Engineering Tripos Part IIB, 4C8: Vehicle Dynamics, 2018-19

Module Leader

Prof. D Cebon [1]

Lecturers

Dr D Cole and Prof. D Cebon [2]

Lab Leader

Dr D Cole [3]

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

Coursework	Format	Du & n
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. 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. <u>Learning objectives:</u> • Measure the lateral and longitudinal force-slip characteristics of a model tyre • Compare measured data with values predicted from a theoretical model	Individual Report anonymously marked	P out fee [15

Coursework	Format	Du & n
• Write a concise report, concentrating on the physics of creep and comparison between experiments and theory		

Booklists

Please see the Booklist for Group C Courses [4] for references for this module.

Examination Guidelines

Please refer to Form & conduct of the examinations [5].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [6] standard:

Toggle display of UK-SPEC areas.

GT1

Develop transferable skills that will be of value in a wide range of situations. These are exemplified by the Qualifications and Curriculum Authority Higher Level Key Skills and include problem solving, communication, and working with others, as well as the effective use of general IT facilities and information retrieval skills. They also include planning self-learning and improving performance, as the foundation for lifelong learning/CPD.

IA1

Apply appropriate quantitative science and engineering tools to the analysis of problems.

IA2

Demonstrate creative and innovative ability in the synthesis of solutions and in formulating designs.

KU1

Demonstrate knowledge and understanding of essential facts, concepts, theories and principles of their engineering discipline, and its underpinning science and mathematics.

KU2

Have an appreciation of the wider multidisciplinary engineering context and its underlying principles.

E1

Ability to use fundamental knowledge to investigate new and emerging technologies.

E2

Ability to extract data pertinent to an unfamiliar problem, and apply its solution using computer based engineering

tools when appropriate.

E3

Ability to apply mathematical and computer based models for solving problems in engineering, and the ability to assess the limitations of particular cases.

E4

Understanding of and ability to apply a systems approach to engineering problems.

P1

A thorough understanding of current practice and its limitations and some appreciation of likely new developments.

P3

Understanding of contexts in which engineering knowledge can be applied (e.g. operations and management, technology, development, etc).

US1

A comprehensive understanding of the scientific principles of own specialisation and related disciplines.

US3

An understanding of concepts from a range of areas including some outside engineering, and the ability to apply them effectively in engineering projects.

US4

An awareness of developing technologies related to own specialisation.

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Links
[1] mailto:dc29@cam.ac.uk
[2] mailto:djc13@cam.ac.uk, dc29@cam.ac.uk
[3] mailto:djc13@cam.ac.uk
[4] https://www.vle.cam.ac.uk/mod/book/view.php?id=364101&chapterid=51721
[5] https://teaching25-26.eng.cam.ac.uk/content/form-conduct-examinations
[6] https://teaching25-26.eng.cam.ac.uk/content/uk-spec