London South Bank University

EST 1892

Module Guide

Principles of Control

ENG_5_415

School of Engineering

Level 5

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1. MODULE DETAILS

Module Title:	Principles of Control
Module Level:	5
Module Reference Number:	ENG_5_415
Credit Value:	20
Student Study Hours:	200 hours
Contact Hours:	72 hours
Private Study Hours:	128 hours
Pre-requisite Learning (If applicable):	Engineering Mathematics and Modelling (or equivalent)
Co-requisite Modules (If applicable):	None
Course(s):	4526.2 MEng Electrical and Electronic Eng. FT 4528.2 MEng Petroleum Eng. FT 4529.2 MEng Electrical and Electronic Eng. PT 4622.2 MEng Elec. Eng and Power Electronics FT 502.2 BEng Electrical and Electronic Eng. PT 501.2 BEng Electrical and Electronic Eng. FT 4633.2 BEng Elec. Eng and Power Electronics PT 4623.2 MEng Elec. Eng and Power Electronics PT 2134.2 BEng Chemical and Process Eng FT 3016.2 BEng Petroleum Eng. FT 4632.2 BEng Elec. Eng and Power Electronics FT
Year and Semester	2019-2020, Semester 2
Module Coordinator:	Professor M. Osman Tokhi
MC Contact Details (Tel, Email, Room)	020 7815-7533, tokhim@lsbu.ac.uk, T800
Teaching Team & Contact Details (If applicable):	Saham Sherhani, Mehdi Zahir
Subject Area:	Electrical and Electronic Engineering
Summary of Assessment Method:	Exam (2hr) - 70% Course Work (Logbook + test) – 30%
External Examiner appointed for module:	Professor Danny Morton, University of Bolton

2. SHORT DESCRIPTION

This level 5 module aims to give a sound understanding of a range of topics in Control Systems Engineering.

It imparts methods to model and analyse dynamical systems met in the engineering of systems such as robotics, automobiles, aircraft, automatic machinery, chemical process plant, etc. Determine the stability of a system and to predict system responses in the time domain (transient and steady state) and in the frequency domain. Handle the interconnection of many Single Input Single Output systems connected in feedback and feed forward configurations. Modify the behaviour of a given system by using feedback control to improve stability, to make the system act quickly and precisely, and to reduce the effect of disturbances.

Learning is supported by a laboratory workshop that enables the study of control systems using both analysis methods and computer simulation using MATLAB and SIMULINK.

3. AIMS OF THE MODULE

This module is designed to provide the engineering student with a good foundation in control systems by emphasising topics in the design and analysis of control systems. The main aims are to provide the tools to mathematically model dynamical systems, predict their time and frequency responses, analyse their stability and understand the role of feedback loops to modify the behaviour of a system.

4. LEARNING OUTCOMES

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

4.1 Knowledge and Understanding Science and Mathematics (SM)

- Understand the fundamental concepts and principles of control theory and appreciate the role played by feedback
- Appreciate the use of Proportional, Integral and Derivative (PID) controllers as a non-model based method to improve the servo following of systems (SM1, SM2)

4.2 Intellectual Skills Engineering Analysis (EA)

- Analyse the behaviour and performance of simple control systems in the time domain and frequency domain (EA1, EA2)

4.3 Practical Skills Engineering Practice (EP)

- Document and analyse engineering data gained from practical laboratory measurements
- Use Matlab/Simulink to handle engineering problems that include modelling and simulation of dynamic systems, predicting time and frequency responses, etc. (EP2, EP3)

4.4 Transferable Skills Additional General Skills

Effectively communicate and critically evaluate observed results in a technical format after organising and presenting data. General IT skills.

5. ASSESSMENT OF THE MODULE

There are two components of assessment – an examination and coursework. The pass mark for the module is 40% and you must obtain a minimum mark of 30% in each component.

Examination A two hour unseen written examination at the end of the module which will contribute 70% of the module mark, see the table below. The exam paper will have 6, equal value, 30-minute questions. Your exam mark will be calculated from your answers to 4 questions which achieve the best marks. The university's examination rules apply and you must make yourself familiar with these.

Coursework i) The laboratory logbook, and ii) a Phase-test. These are treated together as one assessment component and will contribute 30% of the module mark. The logbook must be handed in by the Friday of Week 12 (see calendar). The phase-test will take place during your scheduled laboratory session in week 12. The test will consist of 15 multiple choice questions. The logbook and phase test will be equally weighted when computing your final coursework mark.

