240AU017 - Automobile Dynamics

Coordinating unit: 240 - ETSEIB - Barcelona School of Industrial Engineering
Teaching unit: 712 - EM - Department of Mechanical Engineering
Academic year: 2017
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: Spanish

Teaching staff
Coordinator: ANA BARJAU CONDOMINES

Opening hours
Timetable: Monday and Wednesday, 5 pm - 6 pm

Prior skills
Basic knowledge of rigid body kinematics and dynamics (vectorial formulation).

Degree competences to which the subject contributes

Specific:
1. 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
2. Perform, present and defend an original exercise performed individually before a university tribunal, consisting of a
comprehensive project of Automotive Engineering professional nature which synthesize the skills acquired in the
teachings

General:
3. Ability to apply appropriate knowledge of mathematical aspects, analytical, scientific, instrumental, technological
and management, the resolution of the problems of the automotive
4. Develop independent learning skills to maintain and enhance the powers of Automotive Engineering, to allow the
continued development of the profession.

Transversal:
5. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of
contributing to projects pragmatically and responsibly and making commitments in view of the resources that are
available.
6. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data
and information in the chosen area of specialisation and critically assessing the results obtained.

Teaching methodology
Lectures.
Compulsory practical sessions to solve and implement problems in the computer lab(groups of 2 students).

Learning objectives of the subject

General objectives:
Analyse the kinematic and dynamic characteristics of vehicles with one single steering system.
Specific objectives:
Accurately describe the kinematics group of wheels and chassis of vehicles with one single steering system. Rigorously implement the laws and theorems of rigid body dynamics in the case of vehicles in motion (both in stationary and transient regimes). Analyse the vehicle response to changes in the control parameters.

<table>
<thead>
<tr>
<th>Study load</th>
<th>Hours large group:</th>
<th>Hours medium group:</th>
<th>Hours small group:</th>
<th>Guided activities:</th>
<th>Self study:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total learning time:</strong></td>
<td>0h</td>
<td>36h</td>
<td>18h</td>
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<td>96h</td>
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## Content

<table>
<thead>
<tr>
<th><strong>1. Vehicles kinematics</strong></th>
<th><strong>Learning time:</strong> 22h</th>
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<tbody>
<tr>
<td><strong>Description:</strong> General motion of the chassis, general motion of a wheel. Axes conventions. 2 and 3 Degrees of Freedom models. Kinematics of a vehicle without suspension: · With two directional wheels · With four directional wheels · With omnidirectional wheels · Without steering wheel and with articulated chassis · With trailer</td>
<td>Theory classes: 4h Practical classes: 4h Self study : 14h</td>
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<tr>
<td><strong>Related activities:</strong> Interactive lectures, resolution of problems, deliveries.</td>
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<td><strong>Specific objectives:</strong> Understand the chassis kinematics from the type of wheels of the vehicle; determine the corresponding Jacobian matrix.</td>
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<tr>
<th><strong>2. Dynamics of conventional wheels</strong></th>
<th><strong>Learning time:</strong> 22h</th>
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<tr>
<td><strong>Description:</strong> Fundamental equations of dynamics: Newton’s 2nd law, Theorem of the Amount of Movement, Theorem of Kinetic Moment. Ground-wheel interaction forces: · Ideal case: single-point contact. · Real case: torque of the multipoint contact, linear model. Dynamics of wheels with/without inertia, drive/non drive wheels.</td>
<td>Theory classes: 4h Practical classes: 4h Self study : 14h</td>
</tr>
<tr>
<td><strong>Related activities:</strong> Interactive lectures, resolution of problems.</td>
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<tr>
<td><strong>Specific objectives:</strong> Understand the origin of the forces and torques transmitted to the chassis.</td>
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### 3. Experimental determining of the dynamic parameters of a vehicle

<table>
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<th>Learning time: 10h</th>
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<tbody>
<tr>
<td>Theory classes: 2h</td>
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<tr>
<td>Practical classes: 2h</td>
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<tr>
<td>Self study: 6h</td>
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</tbody>
</table>

**Description:**
- Mass, position of the center of masses (G), inertia tensor at G.
- Static measure: mass and position of G.
- Dynamic measure: inertia tensor at G (chassis); inertia tensor of a wheel (at its center).

**Related activities:**
Interactive lectures, resolution of problems.

**Specific objectives:**
Learn how to design experiments in order to determine the inertial characteristics of vehicles.

### 4. Dynamics of vehicles without suspension: longitudinal motion

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<th>Learning time: 22h</th>
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<tbody>
<tr>
<td>Theory classes: 4h</td>
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<tr>
<td>Practical classes: 4h</td>
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<tr>
<td>Self study: 14h</td>
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**Description:**
- The Method of Virtual Power.
- Braking and acceleration motions on a plain road.
- Motion on a concave/convex road.

**Related activities:**
Interactive lectures, resolution of problems.

**Specific objectives:**
Study the most relevant aspects on a vehicle's longitudinal motion based on the traction (forward, rear, four-wheel traction).
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5. Dynamics of vehicles without suspension: curve movement

Description:
- Motion equations of a vehicle. Linear approximation.
- Stationary regime (celerity, drive angle and yaw constants):
  - understeer and oversteer characteristics.
- Transient regime: critical speed and stability.

Related activities:
- Interactive lectures, resolution of problems, deliveries.

Specific objectives:
- Study the curve movements of a vehicle and analyse its sensibility on the parameters taking part.

Learning time: 22h
- Theory classes: 4h
- Practical classes: 4h
- Self study: 14h

6. Dynamics of vehicles without suspension: effect of lateral perturbations, time and frequency responses

Description:
- Vehicle response to lateral perturbations forces: neutral driving point, static margin.
- Transient responses to impulsive stimulation of the control variables (steering angle and longitudinal speed).
- Stable responses to sinusoidal stimulations of the control variables (steering angle and longitudinal speed).

Related activities:
- Interactive lectures, resolution of problems, deliveries.

Specific objectives:
- Analyse the effect of various inputs (forces and control variables) on the vehicle motion.

Learning time: 30h
- Theory classes: 6h
- Practical classes: 6h
- Self study: 18h

Qualification system

NEP = Mark for the partial exam
NEF = Mark for the final exam
NL = Mark for the assignments
NTM1 = Mark for the monographic work 1
NTM2 = Mark for the monographic work 2

Final mark = 0.2 NP + 0.1 NL + 0.2 NTM1 + 0.2 NTM2 + 0.3 NF
Regulations for carrying out activities

The exams will generally consist on a theoretical part and a practical part. Only a standard summary of equations will be allowed.

The assignments will correspond to short reports associated to the practical (lab) sessions. They will be submitted through the digital campus; at least three will be carried out, and will be done in groups of 2 students.

The monographic works will be a summary of the whole course content. The first one (TM1) will consist on the study of the motion, under different conditions, of a real vehicle (whose dynamic parameters will have to be extracted from the literature). Each group will be working on a different vehicle and will define the conditions of its study. The proposal will be analyzed by the Professors and eventually modified following its indications. The second one (TM2) will be related to the design requirements of different kinds of vehicles, and will be directly proposed by the Professors. No written reports will have to be submitted, but there will be a 15 minutes oral presentation for each of them.

Bibliography

Basic:


Others resources:

Lecture notes, exercises and short questions (Digital Campus)