ES480-15 Dynamic Analysis of Mechanical Systems

22/23

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

Description

Introductory description

ES480 -15 Dynamics Analysis of Mechanical Systems

Module web page

Module aims

The module aims to deliver an overview of important techniques of engineering dynamics, and providing insight into advanced knowledge in kinematics, kinetics, and vibrations.

The dynamics of engineering systems important to modern engineering applications such as spatial mechanisms and robots are examined. The complexities of kinematic and kinetic analysis of fully 3D motion will provide an appropriate challenge for the fourth year Master's level course.

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
   a. Importance of classical mechanics in 3D formulation
   Main topic in dynamics
   b. Main contents of the module
   c. Key issues in studying dynamics
   d. Course objectives and assignment
2. Mathematic background
   a. Vector and matrix operations
   b. Coordinate transformation
3. Kinematics of 2/3D systems
   Topology structure of mechanical systems
   a. Mobility analysis of mechanical systems
   b. Vector presentation of kinematics of a single body in 2/3D space
   c. Moving coordinate system
   d. Application to kinematic analysis of rigid body systems, e.g. planar/spatial linkages and robotic mechanisms
4. Kinetics of 2/3D systems
5. Newtonian method
   a. Vector presentation of force and moment equations of a rigid body in 2/3D (Newton-Euler equations)
   b. Application to kinetostatic analysis of planar linkages as a special topic
   c. Formulation of general equations of motion of rigid body systems in moving coordinate system, e.g. planar/spatial linkages and robotic mechanisms
6. Work-Energy method
   a. Virtual work principle
   b. Application to dynamic analysis of planar/spatial linkage and robotic mechanisms
7. Gyroscopic motions
   a. Explanation to procession phenomena
   b. Formulation of Euler’s Equation
   c. Steady state procession
   d. Application to satellite and gyro compass, etc.

Learning outcomes

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

- Autonomously evaluate mobility characteristics of 3D mechanical systems.
- Perform advanced kinematic analysis on spatial mechanisms and robots using vector and matrix representations.
- Evaluate complex mechanisms sensitivity to design parameters, and interpret usability.
- Apply a systematic approach to the approximations of complex engineering problems to enable efficient analysis with acceptable predictive accuracy and so apply a practical treatment to engineering uncertainty.
- Use either Newtonian method or virtual work principle to evaluate the motions produces by driving forces, or the reaction forces and driving forces necessary to generate specific motions of 3D mechanical systems, e.g, robotic mechanisms.
- Predict forces and motions of important special cases of general motion such as gyroscopes.

Indicative reading list

- Design of Machinery: an Introduction to the Synthesis and Analysis of Mechanisms and Machines, Norton, RL, 5th edition (McGraw Hill 2012).
- Shigley, J.E. Uicker, J.J. Theory of machines and mechanisms, McGraw-Hill Education, 2016.
- J.R. Meriam and L.G. Kraige, Engineering Mechanics, Dynamics (7th Edition), Wiley, 2006.
- Grosjean, J., Kinematics and Dynamics of Mechanisms, McGraw Hill 1991.
- AShabana, A. A., Computational Dynamics, 2nd Ed., Wiley 2001 .

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%)
Tutorials	2 sessions of 1 hour (1%)
Private study	118 hours (79%)
Total	150 hours

Private study description

118 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.

Students can register for this module without taking any assessment.

Assessment group D6

	Weighting	Study time
Assignment	30%	
Computer-based Modelling Assignment 2000 words/9 pages of text		
Online Examination	70%	
2 * 1 hour QMP online tests to be scheduled in same time slot with short break inbetween		
~Platforms - AEP,QMP		

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

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 ES480

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 4 of UESA-H116 MEng Engineering with Exchange Year
- Year 5 of UESA-H115 MEng Engineering with Intercalated Year

This module is Option list A for:

- Year 5 of UESA-H636 MEng Electronic Engineering with Intercalated Year
- Year 4 of UESA-H114 MEng Engineering
- Year 5 of UESA-HH38 MEng Manufacturing and Mechanical Engineering with Intercalated Year
- UESA-H311 MEng Mechanical Engineering
  - Year 4 of H311 Mechanical Engineering
  - Year 4 of H30J Mechanical Engineering with Appropriate Technology
  - Year 4 of H30L Mechanical Engineering with Automotive Engineering
  - Year 4 of H30G Mechanical Engineering with Business Management
  - Year 4 of H30P Mechanical Engineering with Fluid Dynamics
  - Year 4 of H30K Mechanical Engineering with Instrumentation
  - Year 4 of H30M Mechanical Engineering with Robotics
  - Year 4 of H30H Mechanical Engineering with Sustainability
  - Year 4 of H30N Mechanical Engineering with Systems Engineering

- Year 4 of UESA-H316 MEng Mechanical Engineering
- Year 4 of UESA-H318 MEng Mechanical Engineering with Exchange Year
- Year 5 of UESA-H317 MEng Mechanical Engineering with Intercalated Year

This module is Option list B for:

- Year 5 of UESA-H636 MEng Electronic Engineering with Intercalated Year
- UESA-H311 MEng Mechanical Engineering
    - Year 4 of H30M Mechanical Engineering with Robotics
    - Year 4 of H30N Mechanical Engineering with Systems Engineering