

## **Engineering Tripos Part IB, 2P1: Mechanics, 2018-19**

### **Lecturer**

[Dr H Hunt](#) [1]

### **Leader**

[Dr JS Biggins](#) [2]

### **Timing and Structure**

16 Lectures, 2 lectures/week

### **Aims**

The aims of the course are to:

- Show how the concepts of kinematics are applied to rigid bodies.
- Explain how Newton's laws of motion and the equations of energy and momentum are applied to rigid bodies.
- Develop an appreciation of the function, design and schematic representation of mechanical systems.
- Develop skills in modelling and analysis of mechanical systems, including graphical, algebraic and vector methods.
- Show how to model complex mechanics problems with constraints and multiple degrees of freedom.
- Develop skills for analyzing these complex mechanical systems, including stability, vibrations and numerical integration.

### **Objectives**

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

- Specify the position, velocity and acceleration of a rigid body using > graphical, algebraic and vector methods.
- Understand the concepts of relative velocity, relative acceleration and instantaneous centres of rigid bodies.
- Apply Newton's laws and d'Alembert's principle to determine the acceleration of a rigid body subject to applied forces and couples, including impact in planar motion.
- Determine the forces and stresses in a rigid body caused by its motion.
- Apply Lagrange's equation to the motion of particles and rigid bodies under the action of conservative forces
- Identification of equilibrium points, and linearization around equilibrium points
- Linearization around equilibrium points to extract stability information, vibrational frequencies and growth rates.
- Use of the "Effective potential" when  $J_z$  is conserved.
- Understand chaotic motion as observed in simple non-linear dynamics systems
- Understand simple gyroscopic motion.

### **Content**

#### **Introduction and Terminology**

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## **Kinematics**

- Differentiation of vectors (4: pp 490-492)
- Motion of a rigid body in space (3: ch 20)
- Velocity and acceleration images (1: p 124)
- Acceleration of a particle moving relative to a body in motion (2: pp 386-389)

## **Rigid Body Dynamics**

- D'Alembert force and torque for a rigid body in plane motion (4: pp 787-788)
- Inertia forces in plane mechanisms (1: pp 200-206)
- Method of virtual power (4: pp 429-432)
- Inertia stress and bending (1) Ch 5

## **Lagrange's Equation**

- Introduction to Lagrange's Equation (without derivation)
- Concept of conservative forces
- Application to the motion of particles and rigid bodies under the action of conservative forces

## **Non-linear dynamics**

- Solution of equations of motion for a double pendulum
- Illustration of motion on a phase plane
- Concept of chaos and the sensitivity to initial conditions

## **Gyroscopic Effect**

- Introduction to gyroscopic motion (2: pp 564-571)

## **REFERENCES**

- (1) BEER, F.P. & JOHNSTON, E.R. VECTOR MECHANICS FOR ENGINEERS: STATICS AND DYNAMICS
- (2) HIBBELER, R.C. ENGINEERING MECHANICS – DYNAMICS (SI UNITS)
- (3) MERIAM, J.L. & KRAIGE, L.G. ENGINEERING MECHANICS. VOL.2: DYNAMICS
- (4) PRENTIS, J.M. ENGINEERING MECHANICS

## **Booklists**

Please see the [Booklist for Part IB Courses](#) [3] for references for this module.

## **Examination Guidelines**

Please refer to [Form & conduct of the examinations](#) [4].

## **UK-SPEC**

The [UK Standard for Professional Engineering Competence \(UK-SPEC\)](#) [5] 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 [6] which sets out the standard for degree accreditation.

The [Output Standards Matrices](#) [7] 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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### Links

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

[2] <mailto:jsb56@cam.ac.uk>

[3] <https://www.vle.cam.ac.uk/mod/book/view.php?id=364081&chapterid=43321>

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

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

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

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