

Annexe A: New/Revised Course Content in OBTL+ Format

Course Overview

Expected Implementation in Academic Year	AY2025-2026
Semester/Trimester/Others (specify approx. Start/End date)	Semester 1 Semester 2
Course Author * Faculty proposing/revising the course	Fedor Duzhin
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Course Title	Mathematics 2
Course Code	MH1811
Academic Units	3
Contact Hours	38
Research Experience Components	Not Applicable

Course Requisites (if applicable)

Pre-requisites	
Co-requisites	MH1810
Pre-requisite to	
Mutually exclusive to	MS2900,MH1100,MH1101,MH1801
Replacement course to	
Remarks (if any)	

Course Aims

This course extends the basic concepts of differentiation and integration learned in Mathematics 1 to the operations on functions of multiple variables. Advanced applications of differential and integral calculus are included. In addition, the course covers topics on sequences, series, and ordinary differential equations.

This course aims to equip you with

- mathematical knowledge and analytical skills so that you can apply techniques of advanced calculus (along with their existing mathematical skills) to solve engineering or scientific problems whenever applicable;
- mathematical reading skills so that you can read and understand related mathematical content in the basic and popular scientific and engineering literature; and
- mathematical communication skills so that you can effectively and rigorously present your mathematical ideas to mathematicians, scientists, and engineers.

Course's Intended Learning Outcomes (ILOs)

Upon the successful completion of this course, you (student) would be able to:

ILO 1	Express the general term of a sequence, determine and evaluate the limit of a convergent sequence, apply the squeeze theorem for sequences, and explain why a sequence is convergent or divergent.
ILO 2	Manipulate basic series such as geometric series, telescoping series, and determine their convergence and sum. Identify properties of convergent and divergent series.
ILO 3	Determine whether a series is divergent by the Divergence Test. Apply the alternating test to determine whether an alternating series is convergent. Apply the integral test, comparison test and limit comparison test, ratio test, and root test appropriately to series to determine the convergence of series with positive terms. Determine absolute, conditional, or divergence of a general series
ILO 4	Manipulate some power series related to geometric series; determine the radius and the interval of convergence for power series. Apply term-by-term differentiation and integration of power series. Apply a power series to approximation.
ILO 5	Evaluate Taylor's series (Maclaurin series) of functions, including exponential and sine functions. Determine Taylor series of some functions using known Taylor series. Use Taylor's Remainder Theorem and Estimation Theorem to determine the upper bound of the estimation error of a series.
ILO 6	Determine the domain of simple 2-variable function and sketch the domain and level curve.
ILO 7	Evaluate the limits of 2-variable and 3-variable functions; explain why the limit does not exist.
ILO 8	Interpret the concept and meaning of partial derivatives and evaluate partial derivatives. Apply the Chain rule for partial differentiation.
ILO 9	Evaluate the gradient vector and use its orthogonality to determine the equation of the tangent plane to a level surface and the graph $z=f(x,y)$. Determine the equation of normal line. Apply the equation of the tangent plane to $z=f(x,y)$ to linear approximation. Use the total differential to approximate the errors or changes.
ILO 10	Evaluate directional derivative, and use it to determine rate of change.
ILO 11	Find stationary points and classify them as local maximum, minimum, or saddle points.
ILO 12	Use the Lagrange Multiplier method to determine global maximum or minimum of a function subject to an equality constraint. Apply the method to solve optimization problems.
ILO 13	Sketch the region of integration for a 2-variable function and evaluate the double integral, and apply it to some problems. Generalize the concept of double integrals to triple integrals.
ILO 14	Solve separable first-order ordinary differential equations (ODEs), homogeneous first-order ODEs, and first-order linear ODEs by integrating factors, Bernoulli's equations, and exact ODEs.

ILO 15	Solve linear homogeneous second-order ODEs with constant real coefficients. Use the undetermined coefficient method and the method of variation of parameters to find a particular solution to non-homogeneous second-order ODEs with constant real-number coefficients. Obtain the general solution for non-homogeneous second-order ODEs with constant real coefficients.
ILO 16	Apply ODEs to model and solve simple practical problems.

