London South Bank University

Module Guide

Dynamics and Control

EEG-5-447

School of Engineering

Academic Year 2018-19

Level 5

Table of Contents

1. MODULE DETAILS

Module Title:	Dynamics and Control
Module Level:	Level 5
Module Reference Number:	EEG_5_447
Credit Value:	20
Student Study Hours:	200
Contact Hours:	78
Private Study Hours:	122
Pre-requisite Learning (If applicable):	Appropriate Mathematics and Dynamics modules at level 4
Co-requisite Modules (If applicable):	None
Course(s):	MEng, BEng (Hons) Mechanical Engineering
Year and Semester	2015-16, Semester 2
Module Coordinator:	• Dr Geoff Goss Ext7625, gossga@lsbu.ac.uk, T708
Teaching Team & Contact Details	• Dr Shyamal Mondal Ext7175, mondals@lsbu.ac.uk T402 • Mehdi Zahir Ext7530, zahirm@lsbu.ac.uk T411
Subject Area:	Division of Mechanical and Design
Summary of Assessment Method:	70% written examination, 30% coursework

2. SHORT DESCRIPTION

This module builds on the platform established at level 4. The module covers dynamics and classical control theory. Students extend their treatment of dynamics from point masses to rigid bodies and cover a wider scope of application of the principles of mechanics. The students will apply a variety of mathematical techniques to the study of dynamics and feedback problems. Students additionally study various methods of classical control theory such as Bode, Nyquist and Root Locus.

3. AIMS OF THE MODULE

- To extend the student's skill in solving analytical and practical design problems relating to engineering systems which involve translation, rotation about a fixed axis, and general plane motion.
- To develop the students’ understanding of the fundamental principles of rigid body mechanics and their application to linkages, mechanisms, and machines.
- To provide a grounding in classical control theory and its application to engineering feedback systems.

4. LEARNING OUTCOMES

At the end of the module, students will be able to undertake the actions described in each of the four areas below.

Knowledge and Understanding

Upon completion of this module the student should be able to:

- Use the principles of mechanics and mathematical techniques to analyse and solve applied dynamics problems involving translation and rotation in the plane.
- Know how to apply the principles of mechanics and mathematical techniques to the interpretation and analysis of data obtained from dynamics experiments.
- Sketch and plot (using MATLAB) solutions to dynamics and control problems.
- Model and analyse the stability, frequency and time behaviour of continuous-time systems.
- Perform analysis of approximate higher order polynomial control systems with a second order model and determine system parameters
- Distinguish between open loop and close loop control system and understand the concept of automatic control theory and appreciate the role played by feedback
- Know how to apply the PID controllers as a non-model based method to improve the servo following of systems.
- Use model simulation techniques to help in the modelling and design of complex control systems

Intellectual Skills

Students will know

- how to derive linear second order differential equations from free body diagrams and solve them.
- how to apply Laplace Transforms to the study of PID control systems.

- the advantages and disadvantages of applying different mechanical principles and analytical techniques to mechanics problems e.g., work-energy, impulse-momentum; force acceleration, moments.
- how to different coordinate systems for the analysis of mechanics problems

Practical Skills

Students will be able to

- utilise mathematical/computer methods to simulate dynamical and feedback control systems.
- analyse experimental data using software (e.g. MATLAB) and compare the results with theoretical predictions.

Transferable Skills

Students will have the ability to

- critically evaluate experimental data and identify how it differs from predicted results based on mathematical models.
- produce concise and cohesive reports that include mathematical equations, tabulated data, graphs and diagrams, using software.

5. ASSESSMENT OF THE MODULE

- Control laboratory work: log-book plus mini-test: 30%
- Examination on Control Theory and Dynamics: 70% (end of semester)

All coursework assignments are summative, formal reports will contain formative feedback.

6. FEEDBACK

Feedback will normally be given to students 15 working days after the submission of an assignment.

7. INTRODUCTION TO STUDYING THE MODULE

7.1 Overview of the Main Content

- Kinematics of Particles: rectilinear and polar coordinates. Variable acceleration.
- Linkages, Mechanisms and Machines: Relative velocity and acceleration analysis for planar mechanisms.
- Rigid Body Kinetics: Rectilinear and Rotary motion. Applications: cars, flywheels. Out of balance flywheels.

- Work energy principle and its applications
- Impulse momentum principle and its applications
- Damped vibrations.

Control systems

- Analysis of transient and steady state response and Ruth's Hurwitz stability criterion
- PID control of second order systems. Analyse the effect of using PID gain in reducing steady-state errors, overshoot and quick response to command inputs.
- Analysis of Nyquist Stability criterion and application of the mapping theorem to the stability of closed loop system
- Frequency response methods for the analysis of systems. Identification of system transfer function from Bode diagrams. Determination of system stability from Bode plots. Gain and phase margins.
- Design of control systems with Root Locus and investigation of centroid and pole zero excess and determine the range of gains for which the system remains stable.
- Investigation of sketching Bode plots, Root Locus, PID gain and verifying with MATLAB and SIMULINK.

Practical

- Experimental investigations
- Computer simulations

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7.2 Overview of Types of Classes

The module involves

- Experimental investigations
- Computer simulations
- Lectures
- Tutorials

7.3 Importance of Student Self-Managed Learning Time

This module involves a significant amount of analytical techniques, including vectors, calculus, matrices, and algebra. Students who lack confidence in these areas will be given step-by-step assistance in tutorial sessions. Students should set aside adequate time to tackle tutorial sheets in their private study time.

7.4 Employability

This module is suitable for students who intend to work in organisations that involve systems and machinery for control and dynamics.

8. THE PROGRAMME OF TEACHING, LEARNING AND ASSESSMENT

Average 5hs per week throughout the semester, typically lecture & tutorial and structured laboratory sessions

Refer to the WEEKLY GUIDE for a breakdown of the schedule

9. STUDENT EVALUATION

This is a new module and no student evaluation is available.

10. LEARNING RESOURCES

Core Materials

- Meriam J.L., and Kraige. L.G., *Engineering Mechanics: Statics and Dynamics,* 7th Ed, Wiley, 2007.
- Hibbleler, R.C., *Engineering Mechanics: Statics and Dynamics*, 11th Ed, Prentice Hall, 2007.
- Nise N.S., *Control systems Engineering*, 6th Ed, 2011.
- Dorf, R.C., and Bishop, Robert H., *Modern Control Systems*, 11th Pearson Prentice Hall, 2008.

Optional Materials

- Rao, S.S. *Mechanical Vibrations* Pearson 2005.
- Ogata K., *Modern Control Engineering*, 5th Edition, Pearson, 2010.
- Gene F. F. J., Powell D., and Emami-Naeini A., *Feedback Control of Dynamic Systems*, 6th Ed Pearson International, 2010.
- Close C., and Federick D.K., *Modelling and Analysis of Dynamics Systems*, 2001.