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

Course Overview

Expected Implementation in Academic Year (New format)	AY2026-2027
Semester/Trimester/Others (specify approx. Start/End date)	Semester 1
Course Author * Faculty proposing/revising the course	Anders Gustavsson
Course Author Email	erik@ntu.edu.sg
Course Title	Calculus
Course Code	MH1805
Academic Units	4
Contact Hours	56
Research Experience Components	Not Applicable

Course Requisites (if applicable)

Pre-requisites	
Co-requisites	
Pre-requisite to	
Mutually exclusive to	CY1601, MH1100, MH1101, MH1802, RE1011
Replacement course to	
Remarks (if any)	

Course Aims

This course aims to equip you with the subject knowledge, logical reasoning and analytical skills so that you are able to apply the concepts and techniques of calculus of one variable to solve problems encountered in science.

Course's Intended Learning Outcomes (ILOs)

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

ILO 1	Independently process and interpret concepts and methodologies related to differentiation, integration, power series and ordinary differential equations, and apply them to problems occurring in science.
ILO 2	Critically assess the applicability of mathematical tools in the workplace.
ILO 3	Critically assess the validity of a mathematical argument involving concepts from the course content.
ILO 4	Present mathematical ideas logically and coherently at the appropriate level for the intended audience.

Course Content

Sets and functions
Limits and continuity, one-to-one and inverse functions
Differentiation and optimization
Definition of Riemann Integral, Fundamental Theorem of Calculus, applications of integration.
Methods of integration
Elementary theory, and methods of Ordinary Differential Equations
Series, Power Series, Taylor Series

Reading and References (if applicable)

Besides notes provided in the course, the textbook "Calculus" by Spivak (ISBN 978-0-914098-91-1) covers most of the detail that is omitted in the lectures. Sometimes, chapter or page references to this book are given in the lecture notes.

NOTE: The above readings comprise 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	Sets, logic, and functions.	1-4	Online	Recorded lecture, self study	
2	Limits.	1-4	Online	Recorded lecture, self study, tutorial.	
3	Limits and continuity, one-to-one and inverse functions.	1-4	Online	Recorded lecture, self study, tutorial.	
4	Derivatives: Definition, differentiation rules, and applications.	1-4	Online	Recorded lecture, self study, tutorial.	
5	The Mean Value Theorem and its consequences, concavity, and higher order derivatives.	1-4	Online	Recorded lecture, self study, tutorial, AE.	
6	The Riemann Integral, definition and properties. The Fundamental Theorem of Calculus. Applications of integration.	1-4	Online	Recorded lecture, self study, tutorial, AE, Quiz 1	
7	Integration methods.	1-4	Online	Recorded lecture, self study, tutorial, AE.	
8	Ordinary Differential Equations.	1-4	Online	Recorded lecture, self study, tutorial, AE.	
9	Series: Definition and basic properties. Tests for convergence and divergence.	1--4	Online	Recorded lecture, self study, tutorial, AE.	

Week or Session	Topics or Themes	ILO	Delivery Mode	Activities	Readings
10	Power series, radius of convergence, Interval of convergence, Differentiation and integration of power series. Taylor series and applications of Taylor series.	1-4	Online	Recorded lecture, self study, tutorial, AE.	
11	Revision.	1-4	In-person	Self study, tutorial, AE.	
12	Revision.	1-4	In-person	Self Study, tutorial. AE, Quiz 2	
13	Revision	1--4	In-person	Self-study, tutorial.	

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Derivation of formulas and demonstrating problem solving (TEL Lecture and Tutorial)	You will watch pre-recorded lecture videos to learn basic definitions, formulas and theorems in the course. Examples will also be given to illustrate concepts and applications. Written materials (e.g. lecture notes) covering the content will be provided alongside with the pre-recorded videos. This helps you to be independent learners who are able to derive ideas/concepts from first principle and study the relevant examples to reinforce understanding. Given the flexibility in using these lecture materials, you can take ownership of your own learning according to your own pace.
In-class discussion and Problem solving (Tutorial)	During the 2-hour face-to-face tutorial session, you will learn how to solve problems using the concepts and techniques learned. The instructor who facilitate the discussion will help you in your learning by bridging any gap in their understanding as well as connecting theories and applications.
Individual and team-based quizzes	These will be conducted in two sessions during the semester, where each session is conducted in two steps: 1. An individual quiz. The questions, which focus on the definitions and theorems that are taught in the relevant module, are designed to test your conceptual understanding and train your logical reasoning skills rather than procedural/calculational skills. 2. The individual quiz is immediately followed by a team-based quiz where you answer the same questions again, but this time your team has to agree on the correct answer to submit. This trains you to communicate and explain your reasoning and technical ideas effectively, thus developing confidence and competence not just in problem-solving but also in communication.
Application Exercises.	The Application Exercises are team exercises to be completed outside of class. Each Application Exercise consists of one or a few slightly longer problems for the team to discuss and answer. The longer format allows for more authentic problems closer to applications or research. They often involve large computations and Python programming. Since these are team exercises, they also develop your communication skills, in particular your ability to express technical ideas and explain your reasoning.

