Engineering Tripos Part IB, 2P1: Mechanics, 2017-18

Lecturer

Dr H Hunt [1]

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.

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 in cartesian, polar and intrinsic co-ordinates, using graphical, algebraic and vector methods.
- Understand the concepts of relative velocity, relative acceleration and instantaneous centres of rigid bodies.
- Determine the centre of mass and moment of inertia of a plane lamina.
- Understand and apply the perpendicular and parallel axes theorems.
- Recognise whether a body is in static or dynamic equilibrium.
- Understand the concepts of energy, linear momentum and moment of momentum of a rigid body, and recognise when they are conserved.
- 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.
- Understand the concepts of static and dynamic balance of rotors and the methods for balancing rotors.
- Understand simple gyroscopic motion.

Content

Introduction and Terminology

Kinematics

- Differentiation of vectors *(4: pp 490-492)*
- Motion of a particle *Data book p2*
- 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 I - Inertia Forces and Energy

- Centre of mass, moments of inertia *Data book Section 4*
- D'Alembert force for a particle *(3: p 101)*
- D'Alembert force and torque for a rigid body in plane motion *(4: pp 787-788)*
- Kinetic energy of a rigid body in plane motion *(2: p 461)*
- Conservation of energy for conservative systems *(3: pp 453-458)*
- Inertia forces in plane mechanisms *(1: pp 200-206)*
- Method of virtual power *(4: pp 429-432)*
- Inertia stress and bending *(1) Ch 5*
- Balancing simple rotors *(1: pp 180-182)*

Rigid Body Dynamics II - Conservation of Momentum

- Momentum of a rigid body in plane motion *(2: pp 267-271)*
- Moment of momentum about G in plane motion *(3: pp 555-558)*
- Moment of momentum about a fixed point *(4: p 894)*
- Impact problems in plane motion *(3: pp 487-493)*
- Introduction to gyroscopic motion *(2: pp 564-571)*
- Lamina rotating about an axis in its own plane *(1: pp 185-187)*

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 [2] for references for this module.

Examination Guidelines

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

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [4] 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.

IA3

Comprehend the broad picture and thus work with an appropriate level of detail.

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.

US2

A comprehensive knowledge and understanding of mathematical and computer models relevant to the engineering discipline, and an appreciation of their limitations.

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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