All deadlines must be strictly met, late work will be penalised according to University regulations.

Coursework Assessment Criteria Logbook marks will be awarded for:

- maintaining an accurate, dated record of your work as it is carried out
- exercises completed and questions answered
- tabulating your results and data
- clear graphs with correctly labelled axes and titles, with experimental points clearly shown
- accuracy and clarity of results and analysis comments/observations on your results
- the provision of brief conclusions for each exercise
- quality of the presentation and structure of your log book;
- provision of a contents list at the front

Some common reasons for low marks are,

- missed work,
- failure to document work,
- poor presentation and inadequate 'signposting'
- failure to correctly follow the instructions in the workshop manual
- failure to submit by the deadline

Student attendance in the laboratory sessions is essential, and this will impact on the logbook mark of the student; ***the number of sessions attended relative to the total number of sessions will be used as a scaling factor for determining the final logbook mark***.

6. FEEDBACK

Feedback will normally be given to students 15 working days after the final submission of an assignment or as advised by their module leader.

General feedback, applying to all students, will also be placed on the module VLE site within 15 working days.

7. INTRODUCTION TO STUDYING THE MODULE

7.1 Overview of the Main Content

i. Modelling of linear systems with differential equations. Model first and second order systems e.g. RC and RLC circuits, translation and rotation mechanical systems, DC motors and servomechanisms, flow and liquid level in storage tanks.

ii. Transform differential equations to Transfer Functions (TF) and perform prediction of time and frequency responses.

iii. Perform analysis of first and second order systems from their Transfer function description by determining system parameters such as Open-loop gain, damping ratio, undamped natural frequency, poles and zeros. Relate these to constants of the underlying system e.g. resistance, capacitance, inductance, friction, mass, capacity, etc. State qualitatively the type and speed of transient response a system will have from knowledge of its pole locations and relationship of poles to system parameters. Approximate higher order systems with a second order model. Find the stability of a system using the Routh-Hurwitz criteria. Find the zero-state and zero-input response of a system to inputs such as unit step, unit ramp and parabolic inputs. Find the frequency response of a system to pure sinusoidal inputs from its transfer function description – Bode plots. Perform system identification (find transfer function) using measured frequency response.

iv. Block diagram representation of interconnection of systems and their reduction to a single transfer function.

v. Simple Feedback control. The root locus method. Sketch the root loci, determine the range of gains for which the system remains stable. Design feedback controllers using the root locus method. Tracking systems. Find the Type Number of a system and state the ability of type zero, type one, type two systems to follow power-of-time inputs such as step inputs, ramp inputs and half parabola inputs.

vi. Proportional Integral and Derivative (PID) control. Effect of Proportional gain on the undamped natural frequency and hence speed of response of a system. Effect of Derivative gain on the damping ratio. Effect of using Integral gain in reducing steady-state errors to command inputs. Experimental methods to find initial estimates of PID parameters. Examples of commercially available industrial PID control modules.

7.2 Overview of Types of Classes

Lectures. The taught material will be covered by lectures supported by printed notes that will be given out in the first lab. session. There are two hours of lectures scheduled per week.
Before each lecture session you should consult the course notes and read the lecture material. After each lecture you should, re-read the material within 24 hours, and attempt the tutorial question and past examination questions on the lecture topic. You should also do further reading as necessary to improve your understanding.

Tutorials. Tutorial exercises are in a separate book that will be distributed at the start of the module. You should attempt these as soon as possible after the lecture. A selection of questions will also be discussed in tutorial sessions. The questions answered in these sessions will be largely determined by the by students' requests. Full working and answers will be available from the MOODLE site for this module. There will also be copies of recent past examination papers on MOODLE together with model answers.

Laboratories. In the lab. sessions in T405 you will be using the control systems analysis package MatLab - developed by MathWorks Inc. You will be divided into groups for the laboratory so that ideally no more than two are in each group. Before each scheduled workshop session you should read through the instructions in the workshop manual **before** you attend the workshop session to become familiar with the contents. Please obtain a laboratory notebook (logbook) before your first lab. session. The logbook should be used to take notes as you do the lab. exercises, the principles of control explored with MatLab simulations are assessed by submission of your log book. After each workshop session you should ensure that all questions posed in the instruction manual are answered. Draw up any comparison tables needed and try to take an overview on what has been achieved.

