

MA3H7-15 Control Theory

26/27

Department

Warwick Mathematics Institute

Level

Undergraduate Level 3

Module leader

Randa Herzallah

Credit value

15

Module duration

10 weeks

Assessment

Multiple

Study location

University of Warwick main campus, Coventry

Description

Introductory description

In many areas of science and engineering, systems are modelled using differential equations that describe how the system dynamics evolve over time. These equations help us model systems like robots and cars, electrical circuits, and even how populations of animals interact in nature. These systems can often be influenced through actuators using control inputs. At the same time, we might only have access to limited measurements from which we must infer the internal state of the system.

In this course we will focus on the mathematical tools that can be used to model, analyze, and control such systems. Emphasis will be given to linear, time-invariant systems in state-space form. We will study how to determine whether a system can be controlled or observed, and how to design strategies to stabilise or guide the system to a desired behavior.

Topics include:

- the analysis of controllability, observability, stabilisability, and detectability.
- the design of controllers via feedback, pole placement, and Lyapunov-based methods.
- the design of optimal control using the linear-quadratic regulator (LQR).
- illustration of these concepts through examples and numerical simulations, using programming tools such as MATLAB or Python.

[Module web page](#)

Module aims

This module will introduce you to some of the key mathematical ideas behind control theory. It aims to teach you how to model real-world systems using differential equations, how to analyse their behaviour, and how to design controllers that influence how they develop. Along the way, you will build on mathematics you have already seen and learn new tools that are essential in modern control and systems engineering.

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.

Will include the study of controllability, stabilization, observability, filtering and optimal control. Furthermore connections between these concepts will also be studied. Both linear and nonlinear systems will be considered.

Learning outcomes

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

- Understand how complex systems can be described using mathematical equations, and how to actually control their behaviour.
- Understand of the concepts of controllability, observability, and stabilizability, and know why they matters.
- Learn how to design controllers using feedback control and pole placement methods.
- Be able to analyse systems' stability using Lyapunov's method.
- learn how to design optimal controllers that meet specific goals like minimizing error or energy use using ideas like the Linear Quadratic Regulator.
- Recognise practical problems where control methods can be used effectively.

Indicative reading list

[Reading lists can be found in Talis](#)

Interdisciplinary

The course draws concepts from multiple disciplines including mathematics, engineering, physics, and computer science.

Subject specific skills

Ability to decide whether a linear system is controllable, observable. Ability to design feedback control. Ability to design optimal control.

Transferable skills

Understanding of how mathematics relates to real-world engineering.

Study

Study time

Type	Required
Lectures	30 sessions of 1 hour (20%)
Tutorials	9 sessions of 1 hour (6%)
Private study	111 hours (74%)
Total	150 hours

Private study description

Review lectured material and work on set exercises.

Costs

No further costs have been identified for this module.

Assessment

You do not need to pass all assessment components to pass the module.

Assessment group B2

	Weighting	Study time	Eligible for self-certification
Centrally-timetabled examination (On-campus) A 3-hour written exam.	100%		No

- Answerbook Gold (24 page)

Assessment group R1

	Weighting	Study time	Eligible for self-certification
In-person Examination - Resit	100%		No

- Answerbook Gold (24 page)

Feedback on assessment

Support classes, work returned after marking and exam feedback.

[Past exam papers for MA3H7](#)

Availability

Courses

This module is Optional for:

- Year 1 of TMAA-G1PD Postgraduate Taught Interdisciplinary Mathematics (Diploma plus MSc)
- Year 1 of TMAA-G1P0 Postgraduate Taught Mathematics
- TMAA-G1PC Postgraduate Taught Mathematics (Diploma plus MSc)
 - Year 1 of G1PC Mathematics (Diploma plus MSc)
 - Year 2 of G1PC Mathematics (Diploma plus MSc)
- Year 3 of UCSA-G4G1 Undergraduate Discrete Mathematics
- UCSA-G4G3 Undergraduate Discrete Mathematics
 - Year 3 of G4G1 Discrete Mathematics
 - Year 3 of G4G3 Discrete Mathematics
- Year 4 of UCSA-G4G4 Undergraduate Discrete Mathematics (with Intercalated Year)
- Year 4 of UCSA-G4G2 Undergraduate Discrete Mathematics with Intercalated Year
- Year 3 of USTA-G300 Undergraduate Master of Mathematics, Operational Research, Statistics and Economics
- Year 3 of UMAA-GL11 Undergraduate Mathematics and Economics
- Year 4 of UECA-GL12 Undergraduate Mathematics and Economics (with Intercalated Year)

