Course guide
250704 - 250704 - Structural Dynamics

Last modified: 28/03/2024

Unit in charge: Barcelona School of Civil Engineering
Teaching unit: 751 - DECA - Department of Civil and Environmental Engineering.

Degree: MASTER'S DEGREE IN STRUCTURAL AND CONSTRUCTION ENGINEERING (Syllabus 2015). (Optional subject).

Academic year: 2023 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: JAVIER BONET CARBONELL

Others: JAVIER BONET CARBONELL, ROLANDO ANTONIO CHACÓN FLORES, MIGUEL MASÓ SOTOMAYOR

TEACHING METHODOLOGY

This subject is developed through 7 theory classes with problems, 3 laboratory sessions, a partial exam and a project. The first two laboratory sessions will require the preparation of a deliverable. The third laboratory session is the starting point for the final project, which covers the theoretical and experimental analysis of a structure.

Support material is used in the form of detailed teaching plan using the virtual campus ATENEA: content, programming and evaluation activities directed learning and literature.

Although most of the sessions will be given in the language indicated, support can also be given in other languages.

LEARNING OBJECTIVES OF THE SUBJECT

Subject to acquire knowledge and skills to understand and solve dynamic problems in structures

Capability to understand and solve problems of dynamics in structures. Ability to consider the dynamics in structural design .

Basic concepts of structural dynamics. Dynamic models with a single degree of freedom and with several degrees of freedom. Formulation of the equation of motion . Formulation of the equation of motion and dynamic response of a system with "n " degrees of freedom : Lagrangeanas or generalized coordinates . Introduction to the dynamics of nonlinear structures

The aim of this course is to get students to acquire knowledge and skills to understand and solve problems of dynamic structures and be trained to consider the dynamics in the structural design. This course will lay the foundation for further studies of structures subjected to seismic actions, wind and vibrations caused by machines in general and traffic.

STUDY LOAD

Type	Hours	Percentage
Self study	80,0	63.95
Hours medium group	9,8	7.83
Hours large group	25,5	20.38
Hours small group	9,8	7.83

Total learning time: 125.1 h

CONTENTS

Basis of structural dynamics

Description:
o Mass & Stiffness
o Damping
o Equation of motion
o Energy balance
o Dynamic amplification factor & Transmission ratio

Full-or-part-time: 7h 11m
Theory classes: 3h
Self study : 4h 11m

Formulation of the equation of motion. Dynamic response of a system of 1 DoF

Description:
o SDOF Structures and Rayleigh's method
o Un-damped and damped free oscillation
o Forced oscillation - constant force
o Forced harmonic vibration - response types, resonance
o Laboratory 1
o General forced oscillation: Duhamel integral. Newmark method
o Laboratory practice 2
o Earthquake loading. Response spectra
o Partial Examination

Problem Classes. ASSESSED (70% of grade). Delivery dates mentioned in each case. - Work Problem 1: Calculation of frequencies 1GL simple structures. - Work Issues 2: dynamic time response 1GL simple structures. Harmonic actions. - Work Problem 3: dynamic time response 1GL simple structures. Any actions. I work Problem 4: Dynamic Frequency response - Fourier Transforms. - Work Problem 5: pseudo-spectra and theoretical spectra.
Laboratory classes. ASSESSED (30% of grade). The work is done and delivered on the same day on the date mentioned in each case.
- Laboratory Work 1: Introduction to experimentation. Introduction to computers. Introduction to mounting connections Introduction to data acquisition. Compare Arduino and Traditional measurements.
- Laboratory Work 2: Study of damped free vibrations. Cantilevered strip. It will be done with Arduino for different beam lengths for each student. Initially, Arduino-Spider comparisons will be made to show the ability of low-cost items.
- Laboratory Work 3: Study of damped forced vibrations. Cantilevered strip. It will be done with Arduino for different beam lengths for each student.

Full-or-part-time: 50h 24m
Theory classes: 8h
Practical classes: 4h
Laboratory classes: 9h
Self study : 29h 24m

Formulation of the equation of motion. Dynamic response of a system with N DoF

Description:
o Free vibration - modes of vibration - main frequency(ies) of vibration
o Problem reduction by static condensation or Rayleigh-Ritz method
o Forced vibration - modal decomposition
o Earthquake loading
o Simplified shear building model
o Example of seismic analysis
o Laboratory practice 3
o Final Project

Problem Classes. ASSESSED (70% of grade). Delivery dates mentioned in each case.

- Work Issues 6: Fundamental frequency in continuous structures.

- Work Issues 7: structural "N" GL Systems. Shear frame structure
Laboratory classes. ASSESSED (30% of grade). The work is done and delivered on the same day on the date mentioned in each case.