7.3 Importance of Student Self-Managed Learning Time

You should organise yourself so that you have about 6 hours of your own time per week for private study. This time should be increased as the examination approaches. In the private study time your main tasks are to assimilate the lecture material, attempt the tutorial questions, manage the upkeep of material in your laboratory logbook and prepare for the following week's sessions. To succeed in this and get the most from the module, you will need to exert self-discipline to manage your private study time effectively, particularly as you will be studying other level 5 modules at the same time. Note that coursework from other modules should not stop you from attending the lectures, tutorials and laboratory sessions for this module.

Below are some suggestions that may help (see also the Study Skills Survival Guide available from the Study Skills Centre).

- Always try to re-read the lecture material within 24 hours of the lecture - retention will be helped if the material is still fresh in your mind.
- Plan the pace of your studies with great care and coordinate across modules so that you are not left with a large amount of work to do in the last few weeks when you should be concentrating on revision of the material.
- Try to get into regular study habits at set times and places. Find out when and where you best study and optimise the arrangements for this. For example, find sufficient space for your papers with preferably a dedicated table so that papers do not continually have to be cleared and material for individual modules can be easily accessed and filed.
- Try to minimise external disruptions when you study but give yourself time for rest periods and food.

7.4 Employability

Control system theory and practice is core to most engineering systems (electrical/electronic, mechanical, processes, Mechatronics, manufacturing, etc.) and hence provides employment opportunities in most industries.

8. THE PROGRAMME OF TEACHING, LEARNING AND ASSESSMENT

SEMESTER 2		
Week No.	Duration	TOPIC
Wk1	2hrs	Laplace transforms.
Wk 2	2hrs	Inverse Laplace transformation, partial fraction expansion and tables of transforms.
Wk3	2hrs	System modelling, first order systems
Wk4	2hrs	Modelling of dynamic systems with differential equations, second order systems, transfer functions
Wk5	2hrs	Modelling of electrical, mechanical (rotational and translational) systems. Servomechanisms, Liquid level and flow.
Wk6	2hrs	Control system structure. Types of controller such as feedback and feedforward control systems. Block diagram reduction. Steady state value of the output of a system and approximation of higher order systems by second order systems
Wk7	2hrs	Stability assessment techniques Routh Hurwitz method.
Wk8	2hrs	Root locus method.
Wk9	2hrs	Feedback controllers**.** Proportional, Integral and Derivative (PID) control. Tuning of PID controllers.
Wk10	2hrs	Transient response of systems and Tracking systems First and second order systems. Time responses, specifications and performance indicators
Wk11	2hrs	Steady state tracking errors to unit step, unit ramp and half parabola inputs.
Wk12	2hrs	Frequency response testing of systems.
Wk13	2hrs	Revision

9. STUDENT EVALUATION

The return rate for the module evaluation questionnaire was 28% of all students taking the module. The following is a summary of issues raised.

- 9:00 am start. There were comments from students upset about the early start to the lectures. Several students arrived at around 9:30 and some even later. However, many did not arrive at all. It is difficult to see what can be done about this unless the University takes a decision to start all classes later. Many years ago classes were timetabled to begin at 9:30 to allow students with childcare responsibilities to attend classes from the beginning.

- Too much writing. Some students complained that they we required to do too much note taking in lectures. This is odd as all the notes presented in lectures were posted on the Moodle site for the module, usually within half-an-hour of the end of the lecture. Moreover, this was repeatedly announced at lectures. I can only assume that they could not find these on the site, see next point.

- Not enough relevance to petroleum engineering. The majority of students on the module are studying courses in Petroleum Engineering or Chemical Engineering. It might be helpful if some of the examples, especially the ones at the beginning of the module were relevant to these subjects.

10. LEARNING RESOURCES

Reading List

Core text:

Principles of Control Lecture Notes, Tutorial Workbook – Professor Tariq Sattar

The recommended book for the module is:

1. Gene F. Franklin, J. David Powell & Abbas Emami-Naeini [2014] Feedback Control of Dynamic Systems, 7^{th} Edition, Prentice Hall

Background reading

1. Ogata, Katsuhiko, [2010] Modern Control Engineering, 5^{th} Edition, Pearson, ISBN 10:0-13-713337-5.

2. Dorf, Richard C., and Bishop, Robert H., [2011] Modern Control Systems, 12th ed.: Pearson education Limited