Course Content

Sequences -- convergence and Limit Evaluation
Series -- Geometric series, telescoping series, harmonic series and applications
Series (Convergence Test): Comparison Tests, Ratio and Root Test, Integral test, Alternating Series Test, Absolute and conditional convergence.
Power Series & Applications: Radius and Interval of Convergence, Differentiation and Integration of Power Series
Taylor Series: Evaluation and Applications
Functions of 2 or 3 variables, Domain & Level Sets, Limits and Continuity
Partial Derivatives, Gradient Vectors, Applications
Directional Derivatives & Applications
Classify stationary points. Lagrange Multiplier Method
Double Integration
First order Ordinary Differential Equations -- Separable, Linear, Bernouli, Homogeneous, Exact
Second Order Homogeneous Ordinary Differential Equations: with constant coefficients.
Second Order Non-Homogeneous Ordinary Differential Equations: Undetermined Coefficients, Variation of Parameters

Reading and References (if applicable)

TEXT

Thomas' Calculus, 13th ed, Thomas, GB Jr., Weir MD and Hass J, Pearson-Addison-Wesley, 978-1292089799, 2016

REFERENCE

Calculus (International Student Edition), 9th ed, James Stewart, Thomson, 9780495482826 Brooks/Cole, 2020

NOTE: The above listing comprises the foundational readings for the course and more up-to-date relevant readings will be provided when they are available.

Planned Schedule

Week or Session	Topics or Themes	ILO	Delivery Mode	Activities	Readings
1	Sequences (Order of topics may change according to instructors.)	1	In-person	Lecture	
2	Sequences & Series	1, 2	In-person	Tutorial 1	
3	Series (Convergence Test)	2, 3	In-person	Tutorial 2	
4	Power Series	4	In-person	Tutorial 3	
5	Taylor Series	5	In-person	Tutorial 4	
6	Functions of 2 or 3 variables, Limits	6, 7	In-person	Tutorial 5	
7	Partial Derivatives, Gradient Vectors	8, 9	In-person	Tutorial 6	
8	Applications Directional Derivatives & Applications	9, 10	In-person	Tutorial 7	
9	Classify stationary points. Lagrange Multiplier Method	11, 12	In-person	Tutorial 8	
10	Double Integration	13	In-person	Tutorial 9	
11	Double Integration/ODE	13, 14, 15	In-person	Tutorial 10	
12	ODE	14, 15, 16	In-person	Tutorial 11	
13	ODE	14, 15, 16	In-person	Tutorial 12	

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Lectures and Tutorials	<p>Derivation of formulas and demonstrating problem solving: Train you to be independent learners who are able to derive ideas/concepts from first principles and take ownership of your own learning. Help you understand the motivation behind mathematical theorems, definitions, and formulas. Develop the train of thought in problem solving and presentation skills in presenting mathematical solutions.</p> <p>Problem solving: Develop competence in solving related problems.</p> <p>Peer Instruction: Develop communication skills and competence in mathematics. You also have an opportunity to work with your peers during lectures and tutorial sessions.</p>

Assessment Structure

Assessment Components (includes both continuous and summative assessment)

No.	Component	ILO	Related PLO or Accreditation	Weightage	Description of Assessment Component	Team/Individual	Rubrics	Level of Understanding
1	Continuous Assessment (CA): Assignment(Take-home online assignment.)	1, 2, 3, 4, 5, 6, 7, 8, 9,10, 11, 12, 13, 14, 15, 16	a, b	25	Essentially, it is a multiple-choice online quiz with unlimited attempts. Students who are willing to put in the effort will get 100%.	Individual	Holistic	Multistructural
2	Continuous Assessment (CA): Test/Quiz(Midterm Test)	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16	a, b	25	One-hour long midterm test with math questions that require short answers.	Individual	Holistic	Multistructural
3	Summative Assessment (EXAM): Final exam(Written Examination)	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,16	a, b	50	Two-hour long final exam with math questions that require short answers.	Individual	Holistic	Multistructural

Description of Assessment Components (if applicable)

The graduate attributes as stipulated by the EAB are:

