240AU024 - Steering, Suspension and Braking Systems

Coordination unit: 240 - ETSEIB - Barcelona School of Industrial Engineering
Teaching unit: 712 - EM - Department of Mechanical Engineering
Academic year: 2018
Degree: MASTER'S DEGREE IN AUTOMOTIVE ENGINEERING (Syllabus 2012). (Teaching unit Compulsory)
MASTER'S DEGREE IN INDUSTRIAL ENGINEERING (Syllabus 2014). (Teaching unit Optional)
ECTS credits: 6

Teaching languages: Catalan

Coordinator: JORDI RAMON MARTINEZ MIRALLES

Prior skills


Requirements

Have taken the Q1 course: Longitudinal and lateral dynamics.

Degree competences to which the subject contributes

Specific:
3. Apply knowledge of mathematics, physics and technology obtained through study, experience and practice, using critical reasoning to establish economically viable solutions to technical problems in the automotive sector
4. Conceptualize engineering models, apply innovative methods in problem solving and applications suitable for the design, simulation, optimization and control of processes and systems

General:
1. Be able to conduct research, development and innovation in relation to automotive technology.
2. Develop independent learning skills to maintain and enhance the powers of Automotive Engineering, to allow the continued development of the profession.

Teaching methodology

The teaching methodology is based on two types of activities: i) class sessions in which the lecturer provides concepts and knowledge and, using practical exercises, shows how to apply them to solve real problems and situations. In most of these sessions, exercises are set out and students must resolve them in class with the Professor's guidance; ii) practical laboratory sessions in small groups where students carry out activities under the Professor's supervision. In these practical sessions, students learn the use of pre-design and system development support tools as well as testing, measurement and data analysis techniques. These practical sessions also reinforce generic skills such as teamwork, written communication...

Learning objectives of the subject

- Theoretical and practical understanding of steering, suspension and braking systems, as well as their influence on vehicle dynamic performance.
- Knowledge of the different types of designs and components used in steering, suspension and braking systems, and ability to assess their advantages and disadvantages.
- Competence in the preliminary design of steering, suspension and braking systems. Ability to apply design criteria and assess the results of calculations and simulations.
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- Competence in the testing of steering, suspension and braking systems. Knowledge of the instrumentation and equipment required for testing, and ability to programme tests and to analyse and assess the test results.

### Study load

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Hours large group:</th>
<th>0h</th>
<th>0.00%</th>
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<tbody>
<tr>
<td></td>
<td>Hours medium group:</td>
<td>36h</td>
<td>24.00%</td>
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<tr>
<td></td>
<td>Hours small group:</td>
<td>18h</td>
<td>12.00%</td>
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<tr>
<td></td>
<td>Guided activities:</td>
<td>0h</td>
<td>0.00%</td>
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<tr>
<td></td>
<td>Self study:</td>
<td>96h</td>
<td>64.00%</td>
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## Content

<table>
<thead>
<tr>
<th>1: Steering systems</th>
<th>Learning time: 36h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>Practical classes: 7h 30m</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 3h 30m</td>
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<tr>
<td></td>
<td>Self study: 25h</td>
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</tbody>
</table>

- **Types and components of steering systems. Geometry of a steering system: Ackerman condition and specific dimensions and angles. Maneuverability at very low speed. Power steering systems.**

- **Related activities:**
  - Carrying out exercises regarding to steering system geometry. Simulation of the performance of a steering system by means of multibody simulation software.

- **Specific objectives:**
  - Knowledge of the different types of steering systems: their advantages, disadvantages and areas of application.
  - Ability to characterise geometrically a steering system and how the different steering parameters affect vehicle dynamics. Ability to define the steering mechanism through simulation tools.

<table>
<thead>
<tr>
<th>2: Suspension systems</th>
<th>Learning time: 60h</th>
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<tbody>
<tr>
<td>Description:</td>
<td>Practical classes: 19h 30m</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 5h 30m</td>
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<tr>
<td></td>
<td>Self study: 35h</td>
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- **Types of suspension systems and their description. Components of a suspension system. Performance of a suspension system. Dimensioning of the spring and the shock absorber: dynamic model of 1/4 vehicle. Shock absorber tuning: dynamic model of 1/2 vehicle.**

- **Related activities:**
  - Carrying out design and dimensioning exercises of a suspension system: calculation of the stiffness and damping ratio. Simulation of a suspension geometry and kinematics through multibody simulation software.
  - Characterisation of 1 and 2 degrees of freedom systems in the frequency domain.

- **Specific objectives:**
  - Knowledge of the purpose of a suspension system. Identification of the different types of suspension systems, their components and areas of application. Ability to characterise the geometry of a suspension system and determine its main elements following stability and comfort criteria.
### 3: Braking systems

**Description:**
Braking system types and characteristics. Braking system hydraulic circuits. Power-assisted brake. Braking system dynamics. Optimal balance of the braking loads. Introduction to active safety systems: ABS, ESP, etc.

