Lahore University of Management Sciences

EE-301 – Engineering Modelling

Fall 2017

Course Catalog Description
Modelling & Simulation Concepts and their use for developing sustainable solutions. First order differential equations and their applications. Second and higher order differential equations and their applications. Numerical methods for solving linear ODEs. Partial Differential equations – the heat, wave and Laplace's equation.

COURSE OBJECTIVES
Engineering models allow Scientists and Engineers to understand systems under study by performing experiments. Differential equations have been the main tool (models) for the mathematical analysis, comprehension, design and prediction of things that change. The emergence of digital computers has provided alternative methods for the approximate analysis for both natural and man-made systems through numerical solutions. This course describes both the analytical techniques for solving first order and second order differential equations as well as describes a wide range of unrelated physical phenomenon that can be modelled through them. In addition graphical and numerical methods for solving differential equations are introduced. Furthermore, separable partial differential equations (PDEs) and their boundary value problems are introduced through the classical Heat, Wave and Laplace's equation.

Course Details	
Credit Hours	3
Core	Core
Elective	-
Open for Student Category	Sophomores
Closed for Student Category	-

Course Prerequisite(s)/Co-Requisite(s)/Ante-requisites(s)
Pre-requisites: MATH-101 Calculus I Co-requisites: CS-200 Introduction to Programming Ante-requisites: MATH 210 Introduction to Differential Equations

Course Offering Details				
Lecture(s)	Nbr of Lec(s) Per Week	2	Duration	75 mins
Recitation/Lab (per week)	Nbr of Lec(s) Per Week	-	Duration	
Tutorial (per week)	Nbr of Lec(s) Per Week	-	Duration	

Instructor	Wala Salem Mustafa Saadeh and Tariq M. Jadoon
Room No.	And 9-250 (Tesla Wing) and 9-215A (Maxwell Wing)
Office Hours	Saadeh (TBA) and Jadoon (TR) 11:45 – 13:15)
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TA Office Hours	Khizer – TBA Bisma – TBA
Course URL (if any)	LMS site

Grading Breakup and Policy
Modelica Assignment(s) [2]: 10%. Online submissions of reports detailing solutions in Modelica code. Written/Oral Exam/Attendance. **Homeworks [5]**: 10%: Problem sets for drill. Will be due one week after the announcement. No late submissions are acceptable. **Quiz(s) [6-8 with N-1]:** 15%: Can be announced or unannounced. No retakes will be allowed. **Midterm Examination:** 30% **Final Examination:** 35%

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Assessed Course Learning Outcomes	
EE-203-	The students should be able to:
CLO1:	Describe basic modeling and simulation concepts and their applications to sustainable engineering solutions
CLO2:	Solve first and higher order linear differential equations
CLO3:	Develop Models with first order and higher differential equations
CLO4:	Solve ordinary differential equations using numerical methods
CLO5:	Solve Partial Differential Equations subject to boundary conditions specifically -heat equation, wave equation, and Laplace's equation
CLO6:	Use Modelica – a modeling language to model simple physical systems – for solving Linear ODEs.

Relation to EE Program Outcomes				
EE-301 CLOs	Related PLOs	Levels of Learning	Teaching Methods	CLO Attainment checked in
CLO1	PLO7	Cog-2	Instruction, Tutorial	Midterm
CLO2	PLO2	Cog-3	Instruction, Tutorial, Homework	Midterm, Final
CLO3	PLO2	Cog-5	Instruction, Tutorial, Homework	Midterm, Final
CLO4	PLO2	Cog-3	Instruction, Tutorial	Final
CLO5	PLO2	Cog-3	Instruction, Tutorial	Final
CLO6	PLO5	Cog-3	Instruction, Tutorial, Assignment	Assignment

Course Overview

Week No.	Topics	Book Chapters/ Recommended Reading	Related CLOs & Additional Remarks
1	Modelling & Simulation: Basic Concepts Systems and Experiments, The Model Concept, Simulation, Building and Analysing Models, Types of Models and their use for developing sustainable solutions.	1.1- 1.6 (**IMS**), Handouts	CLO1
2-3	First order differential equations Direction Fields, Separable variables, Linear Equations, Exact Equations, Substitutions	2.1 – 2.5 (**DE**)	CLO2
4	Modeling with First Order Differential Equations Linear Equations, Non Linear Equations, Systems of Linear Equations	3.1 – 3.3 (**DE**)	CLO3
5-7	Second order linear differential equations Initial value and boundary value problems, Linear Dependence, Wronskian, Reduction of order Homogeneous equations, Characteristic equations, Non-homogeneous equations, Method of undetermined coefficients Method, Variation of Parameters, Cauchy Euler Equations, Solving systems of DEs by Elimination.	4.1 – 4.4 (**DE**), 4.6 – 4.8 (**DE**),	CLO2
8-9	Modeling with Higher-Order Differential Equations Linear Equations: Initial Value Problems – Mechanical and Electrical Systems, Linear Equations: Boundary Value Problems – Deflection of a Beam*, Bending Moment & Shear Force Diagrams*	5.1 – 5.2 (**DE**) Handouts	CLO3
	Midterm Exam		
9	A Quick Tour of Modelica Getting Started, Object –Oriented Mathematical Modelling, Classes and Instances, Equations, A causal physical modeling, The Modelica Software Component Model, Examples.	2.1 – 2.7 (**IMS**)	CLO6
10-11	Numerical Methods for Ordinary Differential Equations Euler Methods, Runge-Kutta Methods, Multistep Methods.	9.1. – 9.3 (**DE**)	CLO4
12-14	Partial Differential Equations (PDEs) and Boundary Value Problems in Rectangular Coordinates. Separable PDEs, Classical Equations and Boundary Value Problems – Heat Equation, Wave Equation and Laplace's Equation. Non Homogeneous boundary value problems.	12.1 – 12.5 (**DE**)	CLO5
15	*Final Exam*		

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Examination Detail	
Midterm Exam	Yes/No: Yes Combine Separate: combine Duration: 2 hrs Preferred Date: early in the mid-term week Exam Specifications: Close book, close notes, no help sheets, all the relevant formulas if required will be provided along with the question paper.
Final Exam	Yes/No: Yes Combine Separate: combine Duration: 3 hrs Exam Specifications: Close book, close notes, no help sheets, all the relevant formulas if required will be provided along with the question paper.

Textbook(s)/Supplementary Readings

Text book:

1. Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica by Peter Fritzson (**IMS**). IEEE Press and John Willey, 2011,
2. Differential Equations with boundary-value problems by Dennis G. Zill and Michael R. Cullin (**DE**) (7th Edition Brooks/Cole)
3. Michael Tiller, (2001) Introduction to Physical Modelling with Modelica, Kluwer Academic Publishers.

Reference Books:

4. Fritzson Peter, Principles of Object-Oriented Modeling and Simulation - with Modelica, IEEE Press and John Willey, 2004.
5. Elementary Differential equations and boundary value problems by William E. Boyce and Richard C. Diprima. (Eighth Edition John Wiley & Sons, Inc.) 2004.

Complex Engineering Problem/Activity:	
Complex Engineering Activity Details	Included: No Nature and details of Complex Engineering Activity: N/A Assessment in: N/A

Prepared and Revised by:	**Tariq M. Jadoon**
Revision Date:	**09 September 2017**