- Laboratory Work 4: Session Programming in Matlab, Python, VisualBasic or another language.

- Laboratory Work 5: Shear frame structure.

Full-or-part-time: 43h 12m
Theory classes: 6h
Practical classes: 3h
Laboratory classes: 9h
Self study : 25h 12m

Introduction to the dynamics of non-linear structure

Description:
- Simplified representation of the nonlinear behavior of an oscillator: inertial nonlinearity, damping non-linearity, nonlinearity of stiffness: constitutive and geometric. Ductility of a nonlinear oscillator degree of freedom.
- Inelastic response spectrum: ductility required spectrum, spectrum coefficient project, effective reduction of forces.
- Formulation of dynamic equilibrium for a structure subjected to nonlinear behavior.
- Linearization of the equilibrium equation.
- Various nonlinear effects in structures caused by nonlinear dynamic actions
- Solving the equation of motion in structures subjected to non-linear behavior.
- Explicit-Implicit Solution.
- Introduction to material behavior models, independent of time (damage, plasticity). Effects on the structural behavior.
- Introduction to the models of material behavior, time dependent (viscoelasticity, viscoplasticity, viscodamage). Effects on the structural behavior. The structural damping and its origin in the material.
- Evolution of the natural frequency of structures subjected to dynamic actions. Relationship between the change of natural frequency and structural damage.
Problem Classes. ASSESSED (70% of grade). Delivery dates mentioned in each case.

- Work Issues 8: nonlinear structural systems. Inelastic spectra. Ductility

Full-or-part-time: 7h 11m
Theory classes: 2h
Practical classes: 1h
Self study : 4h 11m

GRADING SYSTEM

The course grade is derived from the scores of a continuous assessment tests (50%), a project (30%) and two laboratory reports (2x10%).

EXAMINATION RULES.

Failure to perform a laboratory or continuous assessment activity in the scheduled period will result in a mark of zero in that activity.

BIBLIOGRAPHY

Basic:

- Barbat, A.H.; Oller, S. Conceptos de cálculo de estructuras en las normativas de diseño sismorresistente [on line]. Barcelona: A.H.Barbat, 1997 [Consultation: 10/02/2023]. Available on: https://upcommons.upc.edu/handle/2117/21168. ISBN 8489925100.
- Barbat, A.H.; Oller, S.; Vielma, J.C. Cálculo y diseño sismorresistente de edificios: aplicación de la norma NCSE-02 [on line]. Barcelona: CIMNE, 2005 [Consultation: 10/02/2023]. Available on: https://upcommons.upc.edu/handle/2117/28500. ISBN 8495999897.
- Barbat; A. H.; Canet, J. M. Estructuras sometidas a acciones sísmicas. 2a ed. Barcelona: CIMNE, 1994. ISBN 8487867103.
- Oller, S. Nonlinear dynamics of structures [on line]. Barcelona: International Center for Numerical Methods in Engineering (CIMNE) : Springer, 2014 [Consultation: 10/02/2023]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-3-319-05194-9. ISBN 9783319051932.
- Blanco, E.; Oller, S.; Gil, L. Análisis experimental de estructuras. Barcelona: CIMNE, 2008. ISBN 9788496736474.
- Paz, M. Dinámica estructural: teoría y cálculo [on line]. Barcelona: Reverté, 1992 [Consultation: 10/02/2023]. Available on: https://www-ingebook-com.recursos.biblioteca.upc.edu/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=13018. ISBN 842914854X.
- Cesari, F. Metodi di calcolo nella dinamica delle strutture. 3a ed. Bologna: Pitagora, 1997. ISBN 9788837109035.
- Clough, R.W.; Penzien, J. Dynamics of structures. 2nd ed. Berkeley: Computer and Structures, 2003. ISBN 0923907505.
- Chopra, A.K. Dynamics of structures: theory and applications to earthquake engineering [on line]. 5th ed SI units. Harlow: Pearson Education Limited, 2020 [Consultation: 16/02/2023]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=5811586. ISBN 9781292249209.

Complementary:

- Chowdhury, I.; Dasgupta, S.P. Dynamics of structure and foundation: a unified approach. CRC Press, 2008. ISBN 9780415471459.
- Weaver, W.; Timoshenko, S.P.; Young, D.H. Vibration problems in engineering. 5th ed. New York: Wiley, 1990. ISBN 0471632287.
- Hanson, C.E.; Towers, D.A.; Meister, L.D. Transit noise and vibration impact assessment [on line]. Washington, DC: Federal Transit Administration. Office of Planning and Environment, 2006 [Consultation: 10/02/2023]. Available on: https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/FTA_Noise_and_Vibration_Manual.pdf.