**Related activities:**
Carrying out braking system dimensioning exercises.

**Specific objectives:**
Knowledge of the different types of braking systems: their characteristics and areas of application. Ability to make brake-system design calculations. Knowledge of the different systems of power-assisted brakes and main concepts of the electronics involved in active safety systems related to braking: ABS, ESP, etc.

**Learning time:** 37h 30m
- Practical classes: 9h
- Laboratory classes: 3h 30m
- Self study: 25h

### 4: Testing

**Description:**

**Related activities:**
Practical sessions dedicated to identify and calibrate sensors. Test data acquisition and processing.

**Specific objectives:**
Knowledge of the different types of lab tests in steering, suspension and braking systems. Knowledge of the most common test beds, sensors and instrumentation. Ability to design a test procedure and define all the required steps and specifications, and to draft them in the test protocol. Ability to process test results and draw conclusions.

**Learning time:** 16h 30m
- Laboratory classes: 5h 30m
- Self study: 11h
# Planning of activities

## PRACTICE 1

**Description:**
Analysis of the basic elements that make up the steering, suspension and braking systems.

**Support materials:**
Real elements and models of these systems.

**Descriptions of the assignments due and their relation to the assessment:**
At the end of the practice, each student submits a detailed report of the session, which is reviewed and assessed by the lecturer and returned to the student.

**Specific objectives:**
Improve the students' knowledge about the different elements of the systems and their operation, by means of direct observation.

**Hours:** 2h
Laboratory classes: 2h

## PRACTICE 2

**Description:**
Computer simulation of steering and suspension systems.

**Support materials:**
Desktop computers. Specific software for mechanisms simulation, with modules for kinematic and kinetostatic analysis.

**Descriptions of the assignments due and their relation to the assessment:**
At the end of the practice, each student submits a detailed report of the session, which is reviewed and assessed by the lecturer and returned to the student.

**Specific objectives:**
Learn how to characterize and develop a steering system and a suspension system with the help of simulation.

**Hours:** 4h
Laboratory classes: 4h

## PRACTICE 3

**Description:**
Sensors. Calibration of a load cell and acceleration sensors.

**Support materials:**

**Descriptions of the assignments due and their relation to the assessment:**
At the end of the practice, each student submits a detailed report of the session, which is reviewed and assessed by the lecturer and returned to the student.

**Specific objectives:**
Familiarity with the use of sensors. Learn how to identify its characteristics. Practice of calibration techniques.

**Hours:** 2h
Laboratory classes: 2h
PRACTICE 4

Description:
Frequency response of 1 and 2 degrees of freedom systems.

Support materials:
Data acquisition system for recording vibrations. Electrodynamical actuator to apply harmonic forces. Sample system of 1 degree of freedom. Demonstration system of 2 degrees of freedom.

Description of the assignments due and their relation to the assessment:
At the end of the practice, each student submits a detailed report of the session, which is reviewed and assessed by the lecturer and returned to the student.

Specific objectives:
Analyse the dynamic characteristics of a vibration system of 1 degree of freedom. Understand the concepts of natural frequency and vibration modes and relate them to the case of the dynamic performance of a vehicle with suspension.

GUIDED TOURS

Description:
Guided tours to automotive companies and technology centres.

Support materials:
None

Description of the assignments due and their relation to the assessment:
None

Specific objectives:
Gain first-hand knowledge of the equipment and instrumentation used in testing facilities of leading companies in the automotive field.

Qualification system

Assessment is based on three types of evaluation activities: a mid-term, partial test; a final exam; and an evaluation of the practices. Both the partial test and the final exam, assess the theoretical and practical aspects of the course. Practices are assessed on the basis of the report that every student must write and deliver to the Professor at the end of each practical session. The assessment criteria for practices is the degree of understanding of the work carried out during the practical session and the clarity when writing and presenting the report.

The algorithm to calculate the final mark is: 

\[ N_{\text{final}} = 0.1 \cdot N_{\text{EP}} + 0.9 \cdot \max[N_{\text{EF}}; 0.7 \cdot N_{\text{EF}} + 0.3 \cdot N_{\text{PP}}] \]

Where:  
- \( N_{\text{EP}} \) = mark of the practices,  
- \( N_{\text{EF}} \) = final exam mark, and  
- \( N_{\text{PP}} \) = partial test mark.

To obtain the assessment of the subject, it is required a minimum mark \( \geq 1 \) in the final exam. Otherwise it is considered not submitted -NP.

A special exam will be offered to those students that have not passed the subject and have an assessment different from NP. The mark obtained with this exam, \( N_{\text{REAV}} \), replaces the final exam mark, \( N_{\text{EF}} \).
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Regulations for carrying out activities

Personal notes and reference material can be used during the practical exercises in both the partial test and the final exam. No documentation may be consulted during the theory part.

Bibliography

Basic:

Complementary:

Others resources:
Audiovisual material prepared by the teaching team. This material is accessible through the Atenea Campus.

Audiovisual material

Transparències de classe
Audiovisual material prepared by the teaching team. This material is accessible through the ATENEA Campus.