

## Engineering Tripos Part IIA, 3C5: Dynamics, 2018-19

### Module Leader

[Dr H Hunt](#) [1]

### Lecturers

Dr H Hunt and Prof R Langley

### Lab Leader

Dr H Hunt

### Timing and Structure

Michaelmas term, 16 lectures. Introduction and Rigid-body Dynamics: 2 lectures/week, weeks 1-5 (Prof J Woodhouse); Lagrangian Mechanics: 2 lectures/week, weeks 6-8 (Prof R S Langley)

### Aims

The aims of the course are to:

- Introduce the ideas and methods of 3D dynamics: the motion of rigid bodies in three dimensions under given forces and moments, and the Lagrangian formulation.
- To show how to apply these methods in a straightforward way to a wide range of problems in mechanics.

### Objectives

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

- Represent the inertia of a rigid body by an inertia matrix, be able to calculate the moments and products of inertia for simple shapes, be able to find the principal axes of inertia.
- Derive Euler's equations for the motion of a rigid body under prescribed moments.
- Apply these equations to the motion of symmetrical rotors, to explain the phenomena of precession, nutation and the rate gyroscope.
- Analyse simple problems involving the rolling of rigid bodies, for example a spinning penny on a table.
- Explain the concept of generalised coordinates, and their associated generalised forces.
- Express the kinetic and potential energies of simple systems in term of their generalised coordinates, and to use these to obtain Lagrange' equations of motion for the system.
- Explain the link between conservation laws and the form of the energy
- Explain the concept of a constraint, and be able to calculate the force of constraint from Lagrange's equations.
- Approximate the kinetic and potential energies by quadratic forms, and hence deduce the mass and stiffness matrices for small vibration of system about its equilibrium position.

### Content

This module aims to present a systematic approach to the study of dynamics. Once the main techniques have been grasped, a very wide range of problems can be tackled with confidence. The first part of the course presents

the tools required to analyse rigid-body motion in three dimensions. These are necessary for a proper understanding of gyroscopic systems, inertial navigation, satellites in space and the stability of high-speed rotating systems such as turbines and compressors.

The second part of the course deals with Lagrangian mechanics, a systematic way to formulate dynamical problems using energy functions.

### **Introduction and Rigid-body Dynamics (10L)**

- Equations of motion of a rigid body in three dimensions.
- The inertia tensor; principal axes.
- Gyroscopes and their application.
- Problems involving rolling bodies.

### **Lagrangian Mechanics (6L)**

- Lagrange's equations; connection to Newton's laws; generalised coordinates and generalised forces.
- Applications; calculation of forces of constraint.

## **Coursework**

### **Gyroscopic Phenomena**

Learning objectives:

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Practical information:

- Sessions will take place in [Location], during week(s) [xxx].
- This activity [involves/doesn't involve] preliminary work ([estimated duration]).
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Full Technical Report:

Students will have the option to submit a Full Technical Report.

## **Booklists**

Please see the [Booklist for Part IIA Courses](#) [2] for references for this module.

## **Examination Guidelines**

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

## **UK-SPEC**

The [UK Standard for Professional Engineering Competence \(UK-SPEC\)](#) [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](#) [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.

Last modified: 13/09/2018 14:36

**Source URL (modified on 13-09-18):** <http://teaching.eng.cam.ac.uk/content/engineering-tripos-part-ii-a-3c5-dynamics-2018-19>

### Links

[1] <mailto:hemh1@cam.ac.uk>

[2] <https://www.vle.cam.ac.uk/mod/book/view.php?id=364091&chapterid=46391>

[3] <http://teaching.eng.cam.ac.uk/content/form-conduct-examinations>

[4] <http://www.engc.org.uk/ukspec.aspx>

[5] <http://www.engc.org.uk/standards-guidance/standards/accreditation-of-higher-education-programmes-ahp/>

[6] <http://teaching.eng.cam.ac.uk/content/output-standards-matrices>