ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

43000439 - Dynamic And Seismic Analysis Of Structures

DEGREE PROGRAMME

04AM - Master Universitario Ingenieria De Estructuras, Cimentaciones Y Materiales

ACADEMIC YEAR & SEMESTER

2019/20 - Semester 2

Index

Learning guide

1. Description

1.1. Subject details

Name of the subject	43000439 - Dynamic And Seismic Analysis Of Structures
No of credits	4.5 ECTS
Type	Optional
Academic year ot the programme	First year
Semester of tuition	Semester 2
Tuition period	February-June
Tuition languages	English
Degree programme	04AM - Master Universitario Ingenieria De Estructuras, Cimentaciones Y Materiales
Centre	04 - Escuela Tecnica Superior de Ingenieros de Caminos, Canales y Puertos
Academic year	2019-20

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Juan Carlos Mosquera Feijoo (Subject coordinator)	Lab Sist Intel	juancarlos.mosquera@upm.es	W - 10:15 - 13:45 Th - 10:15 - 13:45 Laboratorio de Sistemas Inteligentes, 2nd floor

Ivan Muñoz Diaz	Lab Estructuras	ivan.munoz@upm.es	W - 11:00 - 14:00 Laboratorio de Estructuras, Level -2
Jose Manuel Soria Herrera	Lab Estruct	jm.soria@upm.es	Th - 11:30 - 13:30

* The tutoring schedule is indicative and subject to possible changes. Please check tutoring times with the faculty member in charge.

3. Prior knowledge recommended to take the subject

3.1. Recommended (passed) subjects

- Elementos Finitos

3.2. Other recommended learning outcomes

- Skills in MatLab and/or computational analysis

- Mathematical analysis. Differential and Integral Calculus. Vector and Tensor Algebra. Vector and Tensor Analysis. Ordinary differential equations. Partial differential equations. Mechanics. Strength of Materials. Structural analysis. Computational Mechani

4. Skills and learning outcomes *

4.1. Skills to be learned

CB10 - Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo.

CB6 - Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación

CB9 - Que los estudiantes sepan comunicar sus conclusiones y los conocimientos y razones últimas que las sustentan a públicos especializados y no especializados de un modo claro y sin ambigüedades

CE13 - - Capacidad para el ejercicio profesional de alta especialización o para la investigación predoctoral mediante la utilización de recursos de modelización predictiva en Análisis y diseño estructural en régimen dinámico

y/o no lineal.

4.2. Learning outcomes

RA2 - Presenta comunicaciones orales, escritas y gráficas, estructurada y argumentadamente, en lengua española e inglesa

RA47 - RA8

RA13 - Sintetiza e integra con polivalencia y autonomía las competencias específica de formación científico-técnica para iniciación en I+D+i, para la alta especialización y para la investigación doctoral.

RA46 - RA6

RA44 - RA15

RA45 - RA2

RA8 - Utiliza con eficacia recursos de modelización predictiva en una o más de las materias del módulo

RA6 - Aplica normativa europea e internacional de ingeniería estructural, geotécnica y de materiales estructurales en proyecto, construcción, conservación y evaluación técnica

RA43 - RA13

RA15 - Aplica normativa europea e internacional de ingeniería estructural, geotécnica y de materiales estructurales en proyecto, construcción, conservación y evaluación técnica Interioriza los principios de deontología profesional de ingeniería civil

* The Learning Guides should reflect the Skills and Learning Outcomes in the same way as indicated in the Degree Verification Memory. For this reason, they have not been translated into English and appear in Spanish.

5. Brief description of the subject and syllabus

5.1. Brief description of the subject

Unit I. Structural dynamics. General concepts

Chapter 1. Mathematical and dynamic modelling. Discretization methods

Dynamic model. Mathematical model. Space and time discretization. Discrete systems. Degrees of freedom. Continuous systems. Lumped-mass method. Generalized displacements method. The finite element method. Equations of motion. Objectives of the dynamic analysis.

Unit II. Time domain analysis of Single degree-of-freedom systems

Chapter 2. Free vibrations

Undamped vibrations. Damped vibrations. Logarithmic decrement. Vibrations with dry friction.

Chapter 3. Response to harmonic excitations and periodic excitations

Undamped vibrations. Damped vibrations. Amplification factor. Resonant response. Vibration-measuring instruments. Forces transmitted to the ground and vibration isolation. Damping measurement.

