

## MODULE DESCRIPTION FORM

### DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

## 16361 (ME305/16318) DYNAMICS AND CONTROL

<b>Module Registrar:</b> Dr Christie Maddock <a href="mailto:christie.maddock@strath.ac.uk">christie.maddock@strath.ac.uk</a>	<b>Taught To (Course):</b> Cohorts for whom class is compulsory / optional		
<b>Other Lecturers Involved:</b> None	<b>Credit Weighting:</b> 20 (ECTS 10)	<b>Semester:</b> 1 and 2	
<b>Assumed Prerequisites:</b> 16232 Engineering Mechanics, ME209 Mathematical Modelling & Analysis, MM117 Mathematics 1M	<b>Compulsory/ optional class</b>	<b>Academic Level:</b> 3	<b>Suitable for Exchange:</b> Y

#### Alternative codes and credit values for those taking only one semester:

Semester 1: ME305 Dynamics 3 (10 Credits / ECTS 5)

Semester 2: 16318 Measurement, Instrumentation and Control (10 Credits / ECTS 5)

#### Module Format and Delivery (HOURS i.e. 1 credit = 10hrs of study):

Lecture	Tutorial	Laboratory	Groupwork	External	Online	Project	Assignments	Private Study	Total
44	40				2	20		94	200

#### Educational Aim

This module aims to:

The Semester 1 dynamics course will:

- 1) Utilise the fundamentals taught in second year dynamics to demonstrate the principles of analysis of the dynamic performance of mechanical engineering systems.
- 2) Introduce the basics of modelling the vibrations of mechanical systems.
- 3) Combine the fundamental theory of free and forced vibrations of damped and un-damped systems.
- 4) Introduce the general principles of the kinematics of rigid bodies and different types of motion: translation, rotation and general plane motion.
- 5) Study the kinetics of rigid bodies focusing on plane motion.

The Semester 2 control course focuses on modelling the dynamics and analysing the performance of controlled systems, and will:

- 1) Introduce control theory and its application to engineering systems.
- 2) Study methods to develop mathematical models for the dynamics and control of engineering systems.
- 3) Introduce control system analysis techniques in order to predict the system performance to given inputs.
- 4) Show the link between analytical methods and models, and computer models, and explain how to run simulations and analyse the performance of modelled systems.

#### Learning Outcomes

On completion of the 1<sup>st</sup> semester, the student is expected to:

- LO1 Be able to analyse simple one and two degree of freedom vibrating mass-elastic systems.
- LO2 Be capable of applying the theory of classically damped vibrating systems to problems of one and two degrees of freedom.
- LO3 Be able to apply and understand the above methods and principles to predict and analyse the vibration of simple mechanical systems.

LO4 Be able to understand and apply the basic physical principles of kinematics and kinetics of rigid bodies, and to have an understanding of the basic relations between the forces acting on a rigid body, its mass and shape and the resulting motion.

On completion of the 2<sup>nd</sup> semester, the student is expected to be able to:

LO1 Determine a mathematical model of the dynamics and control of an engineering system in the time and frequency domains.

LO2 Determine the system response based on the system model and input.

LO3 Analyse the performance of a system.

LO4 Appreciate fundamental issues of stability, and apply theory correctly to assess closed-loop system stability.

## Syllabus

The module will teach the following:

**Semester 1** will cover the following topics:

- Introduction to dynamics – revision exercises and tutorial.
- Kinematics of a generalised rigid body.
- Free undamped vibration of one degree of freedom systems.
- Free vibrations with viscous friction.
- Applications for single degree of freedom vibration theory.
- Concepts of analysis for multi-degree of freedom vibration.
- Classical analysis of two degree of freedom systems.
- Vibrations of continuous systems.
- Comparisons between experimental and theoretical results for vibrating systems in practice.
- Vibration measurement.