This module is Core option list A for:

- Year 4 of UMAA-GV18 Undergraduate Mathematics and Philosophy with Intercalated Year

This module is Core option list B for:

- Year 3 of UMAA-GV17 Undergraduate Mathematics and Philosophy
- Year 3 of UMAA-GV19 Undergraduate Mathematics and Philosophy with Specialism in Logic and Foundations

This module is Core option list C for:

- Year 3 of UMAA-GV17 Undergraduate Mathematics and Philosophy
- Year 3 of UMAA-GV19 Undergraduate Mathematics and Philosophy with Specialism in Logic and Foundations

This module is Core option list D for:

- Year 4 of UMAA-GV18 Undergraduate Mathematics and Philosophy with Intercalated Year
- Year 4 of UMAA-GV19 Undergraduate Mathematics and Philosophy with Specialism in Logic and Foundations

This module is Core option list F for:

- Year 4 of UMAA-GV19 Undergraduate Mathematics and Philosophy with Specialism in Logic and Foundations

This module is Option list A for:

- TMAA-G1PD Postgraduate Taught Interdisciplinary Mathematics (Diploma plus MSc)
 - Year 1 of G1PD Interdisciplinary Mathematics (Diploma plus MSc)
 - Year 2 of G1PD Interdisciplinary Mathematics (Diploma plus MSc)
- Year 1 of TMAA-G1P0 Postgraduate Taught Mathematics
- Year 1 of TMAA-G1PC Postgraduate Taught Mathematics (Diploma plus MSc)
- UMAA-G105 Undergraduate Master of Mathematics (with Intercalated Year)
 - Year 3 of G105 Mathematics (MMath) with Intercalated Year
 - Year 4 of G105 Mathematics (MMath) with Intercalated Year
 - Year 5 of G105 Mathematics (MMath) with Intercalated Year
- Year 3 of USTA-G300 Undergraduate Master of Mathematics, Operational Research, Statistics and Economics
- Year 3 of UMAA-G100 Undergraduate Mathematics (BSc)
- UMAA-G103 Undergraduate Mathematics (MMath)
 - Year 3 of G100 Mathematics
 - Year 3 of G103 Mathematics (MMath)
 - Year 4 of G103 Mathematics (MMath)
- Year 4 of UMAA-G107 Undergraduate Mathematics (MMath) with Study Abroad
- UMAA-G106 Undergraduate Mathematics (MMath) with Study in Europe
 - Year 3 of G106 Mathematics (MMath) with Study in Europe
 - Year 4 of G106 Mathematics (MMath) with Study in Europe
- Year 3 of UPXA-GF13 Undergraduate Mathematics and Physics (BSc)
- UPXA-FG31 Undergraduate Mathematics and Physics (MMathPhys)
 - Year 3 of GF13 Mathematics and Physics
 - Year 3 of FG31 Mathematics and Physics (MMathPhys)
- Year 4 of UPXA-GF14 Undergraduate Mathematics and Physics (with Intercalated Year)
- Year 4 of USTA-G1G3 Undergraduate Mathematics and Statistics (BSc MMathStat)
- Year 4 of UMAA-G101 Undergraduate Mathematics with Intercalated Year
- Year 3 of USTA-Y602 Undergraduate Mathematics, Operational Research, Statistics and Economics
- Year 4 of USTA-Y603 Undergraduate Mathematics, Operational Research, Statistics, Economics (with Intercalated Year)

This module is Option list B for:

- Year 1 of TMAA-G1PE Master of Advanced Study in Mathematical Sciences
- Year 3 of USTA-GG14 Undergraduate Mathematics and Statistics (BSc)
- Year 4 of USTA-GG17 Undergraduate Mathematics and Statistics (with Intercalated Year)

This module is Option list C for:

- Year 3 of USTA-G300 Undergraduate Master of Mathematics, Operational Research, Statistics and Economics
- Year 3 of USTA-G1G3 Undergraduate Mathematics and Statistics (BSc MMathStat)

This module is Option list E for:

- USTA-G301 Undergraduate Master of Mathematics, Operational Research, Statistics and Economics (with Intercalated
 - Year 4 of G30H Master of Maths, Op.Res, Stats & Economics (Statistics with Mathematics Stream)
 - Year 5 of G30H Master of Maths, Op.Res, Stats & Economics (Statistics with Mathematics Stream)