Exponential form of the solution. Complex frequency response function (CFRF).

Chapter 4. Responses to both an impulsive and an arbitrary dynamic loading

Impulsive excitation. Maximum response analysis. Response to shortduration impulsive loadings. Response to an arbitrary dynamic loading. Convolution integrals. Numerical approach.

Unit III. Time domain analysis of Multi-degree-of-freedom systems

Chapter 5. Multi-degree-of-freedom systems. Modelling and analysis

Selection of dynamic degrees of freedom. Direct approach. Variational formulation. Stiffness and mass matrices. Damping matrix. External loading.

Chapter 6. Analysis of vibration frequencies and mode shapes

Introduction. Undamped vibrations. Vibration frequencies and mode shapes. Interpretation of mode shapes. Characteristic load. Modal Orthogonality. Normalizing the mode shapes. Calculation of vibration frequencies and mode shapes. Modal coordinate transformation methods. Tracking methods.

Chapter 7. Response Analysis. Mode superposition method

Normal coordinates. Uncoupling the equations of motion. Dynamic response. Conditions of modal orthogonality with respect to the damping matrix. Construction of the damping matrix.

Chapter 8. Fundamentals of the dynamic analysis in the frequency domain

Fourier series representation of a periodic loading. Frequency Response Function. Fourier series and the Fourier integral. Fundamental equation of frequency domain analysis. Aliasing and other numerical difficulties with the Fourier transform.

Chapter 9. Tuned mass dampers as an application two-degree-of-freedom systems

Example of TMD for footbridges. Construction of a TMD. Delivery 1. Vibration isolation. Example for high-tech equipment.

Unit IV. Frequency-domain analysis

Chapter 10. Frequency-domain method of response analysis

CFRF. Response analysis in the frequency domain when the vibration modes are known. Response analysis in the frequency domain with unknown modes. Complex frequency-response function matrix

Unit V. Elements of earthquake engineering

Chapter 11. Fundamentals of seismology

Sources of earthquakes. Plate tectonics. Seismic zones. Seismic waves. Earthquake records.

Chapter 12. Seismic risk

Seismic risk and related concepts. Parameters related to earthquakes: intensity, magnitude, moment, displacement, velocity, acceleration. Scales. Relations. Seismic hazard assessment. Deterministic methods. Probabilistic methods. Zoned and not zoned methods. Expression of results.

Chapter 13. Design earthquake. Response spectrum analysis

Design earthquake. Response spectra. Response spectrum analysis (RSA)

Chapter 14. Seismic Codes

Spanish Earthquake-resistant Construction Code for buildings NCSE-02. Eurocode 8

5.2. Syllabus

1. Unit I. Structural dynamics. General concepts

2. Unit II. Time domain analysis of Single degree-of-freedom systems

3. Unit III. Time domain analysis of Multi-degree-of-freedom systems

4. Unit IV. Frequency-domain analysis

5. Unit V. Elements of earthquake engineering

6. Schedule

6.1. Subject schedule*

Week	Face-to-face classroom activities	Face-to-face laboratory activities	Other face-to-face activities	Assessment activities
1	**Chapters 1 and 2** Duration: 03:15 Lecture			
2	**Chapter 3** Duration: 02:00 Lecture		**Exercise classes, problem classes, quizzes** Duration: 01:15 Problem-solving class	
3	**Chapter 4** Duration: 02:10 Lecture		**Exercise classes, problem classes, quizzes** Duration: 01:05 Problem-solving class	**Special assignment Chapters 1 to 4** Individual work Continuous assessment Duration: 01:00
4	**Chapter 5** Duration: 02:10 Lecture		**Exercise classes, problem classes, quizzes,** Duration: 01:05 Problem-solving class	
5	**Chapter 6** Duration: 02:00 Lecture		**Exercise classes, problem classes, quizzes** Duration: 01:00 Problem-solving class	**Special assignment Chapters 5 and 6** Individual work Continuous assessment Duration: 01:00
6	**Chapter 7** Duration: 02:05 Lecture		**Exercise classes, problem classes, quizzes** Duration: 01:10 Problem-solving class	
7	**Chapter 8** Duration: 01:30 Lecture		**Exercise classes, problem classes, quizzes** Duration: 01:30 Problem-solving class	**Special assignment Chapters 7 and 8** Group presentation Continuous assessment Duration: 02:00
8	**Chapter 9** Duration: 02:10 Lecture		**Exercise classes, problem classes, quizzes** Duration: 01:05 Problem-solving class	
9	**Chapter 9** Duration: 02:10 Lecture		**Exercise classes, problem classes, quizzes** Duration: 01:05 Problem-solving class	
10	**Chapter 10** Duration: 02:10 Lecture		**Exercise classes, problem classes, quizzes** Duration: 01:05 Problem-solving class	**Special assignment Chapters 7 and 8** Group presentation Continuous assessment Duration: 01:45
11	**Chapter 11** Duration: 02:10 Lecture		**Exercise classes, problem classes, quizzes** Duration: 01:05 Problem-solving class	