- a. Engineering knowledge: Apply the knowledge of mathematics, natural science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
- b. Problem Analysis: Identify, formulate, research literature, and analyse complex engineering problems, reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- c. Design/development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
- d. Investigation: Conduct investigations of complex problems using research-based knowledge and research methods, including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- e. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities with an understanding of their limitations.
- f. The Engineer and Society: Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to professional engineering practice.
- g. Environment and Sustainability: Understand the impact of professional engineering solutions in societal and environmental contexts, and demonstrate knowledge of—and need for—sustainable development.
- h. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
- i. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.
- j. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large; be able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- k. Project Management and Finance: Demonstrate knowledge and understanding of engineering and management principles and economic decision-making, and apply these to one's own work as a member and leader in a team, to manage projects in multidisciplinary environments.
- l. Life-long Learning: Recognise the need for, and have the preparation and ability to engage in, independent and lifelong learning in the broadest context of technological change.

Formative Feedback

Instructors and tutors will discuss tutorial solution and common mistakes in student work during tutorial sessions or lectures or via online materials.

NTU Graduate Attributes/Competency Mapping

This course intends to develop the following graduate attributes and competencies (maximum 5 most relevant)

Attributes/Competency	Level
Creative Thinking	Basic
Problem Solving	Intermediate
Sense Making	Intermediate
Transdisciplinarity	Basic

Course Policy

Policy (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. On the use of technological tools (such as Generative AI tools), different courses / assignments have different intended learning outcomes. Students should refer to the specific assignment instructions on their use and requirements and/or consult your instructors on how you can use these tools to help your learning. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Policy (General)

As a student of the course, you are required to abide by both the University Code of Conduct and the Student Code of Conduct. The Codes provide information on the responsibilities of all NTU students, as well as examples of misconduct and details about how you can report suspected misconduct. The university also has the Student Mental Health Policy. The Policy states the University's commitment to providing a supportive environment for the holistic development of students, including the improvement of mental health and wellbeing. These policies and codes concerning students can be found in the following link:

<https://www.ntu.edu.sg/life-at-ntu/student-life/student-conduct>

Policy (Absenteeism)

The midterm test is a compulsory component of this course. Students who miss the test without valid reasons will receive a zero grade ("F") for the midterm test. If you are sick or have compassionate grounds and are unable to attend the midterm test, you must:

1. Send an email to the instructor regarding the absence.
2. Submit the Medical Certificate* or death certificate to your home school.

* The Medical Certificate mentioned above should be issued in Singapore by a medical practitioner registered with the Singapore Medical Association. In this case, a make-up midterm test will be arranged.

Please note that only ONE make-up midterm test will be scheduled for this course, and the date will be announced later. In the event that you have a valid reason (approved medical leave/ short leave) for missing the make-up midterm test, you may be eligible for an incomplete ("I") grade for the course if you can provide relevant supporting documents that are accepted by the school. Otherwise, a zero score will be awarded for the midterm test.

Policy (Others, if applicable)

Diversity and inclusion policy

Integrating a diverse set of experiences is important for a more comprehensive understanding of science.

It is our goal to create an inclusive and collaborative learning environment that supports a diversity of perspectives and learning experiences, and that honours your identities; including ethnicity, gender, socioeconomic status, sexual orientation, religion or ability.

To help accomplish this:

- If you are neuroatypical or neurodiverse, have dyslexia or ADHD (for example), or have a social anxiety disorder or social phobia;
- If you feel like your performance in the class is being impacted by your experiences outside of class;
- If something was said in class (by anyone, including the instructor) that made you feel uncomfortable;

Please speak to your teaching team, our school pastoral officer or a peer or senior (either in-person or via email) about how we can help facilitate your learning experience.

As a participant in course discussions, you should also strive to honour the diversity of your classmates. You can do this by: using preferred pronouns and names; being respectful of others opinions and actively making sure all voices are being heard; and refraining from the use of derogatory or demeaning speech or actions.

All members of the class are expected to adhere to the NTU anti-harassment policy. if you witness something that goes against this or have any other concerns, please speak to your instructors or a faculty member.

Appendix 1: Assessment Rubrics

Rubric for Tutorials: Take-home online assignment (25%)

Multiple-choice questions, no rubric is needed.

Rubric for Mid-semester Quiz: Midterm Test (25%)

Point-based marking (not rubrics based)

Rubric for Examination: Written Examination (50%)

Point-based marking (not rubrics based)