eurocode 3 to validate a truss or framed under tensile and bending forces considering buckling resistance

[1] Learning results are observable indicators of the competences acquired, which allow assessing the degree of competence of the students. The competences are usually more general and abstract. Learning results are observable indicators of competences.

CONTENTS AND MODULES

Contents
1: Introduction to Structural Analysis (4h)
1.1 Classification of structures. Structural members
1.2 Purpose of structural design
1.3 General equations: equilibrium, behavior and compatibility
2: Analysis of statically determinate trusses (6h)
2.1 Basic assumptions
2.2 Classifications and typology
2.3 Equations of equilibrium
2.4 The method of joints
2.5 The method of sections
2.6 Compound trusses: the method of secondary trusses
2.7 Complex trusses: the method of Henneberg
2.8 The Principle of Virtual Work (PVW) on trusses
3: Analysis of statically indeterminate trusses (6h)
3.1 Statically indeterminate structures
3.2 Equations of behavior
3.3 Equations of compatibility
3.4 The method of forces
3.5 The method of displacements
4: Generalized Principle of Virtual Work (8h)
4.1 Basics on beams under tensile, bending, torsion and thermal loads
4.2 The Principle of Virtual Work (PVW) on frames
5: The stiffness method (10h)
5.1 Idealized structure
5.2 Calculation methods: stiffness vs flexibility
5.3 Basics of the stiffness method
5.4 Elementary degrees of freedom
5.5 Equations of compatibility and equilibrium: Assembly of the global stiffness matrix
5.6 Boundary conditions
5.7 Calculation of constraints
5.8 Calculation of member forces
6: Influence lines (4h)
6.1 Introduction to moving loads
6.2 Influence lines for statically determinate structures
6.3 Influence lines for statically indeterminate structures
6.4 Application of influence lines for floor girders
7: Eurocode 3: Design of steel structures (10h)
7.1 Introduction: purpose of mandatory codes
7.2 Basis of design
7.3 Partial factor method for load combination
7.4 Materials
7.5 Ultimate limit states
7.6 Serviceability limit states

TEACHING METHODOLOGY

General methodological aspects

In order to achieve the learning objectives stated above, the course will be focused on the students' activity and on their active learning. This implies that both classroom and non-classroom activities will promote active student involvement in learning activities

Classroom methodology: Activities

1. **Lectures and general presentations:** Presentation of key concepts and procedures through explanations by the instructor. They will include theoretical discussions, practical examples and small formal or spontaneous participation of students
2. **Proposed problem solving:** Problems proposed by the instructor and worked by the students, will be explained, analyzed and solved
3. **Tutorials.** They will be conducted in groups or individually in order to solve the doubts were raised by students after working the issues

Non-classroom methodology: Activities

1. Individual study of the concepts explained during the lectures
2. Analysis of problems solved in class
3. Proposed problems solving
4. Mandatory problems as continuous assessment

The main objective of the classroom work is to understand the theoretical concepts of the subject and to be able to use them when solving different types of basic problems. Then, they should be able to face advanced problems and finally they will be evaluated at the end of each unit.

SUMMARY OF THE STUDENT WORKING HOURS			
CLASSROOM ACTIVITIES			
Lectures	**Problems solving**	**Classroom tests**	**Exams**
24	22	2	3
NON-CLASSROOM ACTIVITIES			
Autonomous work-theory	**Autonomous work-problems**	**Continuous assessment**	**Exams preparation**
36	33	30	30
		ECTS:	6.0 (180 hours)

EVALUATION AND GRADING CRITERIA

Evaluation activities	Grading criteria	Weight
Final exam	- Understanding of concepts - Application of concepts to problem solving - Analysis and interpretation of problem results	70%
To pass the course you must get at least 4 out of 10 on the final exam		
Continuous assessment	- Understanding of concepts - Application of concepts to problem solving - Analysis and interpretation of problem results - Writing skills	30%

Grading.

Grading

The final grade of the course will result from the weighted average of:

- Exam (theory and problems):
  - 70% (minimum 4.0)
- Continuous assessment:
  - 30% Problem solving

In the extraordinary exam, the student will be examined of the whole syllabus.

The weighting criterion is:

- 85% Extraordinary exam (minimum 4.0)
- 15% Continuous assessment (of the course)

WORK PLAN AND SCHEDULE[2]

Non-classroom activities	Date
• Reading and study of materials (theory and problems)	Before each session
• Study of the concepts explained	After each session
• Proposed problem solving	Weekly
• Continuous assessment	Monthly
• Final exam preparation	December

REFERENCES AND RESOURCES

Basic references

- **Structural Analysis, 8th Ed., R.C. Hibbeler. Prentice Hall, 2012.**

Complementary references

- Fundamentals of Structural Analysis, 4th Ed., K.M. Leet, C. Uang and A.M. Gilbert. McGraw-Hill, 2011.
- Design of Steel Structures, L. Simoes da Silva, R. Simoes and H. Gervasio. Ernst & Son, 2010.
- The Behaviour and Design of Steel Structures to EC3, 4th Ed., N.S. Trahair, M.A. Bradford, D.A. Nethercot and L. Gardner. Taylor & Francis, 1977.

[2] A detailed planning of the course may be found in the schedule. This planning is indicative and may change along the course