COMILLAS
UNIVERSIDAD PONTIFICIA
ICAI ICADE CIHS

GUÍA DOCENTE
2025 - 2026

FICHA TÉCNICA DE LA ASIGNATURA

Datos de la asignatura

Nombre completo	Injury Biomechanics
Código	DIM-MMS-514
Impartido en	Máster Universitario en Ingeniería Industrial + Máster in Motorsport, Mobility and Safety [Primer Curso] Máster Universitario en Ingeniería Industrial + Máster in Motorsport, Mobility and Safety [Primer Curso] Master in Motorsport, Mobility and Safety [Primer Curso]
Nivel	Master
Cuatrimestre	Anual
Créditos	3,0 ECTS
Carácter	Obligatoria
Departamento / Área	Departamento de Ingeniería Mecánica
Responsable	Francisco J. López Valdés
Descriptor	Injury biomechanics is the part of biomechanics that analyzes how external energy can damage tissue and characterizes the mechanical threshold of the tissue with the goal of preventing injuries

Datos del profesorado

Profesor

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DATOS ESPECÍFICOS DE LA ASIGNATURA

Contextualización de la asignatura

Aportación al perfil profesional de la titulación

Students will receive basic contents about anatomy and most frequent injuries occurring in relevant scenarios (i.e. vehicle collisions), complemented by the introduction to the biomechanical experiments that set the bases for existing injury criteria. The course will also cover some of the most advanced research in the protection of road users.

Prerrequisitos

Knowledge of basic courses of statics, dynamics, materials science and strength of materials. Previous knowledge of human anatomy and biological tissue behavior is not required but will be helpful.

Some notions of statistics advisable.

Competencias - Objetivos

Competencias

Competences

Basic and general competences

GC01 To understand the basic principles that support the development of new methods and theories.

GC02 To foster the initiative, creativity, decision taking, critical thinking, team work and communication skills within the field of mechanical engineering.

Specific competences

SC01 To understand the basic principles in injury biomechanics that can contribute to prevent injuries in human beings.

SC02 To understand, identify and discuss the main limitations and advantages of the different human surrogates used in the field of injury biomechanics.

Resultados de Aprendizaje

LR1. To know the basic anatomical terms used in the study of biomechanics

LR2. To understand the Haddon and Safe System approached to the prevention of injuries caused by external causes.

LR3. To understand the basic mechanical properties of the most important connective tissues in the human body and to relate them to mechanical concepts studied in courses of solid mechanics, elasticity, etc...

LR4. To learn the basic concepts behind the development of the Abbreviated Injury Scale.

LR5. To learn the different surrogates used in Injury Biomechanics and the pros and cons of each one.

LR6. To become familiar with the main injury criteria used in regulation and consumer testing programs tests and to develop a critical perspective.

LR7. To understand the development of injury criteria and to be able to develop an adjusted injury criteria for newly obtained experimental data.

LR8. To learn the most important injury mechanisms of different body regions and to become familiar with the experimental/computational tests that contributed to their development.

LR9. To be able to adopt a critical perspective in the reading of scientific papers.

BLOQUES TEMÁTICOS Y CONTENIDOS

Contenidos – Bloques Temáticos

1. Introduction to injury prevention
2. Introduction to human anatomy and anatomical terms.
    1. Review of general anatomy and anatomical terms
3. Cells and connective tissue of the musculoskeletal system

1. Connective tissue
2. Bone tissue
3. Ligaments and tendons
4. Cartilage
5. Muscles

4. Injury scales, focus on AIS
5. Crash surrogates and related biomechanical experiments: volunteers, animals, Post Mortem Human Surrogates and human body models
6. Injury criteria
    1. Statistical methods
    2. Development of injury criteria
    3. Examples of most relevant injury criteria used in automotive industry
7. Review of body regions, related injuries and biomechanical data:
    1. Head
    2. Cervical spine, thoracic spine and lumbar spine
    3. Thorax
    4. Abdomen
8. Challenges in injury biomechanics
    1. Age effects
    2. Sex effects
    3. Anthropometry effects

Laboratories

Laboratory

Practice 1

Several bone samples will be exposed to tensile tests up to fracture. Students will have to develop an injury criterion for the fracture of an organic sample (2.5 hours).

Practice 2

A sled test will be carried out with the Hybrid III dummy. Students will be required to calculate the risk of injury as predicted by the dummy using the most relevant injury criteria (2.5 hours).

METODOLOGÍA DOCENTE

Aspectos metodológicos generales de la asignatura

Two types of learning modes are planned both for the in class activities and the remote activities: individualized and collaborative. The individualized mode is intended to be completed by each individual student. In the collaborative mode, students will be split into groups of three people that will work together to solve a task.