**Semester 2** will cover the following topics:

- Introduction to automatic control.
- Mathematical modelling 1 (differential equations, electro-mechanical analogies, linear systems, linearisation, revision of Laplace Transforms).
- Mathematical modelling 2 (use of Laplace Transforms, Transfer Functions, DC motor control analysis, introduction to block diagrams).
- Mathematical modelling 3 (poles and zeros, block diagrams, general solution for feedback systems, block diagram reduction, electro-mechanical system design).
- Feedback control system characterisation and performance (errors in closed-loop systems, sensitivity of controllers).
- The performance of feedback control systems 1 (test input signals, second order systems).
- The performance of feedback control systems 2 (damping, percentage overshoot).
- The performance of feedback control systems 3 (system requirements, introduction to the concept of stability).
- The Routh-Hurwitz Stability Criterion and examples.
- Examples of system stability analysis.
- Threshold of stability.

## Assessment of Learning Outcomes

### Criteria

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

#### Semester 1

*All outcomes will be assessed by the ability of the students to do relevant tutorial questions.*

*LO1-LO4 will be assessed by the ability of the students to model appropriate mechanical systems and estimate their characteristics through a series of class examples and tutorials, and this material will also be formally examined at the end of the semester.*

*LO2 and LO3 will also be assessed through the students' performance and understanding of a laboratory exercise.*

For each of the Learning Outcomes the following learning criteria will apply such that students should be able to:

**L01**

- C1 Analyse dynamically the motion of simple rigid bodies and mechanisms in terms of their kinematic characteristics related to the forces applied.
- C2 Model mathematically the dynamics of simple systems and mechanisms.

**L02**

- C3 Derive models for simple 1 DOF vibrating systems.
- C4 Analyse the dynamic motion of simple vibrating systems.
- C5 Understand the principles and the main mechanisms of free damped and un-damped vibration.
- C6 Understand the principles and the main mechanisms of forced vibratory motion and be able to analyse it in terms of the kinematic and dynamic characteristics of appropriate vibrating systems.

**L03**

- C7 Be able to apply the above to the analysis of practical applications of vibrating structures and mechanisms.

**L04**

- C8 Be able to model the kinematic and kinetic performance of simple systems in plane motion.
- C9 Be able to express mathematically the motion characteristics of simple systems in plane motion and derive their equations of motion by using Newtonian mechanics.

**Semester 2**

*All outcomes will be assessed by the ability of the students to do relevant tutorial questions.*

*LO1-LO4 will be assessed by the ability of the students to model appropriate mechanical systems and estimate their characteristics through a series of class examples and tutorials, and this material will also be formally examined at the end of the semester.*

*LO2 and LO3 will also be assessed through the students' performance and understanding of an individual project.*

For each of the Learning Outcomes the following learning criteria will apply such that students should be able to:

**L01**

- C1 Find a set of linearised differential equations to model the dynamics of appropriate electro-mechanical systems.
- C2 Represent the mathematical model as a block diagram.
- C3 Use differential equations and block diagrams to determine system transfer functions.

**L02**

- C4 Solve analytically for the output response in the frequency domain of a system based on a specific input function and a mathematical model.
- C5 Determine the output response of a system in both the time and frequency domains using numerical techniques given a computer model and a specific input.

**L03**

- C6 Determine the poles and zeros of a system.
- C7 Determine the tracking error and the steady-state error of a system.
- C8 Run block diagram simulations in *Matlab & Simulink*.
- C9 Design a specific control system and assess its performance using a model built in *Simulink*.

**L04**

- C10 Assess the characteristics of a system response and its stability by constructing and evaluating a Routh-Hurwitz array.
- C11 Assess the response of a system on the threshold of stability.

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

**Principles of Assessment and Feedback**

(within Assessment and Feedback Policy at: <https://www.strath.ac.uk/staff/policies/academic/> )

Please state briefly how these are incorporated in this module.

**Semester 1 Dynamics**

Feedback is given in different forms:

- Immediate self-directed feedback and self-assessment through question and answers sessions in and after class.
- Written feedback from the dynamics project.

- Informal feedback will be provided at regular tutorial sessions primarily through verbal discussion with individuals or groups on tutorial exercises attempted in advance by students (note: to receive this feedback students should participate in these tutorials).

### Semester 2 Control

Feedback is given in different forms:

- Immediate self-directed feedback and self-assessment through question and answers sessions in and after class.
- Written feedback from the control project.
- Informal feedback will be provided at regular tutorial sessions primarily through verbal discussion with individuals or groups on tutorial exercises attempted in advance by students (note: to receive this feedback students should participate in these tutorials).