12	**Chapter 12** Duration: 02:10 Lecture		**Exercise classes, problem classes, quizzes** Duration: 01:05 Problem-solving class	
13	**Chapter 13** Duration: 02:10 Lecture		**Exercise classes, problem classes, quizzes** Duration: 01:05 Problem-solving class	
14	**Chapter 14** Duration: 02:10 Lecture		**Exercise classes, problem classes, quizzes** Duration: 01:05 Problem-solving class	
15	**Chapter 14** Duration: 02:10 Lecture			**Special assignment Chapters 12 to 14** Group presentation Continuous assessment Duration: 01:05
16				**Final exam** Written test Continuous assessment and final examination Duration: 03:00
17				

The independent study hours are training activities during which students should spend time on individual study or individual assignments.

Depending on the programme study plan, total values will be calculated according to the ECTS credit unit as 26/27 hours of student face-to-face contact and independent study time.

* The subject schedule is based on a previous theorical planning of the subject plan and might go to through experience some unexpected changes along throughout the academic year.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Continuous assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
3	Special assignment Chapters 1 to 4	Individual work	Face-to-face	01:00	5%	/ 10	CB9 CB10 CB6
5	Special assignment Chapters 5 and 6	Individual work	No Presential	01:00	5%	/ 10	CB9 CB10 CB6
7	Special assignment Chapters 7 and 8	Group presentation	Face-to-face	02:00	5%	/ 10	CB9 CB10 CB6
10	Special assignment Chapters 7 and 8	Group presentation	Face-to-face	01:45	5%	/ 10	CB10 CB6 CE13 CB9
15	Special assignment Chapters 12 to 14	Group presentation	Face-to-face	01:05	5%	/ 10	
16	Final exam	Written test	Face-to-face	03:00	100%	5 / 10	CB9 CB10 CB6 CE13

7.1.2. Final examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
16	Final exam	Written test	Face-to-face	03:00	100%	5 / 10	CB9 CB10 CB6 CE13

7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
End-of-year exam	Written test	Face-to-face	03:00	100%	5 / 10	CB10 CB6 CE13 CB9

7.2. Assessment criteria

Each exercise counts ten points. The exam score is the weighted average of the scores of the exercises. Passing grade is five out of ten points

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Basic references	Bibliography	Preumont, A. (2013): Twelve Lectures on Structural Dynamics, Université Libre de Bruxelles. Chopra, A.K. (2012): Dynamics of structures. Structures: Theory and Applications to Earthquake Engineering, Prentice Hall, 4th Ed.
Complementary references	Bibliography	Clough, R.W.; Penzien, J. (2010): Dynamics of structures Mac CEN (2011): Eurocódigo 8: Proyecto de estructuras sismorresistentes UNE-EN 1998-1. Humar, J.L. (1990): Dynamics of structures Prentice Hall.Graw-Hill International.
Further references	Bibliography	Bolt, B. A. (1981): Terremotos. Serie Reverté Ciencia y Sociedad. Min de Fomento (2003): Norma de Construcción Sismorresistente NCSE-02: Parte General y de edificación. Min de Fomento (2008): Norma de

		Construcción Sismorresistente: Puentes NCSP-07.
References on earthquake engineering	Bibliography	Eurocode 8: Seismic Design of Buildings. Worked examples JRC European Commission, 2012. Naeim, F. The seismic design Handbook Van Nostrand Reinhold, 2001.
Electronic platforms	Web resource	Moodle

9. Other information

9.1. Other information about the subject

Supplementary teaching materials may also be available on Moodle platform.