COURSE OUTLINE: MH3110

Course Title	**Ordinary Differential Equations**		
Course Code	**MH3110**		
Offered	Study Year 3, Semester 2		
Course Coordinator	Wang Li-Lian (Prof)	lilian@ntu.edu.sg	6513 7465
Pre-requisites	MH2100 OR CY1602		
AU	4		
Contact hours	Lectures: 39, Tutorials: 12		
Approved for delivery from	AY 2021/22 semester 2		
Last revised	16 Dec 2021, 15:32		

Course Aims

The course builds on Calculus and Linear Algebra. It aims to equip students with useful solution methods for solving various types of ordinary differential equations (ODEs), introduce the fundamental theory of ODEs, and develop skills for modeling real phenomena by ODEs.

Intended Learning Outcomes

Upon successfully completing this course, you should be able to:

1. Solve several types of first-order ODEs including separable equations, first-order linear equations, exact or non-exact equations with integrating factors, and some other equations transformable to the above classes of solvable ODEs through suitable substitutions.
2. Demonstrate mastery of the linear theory of linear ODEs and appreciate the beauty and rigor through the hierarchical structure of the theory. Solve the second- and higher-order homogeneous equations using the linear theory. Solve nonhomogeneous linear ODEs by using method of undetermined coefficients and variation of parameters. Apply concepts and methods in linear second-order ODEs in the modelling of physical systems.
3. Demonstrate understanding of the first integral transform method, i.e., the Laplace transform, and explain its profound importance in mathematics. Solve initial value problems using Laplace Transform.
4. Solve systems of linear equations using the matrix algebra. Extend the methods of undetermined coefficients and variation of parameters for nonhomogeneous linear equations to solve systems of nonhomogeneous linear equations.

Course Content

Solution methods for first-order ODEs including separable equations, first-order linear equations, exact DEs, Non-exact DEs with integrating factors, homogeneous DEs, Bernoulli’s equation and substitution techniques for ODEs.

Linear theory and solutions of linear ODEs: Linear theory: principle of superposition, Wronskian, Linear dependence/independence, Abel’s formula etc.. Solution techniques for linear homogeneous equations with constant coefficients, Cauchy-Euler equation and linear nonhomogeneous equations via method of undetermined coefficients and methods of variation-of-parameters.

Laplace transform: properties of Laplace transform and solution of initial value problems using Laplace transform.

Systems of Linear ODEs: eigen-value method for linear systems of equations and methods of undetermined coefficients and variation-of-parameter methods for nonhomogeneous systems.

Basic skills in modeling by ODEs.

Assessment

Component	Course ILOs tested	SPMS-MAS Graduate Attributes tested	Weighting	Team / Individual	Assessment Rubrics
Continuous Assessment					
Mid-semester Quiz					
Multiple Choice Questions 1	1	**1.** a, b, c **2.** a	12.5	individual	
Multiple Choice Questions 2	2	**1.** a, b, c **2.** a	12.5	individual	
Short Answer Questions 1	1, 2	**1.** a, b, c **2.** a	12.5	individual	See Appendix for rubric
Short Answer Questions 2	3	**1.** a, b, c **2.** a	12.5	individual	See Appendix for rubric
Examination (2 hours)					
Short Answer Questions	1, 2, 3, 4	**1.** a, b, c **2.** a	50	individual	See Appendix for rubric
		Total	**100%**		

These are the relevant SPMS-MAS Graduate Attributes.

1. **Competence**
   a. Independently process and interpret mathematical theories and methodologies, and apply them to solve problems
   b. Formulate mathematical statements precisely using rigorous mathematical language
   c. Discover patterns by abstraction from examples
2. **Creativity**
   a. Critically assess the applicability of mathematical tools in the workplace

Formative Feedback

The Continuous Assessment consists of 4 quizzes with multiple choice questions or short-answer questions that are designed based on the above outcomes. It also contains an 2-hour final examination. These will not only provide a comprehensive coverage of the knowledge points, but also encourage students to study constantly and develop the skills consistently.

