Course guide
820468 - SM - Movement Simulation

Last modified: 08/08/2024

Unit in charge: Barcelona East School of Engineering
Teaching unit: 712 - EM - Department of Mechanical Engineering.

Degree: BACHELOR'S DEGREE IN BIOMEDICAL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Optional subject).

Academic year: 2024 **ECTS Credits:** 6.0 **Languages:** English

LECTURER

Coordinating lecturer: GIL SERRANCOLÍ MASFERRER

Others: Primer quadrimestre:
MOHANAD HARBA - Grup: M11
GIL SERRANCOLÍ MASFERRER - Grup: M11

PRIOR SKILLS

Vectorial Mechanics, kinematics, multibody dynamics, and differential equations (Dynamics, Kinematics, Algebra and Calculus)

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Transversal:
04 COE N3. EFFICIENT ORAL AND WRITTEN COMMUNICATION - Level 3. Communicating clearly and efficiently in oral and written presentations. Adapting to audiences and communication aims by using suitable strategies and means.

TEACHING METHODOLOGY

This subject combines theory lectures (approximately 40%) with individual work (approximately 40%) and the work with small groups (cooperative work, 20%). The autonomous learning process is through the Campus Digital Atenea, which contains several academic materials like autoreviewing questions, tips to carry out the work in groups, discussions and proposed assignments and exercises.
The competence "Oral and written efficient communication" is carried out during the oral presentation of the group work where the students will present their work, results and conclusions.

LEARNING OBJECTIVES OF THE SUBJECT

1. Calculate velocities and accelerations, and forces and moments, in a software of numerical programming.
2. Learn what the equations of motion are and how to use them.
3. Learn basic trajectory optimization methods.
4. Development of a mechanism model and simulate its movement.

STUDY LOAD

Type	Hours	Percentage
Hours small group	15,0	10.00
Hours large group	45,0	30.00
Self study	90,0	60.00

Total learning time: 150 h

CONTENTS

Chapter 1: Kinematic analysis

Description:
- Generalized coordinates (absolute and relative) (1h)
- Open kinematic chain systems (5h)

o Calculus of velocities in 2D (reminder)
o Calculus of velocities in 3D
o Calculus of accelerations (by derivation)

L1: Calculate velocities of a 2D system of an open kinematic chain and visualize the movement, in Matlab. (2h)
L2: Calculate velocities of a 3D system of an open kinematic chain and, reminder of how to create plots in Matlab. (2h)

Full-or-part-time: 10h
Theory classes: 6h
Guided activities: 4h

Chapter 2: Dynamic analysis

Description:
- Linear and angular momentum theorems in 2D (reminder) (1h)
- Inertia tensor, reminder (1h)
- Linear and angular momentum theorems in 3D (3h)
- Equations of motion by momentum theorems (3h)

L3: Calculate the equations of motion by means of dynamics analysis of a double pendulum (2h)

Full-or-part-time: 10h
Theory classes: 8h
Guided activities: 2h

Chapter 3: Lagrange equations

Description:
- Calculate kinetic energy (reminder) (1h)
- Calculate potential energy (1h)
- Lagrange equations (with no multipliers or generalized forces) (3h)
- Virtual power (3h)
- Lagrange equations (with no multipliers), with generalized forces (4h)
- Lagrange equations with multipliers (4h)

L4: Calculate equations of motion by means of Lagrange equations of a double pendulum. Visualization of relations among moments and forces vs. positions, velocities and accelerations. (4h)

Full-or-part-time: 20h
Theory classes: 16h
Guided activities: 4h

Chapter 4: Optimization

Description:
- Static optimization (2h)
- Analytic examples and numerical calculations of static optimization (2h)
- Dynamic optimization by means of direct collocation methods (3h)
- Example of a movement simulation of a double pendulum by means of dynamic optimization based on direct collocation methods. (5h)

L5: Example of movement simulation of a double pendulum by means of dynamic optimization based on direct collocation methods. (6h)

Work presentations (2h)

Full-or-part-time: 20h
Theory classes: 14h
Guided activities: 6h

GRADING SYSTEM

This subject is based on practical lectures. The student gets familiarized with numerical methods usually used in movement simulation. The practical assignment, which the student will have to carry out and defend, represents 50% of the mark. This practical assignment will be followed-up during the course. The student will have to propose a mechanism (simple, between 2 and 4 degrees of freedom) and carry out kinematics and dynamics analyses, and optimize the trajectory of one or more coordinates.

EXAMINATION RULES.

Professors responsible for this subject will provide the rules to carry out the exams and what are the materials that the students can bring during the exams. Overall, all exams will be carried out with no books or notes.

BIBLIOGRAPHY

Basic:
- Agulló Batlle, Joaquim. Mecànica de la partícula i del sòlid rígid. 3a ed. cor. i ampl. Barcelona: OK Punt, 2002. ISBN 8492085061.
- Agulló Batlle, Joaquim. Introducció a la mecánica analítica, percussiva i vibratòria : amb 198 figures, 80 qüestions amb solucions, 47 problemes amb resultats i 48 exemples d'aplicació. Barcelona: OK Punt, DL 1998. ISBN 8492085037.
- Uchida, Thomas K; Delp, Scott L; Delp, David. Biomechanics of movement : the science of sports, robotics and rehabilitation. Cambridge, MA: The Mit Press, [2020]. ISBN 9780262044202.

Complementary:
- Betts, John T. Practical methods for optimal control using nonlinear programming. Philadelphia: Society for Industrial and Applied Mathematics, cop. 2010. ISBN 9780898716887.
- Yamaguchi, Gary T. Dynamic modeling of musculoskeletal motion : a vectorized approach for biomechanical analysis in three dimensions [on line]. New York: Springer US, 2006 [Consultation: 12/06/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=5750363. ISBN 9780387287508.