COURSE OUTLINE: MH4700

Course Title	**Numerical Analysis II**		
Course Code	**MH4700**		
Offered	Study Year 3, Sem 1 | Study Year 4, Sem 1		
Course Coordinator	Viet Ha Hoang (Assoc Prof)	vhhoang@ntu.edu.sg	6513 2021
Pre-requisites	MH3110 and MH3700		
AU	4		
Contact hours	Lectures: 35, Tutorials: 12, Laboratories: 4		
Approved for delivery from	AY 2021/22 semester 1		
Last revised	25 Nov 2020, 10:47		

Course Aims

The course equips students with practical numerical methods for solving ordinary and partial differential equations. The methods are derived mathematically rigorously. The convergence of the methods is analyzed together with their error estimates in terms of the discretization parameters. Stability of the methods will be introduced.

Intended Learning Outcomes

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

1. Use numerical methods to solve ordinary and partial differential equations
2. Derive the methods from finite difference approximations of derivatives and polynomial interpolation
3. Analyze the convergence rates of the methods
4. Compare the computational complexity of different methods
5. Determine stability conditions

Course Content

A recap of Numerical Analysis I

The forward Euler methods: derivation of the method from approximation of derivative, convergence rate in terms of the step size, asymptotic error formula

Euler method for systems of differential equations

Backward Euler and trapezoidal methods, absolute statility of the methods

Taylor methods

Explicit and implicit Runge Kutta methods

Multistep methods: explicit Adams-Bashforth methods and implicit Adam-Moulton methods

Revision of variable separation method for solving partial differential equations

Finite difference methods for the heat equation: derivation of the explicit and implicit methods, Crank-Nicholson method, error analysis, analysis of the stability condition, von Neumann stability, Lax equivalence theorem

Finite difference methods for the wave equation

Finite difference methods for elliptic equations

Assessment

Component	Course ILOs tested	SPMS-MAS Graduate Attributes tested	Weighting	Team / Individual	Assessment Rubrics
Continuous Assessment					
Laboratories					
Assignment	1, 3, 4, 5	**1.** a, b, c, d **2.** a, b, d **3.** a	10	individual	See Appendix for rubric
Mid-semester Quiz					
Midterm Examination	1, 2, 3, 4, 5	**1.** a, b, c **2.** a, b, d **3.** a	30	individual	See Appendix for rubric
Examination (2 hours)					
Final Examination	1, 2, 3, 4, 5	**1.** a, b, c **2.** a, b, d **3.** a	60	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
   d. Use computer technology to solve problems, and to communicate mathematical ideas
2. **Creativity**
   a. Critically assess the applicability of mathematical tools in the workplace
   b. Build on the connection between subfields of mathematics to tackle new problems
   d. Critically analyse data from a multitude of sources
3. **Communication**
   a. Present mathematics ideas logically and coherently at the appropriate level for the intended audience

Formative Feedback

Midterm Exam: Feedback on common mistakes and the level of difficulty of the problems is given.

Lab Assignments: Students will receive individual feedback on their performance in the midterm and lab exercises during the computer labs and tutorial sessions.

Learning and Teaching Approach

Lectures (35 hours)	Present the key ideas behind mathematical concepts. Present important steps used to solve different types of problems.
Tutorials (12 hours)	This will help to develop problem solving and computing skills, and reinforce the understanding of the concepts and notions.
Laboratories (4 hours)	This will help to develop problem solving and computing skills, and reinforce the understanding of the concepts and notions.

Reading and References

R. L. Burden and J. D. Faires, Numerical Analysis, 9th Edition, Thomson, 2011. ISBN: 9780538735643

K. E. Atkinson, W. Han and D. Stewart, Numerical solution of ordinary differential equations, Wiley 2009. ISBN: 9780470042946

A. Tveito and R. Winther, Introduction to Partial Differential Equations, A Computational Approach, Springer 2005. ISBN: 9783540225515

Course Policies and Student Responsibilities

Absence Due to Medical or Other Reasons

If you are sick and not able to attend the midterm, you have to submit the original Medical Certificate (or another relevant document) to the administration to obtain official leave.

Academic Integrity & Collaboration Policy

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.
Collaboration is encouraged for your homework because peer-to-peer learning helps you understand the subject better and working in a team trains you to better communicate with others. As part of academic integrity, crediting others for their contribution to your work promotes ethical practice.
You must write up your solutions by yourself and understand anything that you hand in.

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Course Instructors

Instructor	Office Location	Phone	Email
Viet Ha Hoang (Assoc Prof)	SPMS-MAS-04-19	6513 2021	vhhoang@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course ILO	Readings/ Activities
1	Revision of Numerical Analysis I	1	Study lecture notes
2	Euler method, Euler method for systems of differential equations	1, 2, 3	Study lecture notes
3	Backward Euler and trapezoidal methods	1, 2, 3, 5	Study lecture notes
4	Runge-Kutta methods	1, 2, 3, 4, 5	Study lecture notes
5	Multistep methods	1, 2, 3, 4, 5	Study lecture notes
6	Multistep methods	1, 2, 3, 4, 5	Study lecture notes
7	Revision of variable separation method for partial differential equations	1, 2, 3, 4, 5	Study lecture notes
8	Finite difference methods for the heat equation	1, 2, 3, 4, 5	Study lecture notes
9	Finite difference methods for the heat equation	1, 2, 3, 4, 5	Study lecture notes
10	Finite difference methods for the wave equation	1, 2, 3, 4, 5	Study lecture notes
11	Finite difference methods for the wave equation	1, 2, 3, 4, 5	Study lecture notes
12	Finite difference methods for elliptic equations	1, 2, 3, 4, 5	Study lecture notes
13	Finite difference methods for elliptic equations	1, 2, 3, 4, 5	Study lecture notes

Appendix 1: Assessment Rubrics

Rubric for Laboratories: Assignment (10%)

Point-based marking (not rubrics based)

Rubric for Mid-semester Quiz: Midterm Examination (30%)

Point-based marking (not rubrics based)

Rubric for Examination: Final Examination (60%)

Point-based marking (not rubrics based)