Unit T7: Modelling and Simulation for Engineers

Unit code:	F/503/7343
QCF level:	6
Credit value:	15

Aim

This unit gives learners the opportunity to develop their understanding of Ordinary Differential Equations and Partial Differential Equations (ODEs and PDEs). Learners will gain skills in algorithm design and programming techniques in MATLAB/Simulink; for the modelling, simulation and analysis of dynamic engineering systems.

Unit abstract

Computer-based modelling and simulation of dynamic engineering systems is a key employability skill for engineering graduates. MATLAB/Simulink is the industry standard for this activity and it is therefore vital that learners are well versed in using MATLAB/Simulink to model and solve engineering problems and to simulate engineering systems.

Learning outcomes 1 and 2 of this unit will develop learners' understanding of the formulation and solution of ordinary and partial differential equations. Learning outcomes 3 and 4 then take learners through the processes, procedures and software routines on MATLAB for modelling and graphical analysis of dynamic engineering problems described by ODEs and PDEs. Learning outcome 5 introduces learners to the powerful Simulink simulation environment that enables simulation of complex interconnected dynamic engineering systems.

Learning outcomes

On successful completion of this unit a learner will:

1 understand how standard ordinary differential equations and partial differential equations are used in engineering

2 be able to use numerical techniques in the solution of ordinary differential equations and partial differential equations

3 be able to use MATLAB to model dynamic engineering systems

4 be able to use MATLAB for graphical analysis of dynamic engineering systems

5 be able to use MATLAB/Simulink to simulate dynamic engineering systems.

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Unit content

1 **Understand how standard ordinary differential equations and partial differential equations are used in engineering.**

Ordinary differential equations (ODEs): equations of motion; simple engineering systems, eg 2nd order electrical, mechanical, thermo; analogies between mechanical, electrical and thermo systems; conversion into ODEs

Partial differential equations (PDEs): eg Fourier's equation of heat conduction, Laplace's equation, Poisson's equation, the wave equation

Fourier series and Fourier transforms: definitions; general results; application in ODEs and PDEs governing engineering systems

2 **Be able to use numerical techniques in the solution of ordinary differential equations and partial differential equations**

Numerical techniques: analytical solution of ODEs and PDEs, eg Euler, Runge-Kutta, Taylor's expansions, direct partial integration; initial conditions; boundary conditions; separation of variables; numerical stability; variable step length; Fourier series and Fourier transforms (definitions, general results, application in solving ODEs and PDEs)

3 **Be able to use MATLAB to model dynamic engineering systems**

MATLAB programming: MATLAB syntax, eg for and while loops, relational and logical operators; M-files; scripts, functions; flow control

Use of MATLAB tool boxes for engineering system analysis: eg control systems toolbox, signal processing toolbox

4 **Be able to use MATLAB for graphical analysis of dynamic engineering systems**

Graphics management: plotting commands; two and three-dimensional plotting; surfaces; image manipulation; interactive plotting tools; animation

Graphical analysis: graphical solutions (ODEs, PDEs); integration of MATLAB tool boxes, eg control systems toolbox, signal processing toolbox

5 **Be able to use MATLAB/Simulink to simulate dynamic engineering systems**

Simulink simulation diagrams: simple dynamic systems; dynamic models (PDEs, ODEs, transfer functions, linear systems, non-linear systems); complex interconnected systems (model segmentation, sub-systems, hierarchies, design components, bottom-to-top approach)

Simulation analysis: simple dynamic systems; complex interconnected systems; analytical analysis; graphical analysis

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Learning outcomes and assessment criteria

Learning outcomes On successful completion of this unit a learner will:	**Assessment criteria for pass** The learner can:
LO1 Understand how standard ordinary differential equations and partial differential equations are used in engineering	1.1 Analyse a given engineering problem formulating mathematical models using ODEs 1.2 Analyse a given engineering problem and formulate mathematical models using PDEs 1.3 Critically evaluate the application of Fourier series and Fourier Transforms in ODEs and PDEs
LO2 Be able to use numerical techniques in the solution of ordinary differential equations and partial differential equations	2.1 Critically evaluate numerical techniques in the solution of ODEs and PDEs 2.2 Solve a given engineering problem described by ODEs and PDEs
LO3 Be able to use MATLAB to model dynamic engineering systems	3.1 Construct a MATLAB representation for a given engineering problem described by ODEs and PDEs 3.2 Create a MATLAB program to solve given ODEs and PDEs 3.3 Use MATLAB toolboxes to model dynamic engineering systems
LO4 Be able to use MATLAB for graphical analysis of dynamic engineering systems	4.1 Develop a MATLAB programme using an image manipulation routine 4.2 Produce graphical solutions of ODEs and PDEs using MATLAB 4.3 Use MATLAB toolboxes to produce graphical analysis of dynamic engineering systems
LO5 Be able to use MATLAB/Simulink to simulate dynamic engineering systems	5.1 Develop Simulink diagrams to simulate simple dynamic engineering problems 5.2 Develop Simulink diagrams to simulate complex interconnected dynamic engineering systems 5.3 Use MATLAB/Simulink to produce analytical and graphical analysis of dynamic engineering systems

Guidance

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

The learning outcomes associated with this unit are closely linked with:

Level 5	Level 6
Unit 35: Further Analytical Methods for Engineers	*Unit T1: Major Project*
Unit 59: Advanced Mathematics for Engineering	*Unit T8: Digital Signal Processing*
	Unit T9: Control Engineering Design

The content of this unit has been designed and mapped against the Engineering Council's current Learning Outcomes for IEng Accreditation. The completion of the learning outcomes for this unit will contribute knowledge, understanding and skills towards the evidence requirements for IEng Registration.

See *Annexe B* for summary of mapping information for IEng Accreditation.

Essential requirements

Laboratory use licences for MATLAB/Simulink and associated toolboxes are required for this unit.

Delivery

Laboratory-based work is a dominant feature for the delivery and assessment of this unit.

Resources

Books

Etter D M – *Introduction to MATLAB* (Prentice Hall, 2011)
ISBN 978-0132170659

Moore H – *MATLAB for Engineers* (Prentice Hall, 2009) ISBN 978-0131362178

Knight A – *The Basics of MATLAB and Beyond* (Chapman Hall/CRC, 1999)
ISBN 978-0849320392

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Websites

MATLAB is known to have excellent manuals for their products, they can be downloaded free in PDF format.

Two examples of websites are:

www.mathworks.com/support/product/product.html?product=SL&x=7&y=4 - link for all Simulink support files

www.mathworks.com/help/toolbox/simulink/index.html – link for Simulink documentation in PDF format