Engineering Tripos Part IIB, 4C8: Vehicle Dynamics, 2020-21

Module Leader
Prof. D Cebon [1]

Lecturers
Prof D Cebon and Dr R Roebuck [2]

Lab Leader
Prof D Cebon [1]

Timing and Structure
Lent term. 13 lectures + 2 examples classes + coursework

Prerequisites
3C5 and 3C6 useful

Aims
The aims of the course are to:

- introduce the forces generated by rolling wheels;
- show how these forces affect the lateral stability and steady cornering behaviour of road and railway vehicles;
- introduce some simple mathematical models and performance criteria for vehicle vibration;
- show how vehicle suspension parameter values can be tuned to optimise vibration performance;
- review vehicle suspension technology;

Objectives
As specific objectives, by the end of the course students should be able to:

- understand steady state creep forces and moments in rolling contact and be able to calculate them using the 'brush' model for a variety of simple cases;
- derive the equations of motion of a simple automobile and understand the basic concepts of automobile handling and lateral stability;
- derive the equations of motion of a two-axle rigid railway bogie and to understand the implications for the steady cornering and stability of railway vehicles;
- derive the equations of motion of simple vehicle models and calculate the vibration responses;
- understand the trade-offs involved in suspension design;
- explain the influence of vehicle and road parameters on vehicle vibration behaviour.

Content
Introduction (1L) Prof. D Cebon and Dr D J Cole

Vehicle dynamics (6L) (Prof. D Cebon)

- Introduction to the creep forces and moments generated by rolling wheels, using the 'brush' model.
- Steady state and transient response of a simple automobile model to steering and side force inputs.
- Introduction to understeer, oversteer, and handling diagrams.
- Stability and cornering of a single railway wheelset and a two-axle railway bogie.

Vehicle vibration (6L) (Dr D J Cole)

- Introduction to random vibration, description of road surface roughness.
- Performance criteria.
- Quarter-car model of vehicle vibration, natural modes, conflict diagrams.
- Pitch-plane model, natural modes, wheelbase filtering, suspension tuning.
- Roll-plane model, lateral tyre behaviour, parallel road profiles.
- Vehicle suspension technology.

Further notes

ASSESSMENT

Lecture Syllabus/Written exam (1.5 hours) - Start of Easter Term/75%
Coursework/Laboratory Report - End of Lent Term/25%

Examples papers

Examples paper 1, vehicle dynamics, issued in lecture 1.
Examples paper 2, vehicle vibration, issued in lecture 8.

Coursework

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<tr>
<th>Coursework</th>
<th>Format</th>
<th>Due &amp; return</th>
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<td>One laboratory experiment on behaviour of vehicle tyres, to be performed in pairs, essentially unsupervised. An online booking sheet will offer a wide range of possible times at which the experiment may be performed. A normal laboratory write-up is to be prepared, which will be assessed for the coursework credit.</td>
<td>Individual Report</td>
<td>Put in the coursework post box outside room BE3-39 before the feedback lecture.</td>
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The aim of this experiment is to investigate, qualitatively and quantitatively, the characteristics of a model tyre under a variety of operating conditions. Although the model tyre is not dimensionally similar to a real tyre and is made of solid silicone rubber, it displays many of the important characteristics of road and railway wheels.

Learning objectives:

- Measure the lateral and longitudinal force-slip characteristics of a model tyre
- Compare measured data with values predicted from a theoretical model
### Coursework

- Write a concise report, concentrating on the physics of creep and comparison between experiments and theory

### Booklists

Please refer to the Booklist for Part IIB Courses for references to this module, this can be found on the associated Moodle course.

### Examination Guidelines

Please refer to Form & conduct of the examinations [3].

### UK-SPEC

The [UK Standard for Professional Engineering Competence (UK-SPEC)](http://www.engc.org.uk/ukspec.aspx) [4] describes the requirements that have to be met in order to become a Chartered Engineer, and gives examples of ways of doing this.

UK-SPEC is published by the Engineering Council on behalf of the UK engineering profession. The standard has been developed, and is regularly updated, by panels representing professional engineering institutions, employers and engineering educators. Of particular relevance here is the 'Accreditation of Higher Education Programmes' (AHEP) document [5] which sets out the standard for degree accreditation.

The [Output Standards Matrices](http://teaching.eng.cam.ac.uk/content/output-standards-matrices) [6] indicate where each of the Output Criteria as specified in the AHEP 3rd edition document is addressed within the Engineering and Manufacturing Engineering Triposes.

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