Engineering Tripos Part IB, 2P1: Mechanics, 2021-22

Courese Leader

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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

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 refer to the Booklist for Part IB 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

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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