An *exam in Dynamics* at the end of Semester 1 and a further *exam in Control* at the end of Semester 2 will be used to assess the students' understanding of the theory and analytical problem solving skills developed during the two constituent half-module courses in dynamics and control.

The *dynamics project* in Semester 1 will be used to assess the students' understanding of the concepts inherent in *resonance within single degree of freedom systems*, and will receive an appropriate mark that will be included in the assessment for dynamics, together with the mark for the Semester 1 exam.

The *control project* during Semester 2 will be used to assess the students' understanding of *the theory of modelling the dynamics and then constructing a closed-loop control system for an appropriate mechanical system*. The project will receive a mark that will be included in the assessment for control, together with the mark for the Semester 2 exam.

### Assessment Method(s) Including Percentage Breakdown and Duration of Exams

Examination				Test		Practical		Project	
Number	Month(s)	Duration	Weighting	Number	Weighting	Number	Weighting	Number	Weighting
1	Dec	2 hrs	30%	2	5% each			2	15% each
1	May	2 hrs	30%	(Myplace)					
* Both, LO1-4				* LO2-3		*		* LO2-3	

\* **L/Os:** Indicate which Learning Outcomes (L01, L02, etc) are to be assessed by exam/coursework/practical/project as required.

### Coursework / Submissions deadlines (*academic weeks*):

Semester 1: Project deadline: Week 9

Semester 2: Project deadline: Week 9

### Resit Assessment Procedures:

2 hour examination (1 hr for either ME305 or 16318) in August diet.

### PLEASE NOTE:

**Students need to gain a summative mark of 40% to pass the module. Students who fail the module at the first attempt will be re-assessed during the August diet. This re-assessment will consist entirely of an exam. No marks from any previous attempts will be transferred to a new resit attempt.**

- It is possible for students to be registered for ME305 (Sem 1) or 16318 (Sem 2) or 16361 (Sem 1 & 2), *dependent on their programme*.  
Marks obtained for either ME305-only or 16318-only registered students (totaling 50%) will be scaled to 100%.  
Marks obtained for 16361 registered students are out of 100%.

### Recommended Reading

**\*\*\*Purchase recommended    \*\*Highly recommended reading    \*For reference (do NOT purchase)**

#### Semester 1

- (1) Beer F., Johnston R., Clausen W., Vector Mechanics for Engineering Dynamics, 7<sup>th</sup> edition, McGraw Hill, 2004.
- (2) \*\*Inman, Daniel J. Engineering vibration. Prentice Hall, 1994.

#### Semester 2

- (1) Bishop R., Dorf R., Modern Control System, 12<sup>th</sup> edition, Pearson, 2010.
- (2) \*\*Marshall, S. A., Introduction to Control Theory, Macmillan, 1978.

**Additional Student Feedback**

*(Please specify details of when additional feedback will be provided)*

<b>Date</b>	<b>Time</b>	<b>Room No</b>
Week 9 both semesters	Tutorial	Check timetable webpages for details
Week 11 both semesters	Lecture and tutorial	Check timetable webpages for details

Session: 2019/20

**Approved:**

**Course Director Signature: Dr Stuart Grey**

**Date of Last Modifications: 30/8/19**

(Updated August 2019)

## MODULE TIMETABLE

**Module Code:**

**16361/ ME305/ 16318**

**Module Title:**

**Dynamics and Control**

### Brief Description of Assessment:

For each semester: Assessment is through an online test, an individual or group project and a final exam. The online test will focus on testing the necessary prerequisite knowledge needed. The project will focus on solving a given design problem using mathematical analysis and simulation software.

### Assessment Timing:

Indicate on the table below the start/submission dates for each assignment/project and the timing of each exam/assessment using the dropdowns provided. Dropdowns can be left blank. Add extra notes below the dropdowns.

**Please note: Timings can and will change, this should only be used as a guide.**

Semester One	W&D Wk	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9	WK10	WK11	Exam Period
	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Online Test	Project Set	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Project Submission	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.

Semester Two	C&D Wk	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9	WK10	WK11	Exam Period
	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Online Test	Project Set	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Project Submission	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.