Learning and Teaching Approach

Lectures (39 hours)	The implementation of learning objectives will be built upon well-designed and prepared course materials and interactive means of conducting lectures. Below are student-centered learning and teaching approaches in the lectures. 1) ODEs are rooted in applications and many are arisen from mathematical modeling of real phenomena. In the lecture, some motivated examples will be given to make students feel this course useful for their future career. 2) This course involves some deep theory, and more insightful examples and practice questions are important and useful for engaging students. 3) In view of the depth of some course contents, it will encourage discussions and critical thinking through properly designed topics and related questions.
Tutorials (12 hours)	To better implement the learning outcomes, the tutorial questions will be designed for three levels of difficulty: i) basic questions related to concepts and definitions; ii) working-out questions on must-known methods and iii) open-ended questions for critical thinking. Moreover, some tutorial questions will be focused on helping student explore/learn some real life applications of ODEs.

Reading and References

Textbook: Boyce, William E., Richard C. DiPrima, and Douglas B. Meade. Elementary differential equations and boundary value problems. Vol. 11. New York: Wiley, 2018. ISBN: 978-1-119-50397-2.

Reference Book:

Vladimir Dobrushkin, Applied Differential Equations with Boundary Value Problems, Chapman and Hall/CRC, ISBN 9781498733656, 2017.

Course Policies and Student Responsibilities

You are expected to complete all assigned pre-class readings and activities, attend all classes punctually and take all scheduled quizzes in due course. You are expected to take responsibility to follow up with course notes and course related announcements.

Academic Integrity

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the Academic Integrity website for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructors

Instructor	Office Location	Phone	Email
Wang Li-Lian (Prof)	SPMS-MAS-05-20	6513 7465	lilian@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course ILO	Readings/ Activities
1	Concept of ODE. Solvable First-Order ODEs: Separable DEs, First-order Linear DEs, Exact DEs.	1	Chapter 1 of the textbook
2	Non-exact DEs with integrating factors; Substitution techniques: homogeneous DEs and Bernoulli's equation	1	Chapter 1 of the textbook & Exercises from the reference books
3	Theory on existence and modelling with 1st order ODE. Introduction to Linear theory	1, 2	Chapters 1-2 of the textbook & Exercises from the reference books
4	Linear theory: principle of superposition, Linear dependence/independence, Abel's formula.	2	Chapter 2 of the textbook & Exercises from the reference books Mid-Semester Quiz 1 will be given
5	Linear theory (Continued), Solutions of second-order linear ODEs: constant coefficients and Cauchy-Euler equations	2	Chapter 2 of the textbook & Exercises from the reference books
6	Solutions of nonhomogeneous DEs: method of undetermined coefficients	2	Chapter 2 of the textbook & Exercises from the reference books
7	Non-homogeneous linear DEs: variation-of-parameters. Solution of high-order linear DEs	2	Chapters 2-3 of the textbook & Exercises from the reference books Mid-Semester Quiz 2 will be given
8	Laplace Transform: concept and properties	3	Chapter 4 of the textbook
9	Laplace Transform: concept and properties (Continued) and solution of initial value problems.	3	Chapter 4 of the textbook
10	Systems of 1st linear order ODEs and eigen-methods for homogeneous systems	4	Chapter 5 of the textbook Mid-Semester Quiz 3 will be given
11	Systems of 1st linear order ODEs: nonhomogeneous systems	4	Chapter 5 of the textbook
12	Modeling by ODEs: examples and numerics	1, 2, 3, 4	Lecture notes Mid-Semester Quiz 4 will be given
13	Review for final examination and miscellaneous topics	1, 2, 3, 4	Lecture notes

Appendix 1: Assessment Rubrics

Rubric for Mid-semester Quiz: Short Answer Questions 1 (12.5%)

Point-based marking (not rubrics based).

Rubric for Mid-semester Quiz: Short Answer Questions 2 (12.5%)

Point-based marking (not rubrics based).

Rubric for Examination: Short Answer Questions (50%)

Point-based marking (not rubrics based).