ES4G3-15 Dynamics of 3D Mechanical Systems

24/25

Department
School of Engineering
Level
Undergraduate Level 4
Module leader
Duncan Lockerby
Credit value
15
Module duration
10 weeks
Assessment
30% coursework, 70% exam
Study location
University of Warwick main campus, Coventry

Description

Introductory description

Module aims

The principal aims of the module are to understand, evaluate and optimise, through both analytical and numerical approaches, the dynamic behaviour of a complex mechanical system, in a variety of application contexts (e.g. in aerospace, automotive and robotics).

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

1. Introduction to 3D Dynamics:
   1i. motivation
   1ii. revision of rudimentary concepts in dynamics
   1iii. particle dynamics in 3D
2. 3D Kinematics of Rigid Bodies and Mechanisms:

2i. orientation and configuration (frames of reference, rotation matrices, Euler angles)
2ii. rigid-body kinematic equations
2iii. forward and inverse kinematics of mechanisms
2iv. application case study (robotics)

3. 3D Dynamics of Single Rigid Bodies:
   3i. moment of inertia tensor (principal moments, principal axis, products of inertia)
   3ii. general equations of motion for a 3D rigid body (Euler's laws, Newton-Euler equations)
   3iii. application case study (aerospace)
4. Multi-Body Dynamics:
   4i. degrees of freedom and constraints
   4ii. generalised coordinates, virtual displacements, virtual work and D'Alembert's principle
   4iii. fundamentals of Lagrangian mechanics
   4iv. application of Lagrange's equation to complex mechanical systems

Learning outcomes

By the end of the module, students should be able to:

- Perform advanced kinematic analysis on 3D mechanical systems, including spatial mechanisms. [M1, M2]
- Evaluate the motions produced by driving forces or the driving forces necessary to generate specific motions of 3D mechanical systems. [M1, M2]
- Design and simulate a mechanical system to meet a target specification and evaluate performance metrics with allowance for uncertainty. [M3, M6, M17]
- Evaluate the application of advanced dynamical systems (e.g. gyroscopes, robotics). [M2, M6]

Indicative reading list

- N. J. Kasdin and D. A. Paley, Engineering Dynamics: A Comprehensive Introduction, Princeton University Press, 2011
- D.T. Greenwood, Advanced Dynamics, Cambridge University Press, 2003
- M.W. Spong; S. Hutchinson; M. Vidyasagar, Robot Modelling and Control, John Wiley & Sons, 2006
- . J.R. Meriam and L.G. Kraige, Engineering Mechanics, Dynamics (7th Edition), Wiley, 2006

View reading list on Talis Aspire

Subject specific skills

1. Ability to conceive, make and realise a component, product, system or process;
2. Ability to develop economically viable and ethically sound sustainable solutions;
3. Ability to be pragmatic, taking a systematic approach and the logical and practical steps necessary for, often complex, concepts to become reality;
4. Ability to seek to achieve sustainable solutions to problems and have strategies for being creative and innovative;

5. Ability to be risk, cost and value-conscious, and aware of their ethical, social, cultural, environmental, health and safety, and wider professional engineering responsibilities;

Transferable skills

1. Numeracy: apply mathematical and computational methods to communicate parameters, model and optimize solutions;
2. Apply problem solving skills, information retrieval, and the effective use of general IT facilities;
3. Communicate (written and oral; to technical and non-technical audiences) and work with others;
4. Plan self-learning and improve performance, as the foundation for lifelong learning/CPD;
5. Exercise initiative and personal responsibility, including time management, which may be as a team member or leader;
6. Awareness of the nature of business and enterprise in the creation of economic and social value;
7. Overcome difficulties by employing skills, knowledge and understanding in a flexible manner;
8. Ability to formulate and operate within appropriate codes of conduct, when faced with an ethical issue;
9. Appreciation of the global dimensions of engineering, commerce and communication;
10. Be professional in their outlook, be capable of team working, be effective communicators, and be able to exercise responsibility and sound management approaches.

Study

Study time

Type	Required
Lectures	30 sessions of 1 hour (20%)
Private study	120 hours (80%)
Total	150 hours

Private study description

120 hr of self-guided study

Costs

No further costs have been identified for this module.

Assessment

You must pass all assessment components to pass the module.

Assessment group D

	Weighting	Study time	Eligible for self-certification
Assessment component			
Assignment	30%		Yes (extension)
Computer-based modelling assignment 2000 words/8 pages of text			
Reassessment component is the same			
Assessment component			
Examination	70%		No
1X2 hour QMP online test Answer book required.			
~Platforms - AEP,QMP			

- Online examination: No Answerbook required
- Students may use a calculator
- Engineering Data Book 8th Edition
- Graph paper

Reassessment component is the same

Feedback on assessment

- Coursework will be returned with marks and detailed feedback.
- Model solutions to exam type questions.
- Support through advice and feedback hours.
- Cohort level feedback on examinations

Past exam papers for ES4G3

Availability

Pre-requisites

To take this module, you must have passed:

- All of
  - ES193-15 Engineering Mathematics
  - ES2D5-15 Planar Structures and Mechanisms
  - ES190-15 Dynamics and Thermodynamics
  - ES2C5-15 Dynamics and Fluid Mechanics

Courses

This module is Core for:

- Year 1 of TESA-H341 Postgraduate Taught Advanced Mechanical Engineering

This module is Optional for:

- Year 5 of UESA-H115 MEng Engineering with Intercalated Year

This module is Option list A for:

- Year 4 of UESA-H114 MEng Engineering
- Year 4 of UESA-H316 MEng Mechanical Engineering
- Year 5 of UESA-H317 MEng Mechanical Engineering with Intercalated Year