Course guide
340706 - FORM1 - Formula Student 1

Last modified: 04/07/2024

Unit in charge: Vilanova i la Geltrú School of Engineering
Teaching unit: 707 - ESAII - Department of Automatic Control.

Degree: BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN INDUSTRIAL DESIGN AND PRODUCT DEVELOPMENT ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN INFORMATICS ENGINEERING (Syllabus 2018). (Optional subject).

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

LECTURER

Coordinating lecturer: Stefano De Pinto

Others: Stefano De Pinto

PRIOR SKILLS

Knowledge in Physics and Mathematics: A good understanding of physical concepts such as forces, energy, and motion, as well as mathematical skills, is fundamental for the design and analysis of mechanical and electrical systems.

Knowledge in Mechanics: Students should be familiar with principles of mechanics, such as statics, fluids, and dynamics. This will help students in the development of the vehicle, understanding aspects of vehicle dynamics, aerodynamics, engine behavior, and tires.

Knowledge of Applied Mechanics: Static and dynamic equilibrium, calculation of forces and moments for a rigid body, fluid dynamics for the aerodynamics section, and basic knowledge of propulsion systems.

Skills in Computer-Aided Design (CAD) and Matlab: The ability to use various CAD programs and Matlab to model and simulate mechanical and electrical components is valuable.

Interest in Innovation and Sustainability: Students should be motivated to explore creative and sustainable solutions in the design of competition vehicles.

Strong Teamwork Skills.

THESE SKILLS WILL BE EXPANDED AND ENHANCED DURING THE COURSE, THEREFORE, PRIOR KNOWLEDGE IS RECOMMENDED.

TEACHING METHODOLOGY

The course is structured as an engineering project in which the students have the challenge of designing and building a competition car for the annual international Formula Student event. The project will be developed in two parts: a first virtual part to allow the team to decide the vehicle targets (Formula Student 1) and a second part where the vehicle will be built/modified and tested (Formula Student 2).

The project is divided into different applied engineering fields (mechanical, electrical, electronics, computer science, product design, and project management), providing students with an overall vision of all the parts, to finally understand the functionalities of the vehicle and how they relate to all the concepts studied during the course, applied in a practical and real way.

This first course is essential to understand the basics and assumptions behind vehicle development. The main topics to be covered are the following:

- Tire behavior 1
- Tire behavior 2
- Longitudinal dynamics 1
- Longitudinal dynamics 2
- Lateral dynamics 1
- Lateral dynamics 2
- Lateral dynamics 3
- Aerodynamics
- Load transfers
- Aerodynamics concepts
- Engine - basic concepts
- Brakes
- Vehicle performance figures

LEARNING OBJECTIVES OF THE SUBJECT

The objective of this course is to provide all the key tools for analyzing the performance of a competition vehicle. These concepts are essential for developing complex projects such as Formula Student and other competition vehicles. Through lectures, group projects, and the use of dedicated software, students will understand all aspects related to vehicle design and analyze its performance.

STUDY LOAD

Type	Hours	Percentage
Hours large group	30,0	20.00
Guided activities	10,0	6.67
Self study	110,0	73.33

Total learning time: 150 h

CONTENTS

Tyre behaviour

Description:
Study and analysis of tire behavior under different usage conditions: pure lateral, pure longitudinal, and combined. Analysis of the factors that most influence tire performance and the characteristic angles of the suspension. Además, durante una de las clases, se utilizará la fórmula de Pacejka para modelar el comportamiento del neumático.

Full-or-part-time: 4h
Guided activities: 4h

Longirudinal dynamics

Description:
Study of the longitudinal performance of a vehicle in the case of front-wheel drive, rear-wheel drive, and all-wheel drive. Analysis of the forces acting on the vehicle and the factors related to the choice of powertrain and tires. Introduction to aerodynamics and drag minimization.

Full-or-part-time: 4h
Theory classes: 4h

Lateral dynamics

Description:
Study of the lateral dynamics of a vehicle using the classic "single track" model. Analysis of the factors that induce understeer and oversteer; setting up the vehicle balance and factors that contribute to stability. Analysis of the "two track" model and its differences from the "single track" model. Definition of the main target parameters for lateral dynamics.

Full-or-part-time: 6h
Theory classes: 6h

Lateral and longitudinal load transfer

Description:
Analysis and calculation of vehicle load transfers and initial concepts on how to minimize them. Calculation of longitudinal and lateral load transfers, anti-roll bars, anti-squat, and anti-dive mechanisms.

Full-or-part-time: 4h
Theory classes: 4h

Aero Dynamics

Description:
Study of the main aerodynamic systems applied to competition vehicles. The class will be taught by the Subject Matter Expert from McLaren.

Full-or-part-time: 2h
Theory classes: 2h

Propulsion system (electric motors and engine)

Description:
Study and analysis of the main sensors and actuators of an engine (electric and thermal). Analysis of torque curves and their effects on vehicle dynamics. Overview of the main control algorithms for a thermal engine.

Full-or-part-time: 4h
Theory classes: 4h

Brake systems

Description:
Study and analysis of the main components that are part of a braking system. Analysis of the ideal brake curve and optimal brake distribution between the front and rear axles.

Full-or-part-time: 4h
Theory classes: 4h

Vehicle performance figures

Description:
Main maneuvers and Key Performance Indicators (KPIs) to analyze vehicle performance. Longitudinal maneuvers, pure lateral maneuvers, and transient maneuvers. Presentation of results, Spider Charts, and overview of data analysis using toolboxes.

Full-or-part-time: 2h
Theory classes: 2h

GRADING SYSTEM

The evaluation will be based on each student's participation in the project according to the following criteria:

Two partial exams (one mid-term and one at the end of the course) with a final oral interview (60%)
Development of a group project dedicated to one of the vehicle areas (Dynamics, Ergonomics, Chassis, Powertrain, Electrical, Aerodynamics) (40%)

BIBLIOGRAPHY

Basic:
- Froì□mmig, Lars. Basic course in race car technology : introduction to the interaction of tires, chassis, aerodynamics, differential locks and frame . 1st ed. 2023. ©2023. ISBN 9783658384692.
- Gillespie, T. D. Fundamentals of vehicle dynamics . Warrendale : Society of Automotive Engineers, [1992]. ISBN 9781560911999.
- Guiggiani, Massimo. The science of vehicle dynamics: handling, braking, and ride of road and race cars . Third edition. Cham, Switzerland : Springer, [2023]. ISBN 9783031064609.

RESOURCES

Other resources:
Matlab
Excel
Adams Car
ViCarRealTime