Metodología Presencial: Actividades

Activities	Learning mode	Hours	Competences
Lectures: instructor will provide explanations of the topics	Individualized	17	GC01, SC01, SC02

included in the outline using slides. The slides will be shared with the students ahead of the class.			
Problem solving: three types of problems will be proposed to the students to reinforce how basic mechanical methods are used in the field of injury biomechanics. Problems will be extracted from real projects. The problems will be proposed one week ahead of the class and will be solved jointly in the class.	Collaborative	5	GC01, GC02, SC01
Practice lab 1: Development of an injury criterion based on real data obtained by the students. Practice lab 2: Calculation of the risk of injury based on dummy readings and using some of the most commonly used injury criteria in the field.	Collaborative	5	GC02, SC01, SC02
Presentation of paper's critique	Collaborative	3	GC02, SC01, SC02

Metodología No presencial: Actividades

Activities	Learning mode	Hours	Competences
Reading of papers: students will be required to read scientific papers in advanced of some of the in class lectures (that will be evaluated in a quiz at the beginning of the class) and to prepare the paper critique to be held at the end of the semester.	Individualized	20	GC01, SC01, SC02
Individual study for quizzes	Individualized	10	GC01, SC01, SC02
Lab reports: students will work in groups to draft the reports from each of the practice labs	Collaborative	10	GC02, SC01, SC02
Practice lab 1: Development of an injury criterion based on real data obtained by the students. Practice lab 2: Calculation of the risk of injury based on dummy readings and using	Collaborative	10	GC02, SC01, SC02

some of the most commonly used injury criteria in the field.			
Draft of presentation of paper's critique: students will work in groups to create the presentation that will be shared in class with the rest of the students	Collaborative	10	GC02, SC01, SC02

EVALUACIÓN Y CRITERIOS DE CALIFICACIÓN

Standard evaluation at the end of the term:

- 20% Lab project 1
- 20% Lab project 2
- 20% Quiz/quizzes on reading materials provided by the instructor
- 15% Homework
- 25% Critique of a relevant published paper
- Attendance: minimum 85% to be allowed to take the exam.

Additional evaluation during July (Retake):

- 25% Lab project 1 (individual)
- 25% Lab project 2 (individual)
- 50% Critique of a relevant published paper

BIBLIOGRAFÍA Y RECURSOS

Bibliografía Básica

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Arregui C, Luzón J, López-Valdés FJ, Del Pozo de Dios E, Seguí-Gómez M, Fundamentos de Biomecánica en las Lesiones por Accidente de Tráfico 2ª edición, ETRASA Madrid, 2010 ISBN: 978-84-92625-40-6

Bartel D, Dave D, Keaveny T. Orthopeadic Biomechanics: Mechanics and Design in Musculoskeletal Systems. 1st edition. Pearson. 2006 ISBN-13: 978-0130089090

Lakes, Roderic S. *Viscoelastic solids*. CRC press, 2017.

Bibliografía Complementaria

Foret-Bruno, J. Y., Trosseille, X., Le Coz, J. Y., Bendjellal, F., Bendjella, F., Steyer, C., ... & Got, C. (1998). Thoracic injury risk in frontal car crashes with occupant restrained with belt load limiter. *SAE transactions*, 2955-2975.

Forman, J. L., Kent, R. W., Mroz, K., Pipkorn, B., Bostrom, O., & Segui-Gomez, M. (2012, October). Predicting rib fracture risk with whole-body finite element models: development and preliminary evaluation of a probabilistic analytical framework. In *Annals of Advances in*

Automotive Medicine/Annual Scientific Conference (Vol. 56, p. 109). Association for the Advancement of Automotive Medicine.

Kent, Richard, Robert Salzar, Jason Kerrigan, Daniel Parent, David Lessley, Mark Sochor, Jason F. Luck et al. "Pediatric thoracoabdominal biomechanics." *Stapp car crash journal* 53 (2009): 373.

Kroell, Charles K., Dennis C. Schneider, and Alan M. Nahum. "Impact tolerance and response of the human thorax II." *SAE Transactions* (1974): 3724-3762.

Kroell, Charles K., Mary E. Pope, David C. Viano, Charles Y. Warner, and Stanley D. Allen. "Interrelationship of velocity and chest compression in blunt thoracic impact to swine." *SAE Transactions* 90 (1981): 3216-3231.

Mertz, Harold J., and Lawrence M. Patrick. "Strength and response of the human neck." *SAE transactions* (1971): 2903-2928.