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): Class Participation(Technology-enhanced Learning - Peer Evaluation)	1, 2, 3, 4	Not Applicable	10		Individual	Analytic	Not Applicable
2	Continuous Assessment (CA): Assignment(Technology-enhanced Learning - Application Exercises)	1, 2, 3, 4	Not Applicable	10		Team	Holistic	Relational
3	Continuous Assessment (CA): Test/Quiz(Individual quizzes)	1, 2, 3, 4	Not Applicable	10		Individual	Holistic	Relational
4	Continuous Assessment (CA): Test/Quiz(Team-based quizzes)	1, 2, 3, 4	Not Applicable	10		Team	Holistic	Relational
5	Summative Assessment (EXAM): Final exam(Final Exam)	1, 2, 3, 4	Not Applicable	60		Individual	Holistic	Extended Abstract

Description of Assessment Components (if applicable)

1. Peer Evaluation: Your individual contribution to team-based components (team-quizzes and application exercises), as evaluated by your teammates.
2. Application Exercises: Each Application Exercise consists of one or a few problems for your team to discuss and answer out of class. The problems are more authentic and closer to real life applications than typical tutorial problems, and often involve some programming.
3. Individual quizzes: Quizzes designed to test your understanding of the basic definitions, and theorems from the course. The questions are conceptual in nature and focus on logical reasoning rather than calculations and procedures.
4. Team-based quizzes: Follow directly after each individual quiz. You answer the same questions as in the individual quiz, but this time you are allowed to discuss the problems with your team, and your team has to agree on which answer to submit.
5. Final Exam: A written individual test with a mix of conceptual and procedural problems, based on the entire

course content.

Formative Feedback

Immediate feedback (correct/incorrect) is given when you submit a Team-based quiz or Application Exercise (AE). Upon submission of these assessments, your team can also submit questions that will be followed up by the course instructor.

You will also be given general feedback on the Final Exam, in the form of an Examiner's report.

The feedback addresses all intended learning outcomes.

NTU Graduate Attributes/Competency Mapping

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

Attributes/Competency	Level
Collaboration	Basic
Creative Thinking	Basic
Digital Fluency	Basic
Problem Solving	Basic
Sense Making	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)

You are expected to complete all assigned pre-class readings and activities, attend all classes (face to face or online) punctually and take all scheduled assignments and tests by due dates. You are expected to take responsibility to follow up with course notes, assignments and course related announcements for seminar sessions you have missed. You are expected to participate in all activities.

Policy (Absenteeism)

Individual and team-based quizzes require you to be present at the session and contribute to team work. In-class or online activities make up a significant portion of your course grade. Absence from a class or online meeting without a valid reason will affect your overall course grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU's approved activities supported by an excuse letter from the relevant bodies. There will be no make-up opportunities for such activities.

If you miss a quiz session, you must inform your team members and me via email (erik@ntu.edu.sg) prior to the start of the class.

Students who miss Continual Assessment activities with valid reasons will be exempted from that activity in score calculations. Students who miss CA activities without a valid reason will get a zero score for that session of absence.

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.

Technical Skills To Be Developed

All skills to be developed for this course:

Appendix 1: Assessment Rubrics

Rubric for Technology-enhanced Learning: Peer evaluation (10%)

The peer review is conducted by you as a student. You can use these recommended rubrics:

Criteria	Standards		
	Fail standard	Pass standard	High standard
Punctuality	The team member arrives late without a valid reason to team sessions on more than one or two occasions	Except for one or two occasions, the team member arrives on time to team sessions, or has a valid reason to be late.	The team member arrives on time to every team session, or has a valid reason to be late.
Valuable contribution	The team members provides no or little valuable input at team sessions.	The team member provides some valuable contributions at team sessions.	The team member provides creative and useful ideas at team sessions.
Facilitates discussion	The team member pays little attention to the rest of the team.	The team member pays attention to ideas from other team members.	The team member recognizes the strengths of individual team members and incorporates the best ideas for the benefit of the team.

Rubric for Technology-enhanced Learning: Application Exercises (10%)

AEs are assessed by multiple-choice questions.

Rubric for Technology-enhanced Learning: Individual and Team quizzes (20%)

Individual and team quizzes consist of multiple-choice questions.

Rubric for Examination: Final Exam (60%)

Criteria	Standards		
	Fail standard	Pass standard	High standard
Method of approach (LOs 1- -3)	Using methods that are irrelevant or do not apply to the given problem. Invoking theorems whose conditions are not satisfied.	Using relevant arguments or theorems that help solve the problem. Invoking theorems whose conditions are satisfied.	Using arguments and theorems in logically consistent ways to solve nonstandard problems.

Validity of reasoning (LO 3)	The student's reasoning is logically invalid.	The student's reasoning is logically valid.	The student's reasoning is logically valid and effective.
Clarity of argument (LO 4)	The student's reasoning is poorly explained or not explained at all.	The student's reasoning is clear, but may contain some gaps.	The student's reasoning is clear, precise, with no or insignificant gaps.