COURSE OUTLINE: MH1810

Course Title	**Mathematics 1**		
Course Code	**MH1810**		
Offered	Study Year 1, Sem 1 | Study Year 1, Sem 2		
Course Coordinators	Wang Huaxiong (Assoc Prof)	hxwang@ntu.edu.sg	6513 7472
	Wang Li-Lian (Assoc Prof)	lilian@ntu.edu.sg	6513 7465
	Tang Wee Kee (Dr)	weekeetang@ntu.edu.sg	6513 8654
Pre-requisites	None		
Mutually exclusive	MH2813, CE1011, CZ1011, MH1100, MH1101, MH1800, MH1801		
AU	3		
Contact hours	Lectures: 26, Tutorials: 12		
Approved for delivery from	AY 2020/21 semester 2		
Last revised	7 Dec 2020, 13:54		

Course Aims

In this course, the basic concepts of limits, differentiation and integration are introduced. Applications of differential and integral calculus are included. In addition, the course also covers topics on complex numbers, vectors and matrices. It aims to prepare the first year engineering students for further courses in engineering disciplines and more advanced mathematics in year 2.

This course aims to equip you with
• mathematical knowledge and analytical skills so that you are able to 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.

Intended Learning Outcomes

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

1. Evaluate product, quotient, power and roots of complex numbers.
2. Use vector operators (dot product and cross product) to solve simple mechanics and geometry problems (e.g. find work done, moment, equations for planes, distance form a point to a plane etc.).
3. Evaluate matrix determinants and use Cramer’s rule to solve simultaneous equations
4. Use limit to determine if a function is continuous.
5. Evaluate the derivatives of simple functions from the definition.
6. Evaluate the derivatives of more complicated functions by using rules of differentiation (e.g. product rule and chain rule).
7. Use the derivatives to establish linear approximations, estimate changes and solve nonlinear equations (by Newton’s method).
8. Use the derivatives to assist in curve sketching and solving optimization problems.
9. Evaluate integrals by using integration formulae, rules of algebra and substitution techniques.
10. Evaluate more complicated integrals by using “integration by parts”, “trigonometric substitutions”, “partial fractions”, “reduction formulae” and special techniques for integrands

involving quadratic or trigonometric expressions.

11. Evaluate definite integrals by using trapezium & Simpson's rules and perform error analysis.
12. Evaluate improper integrals of the first, second & third kinds, and test for convergence.
13. Interpret the meaning of integration by using the concept of Riemann sum.
14. Use integration to find areas between curves (by dividing into vertical or horizontal strips) and volumes of solids (slicing & cylindrical shells methods).
15. Use integration to find volumes of solids of revolution (slicing & cylindrical shells methods).
16. Use integration to find lengths of plane curves and areas of surfaces of revolution.
17. Use mean value theorem, fundamental theorem of calculus and Leibniz's rule to evaluate expressions involving differentiation and integration.

Course Content

COMPLEX NUMBERS, VECTORS AND MATRICES Complex plane, polar coordinates and polar form of complex numbers, powers and roots, fundamental theorem of algebra. Vector algebra in 2-D and 3-D space, dot product and cross product, lines and planes in space, applications. Matrices, matrix addition and multiplication, determinants, Cramer's rule.

LIMITS AND CONTINUITY OF FUNCTIONS Limits of functions, types of limits, the Sandwich Theorem, evaluation of limits, continuity of functions, properties of continuous functions.

DERIVATIVES Derivatives, differentiability, rules and properties, differentiation of transcendental functions, higher order derivatives, implicit differentiation, formulae, linearization, estimate changes, Newton's Method, hyperbolic functions.

APPLICATIONS OF DERIVATIVES Extreme values, points of inflection and curve sketching, Rolle's Theorem, Mean Value Theorem, optimization, indeterminate forms, L'Hopital's Rule.

INTEGRATION Anti-derivatives, Riemann Sum, indefinite and definite integration, Mean Value Theorem for definite integral, Fundamental Theorem of Calculus. Trapezoidal Rule, Simpson's Rule.

INTEGRATION METHODS Basic integration formulae for algebraic and transcendental functions. Integration by special devices: integration by parts, rationalizing substitution or trigonometric substitution, partial fractions, reduction formulas, improper integrals, convergence tests.

APPLICATIONS OF INTEGRATION Area between curves, volume of a general solid by slicing and cylindrical shell methods, volume of a solid of revolution, length of a plane curve, area of a surface of revolution.

Assessment

Component	Course ILOs tested	EAB Graduate Attributes tested	Weighting	Team / Individual	Assessment Rubrics
Continuous Assessment					
Technology-enhanced Learning					
Multiple Choice Questions	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17	a, b	16	individual	
Mid-semester Quiz					
Take Home Test	7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17	a, b	9	individual	See Appendix for rubric
Multiple Choice Questions	1, 2, 3, 4, 5, 6	a, b	15	individual	
Examination (2 hours)					
Final Examination	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17	a, b	60	individual	See Appendix for rubric
		Total	**100%**		

Mapping of Course Intended Learning Outcomes to Engineering Accreditation Board (EAB) Graduate Attributes

Category	Core					
EAB's 12 Graduate Attributes*						
(a) ●	(b) ●	(c)	(d)	(e)	(f)	
(g)	(h)	(i)	(j)	(k)	(l)	

Overall statement

In this course, the basic concepts of limits, differentiation and integration are introduced. Applications of differential and integral calculus are included. In addition, the course also covers topics on complex numbers, vectors and matrices. It aims to prepare the first year engineering students for further courses in engineering disciplines and more advanced mathematics in year 2. This course aims to equip you with • mathematical knowledge and analytical skills so that you are able to 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 Student Learning Outcomes		**EAB Graduate Attributes**
1	Evaluate product, quotient, power and roots of complex numbers.	a, b
2	Use vector operators (dot product and cross product) to solve simple mechanics and geometry problems (e.g. find work done, moment, equations for planes, distance form a point to a plane etc.).	a, b
3	Evaluate matrix determinants and use Cramer’s rule to solve simultaneous equations	a, b
4	Use limit to determine if a function is continuous.	a, b
5	Evaluate the derivatives of simple functions from the definition.	a, b
6	Evaluate the derivatives of more complicated functions by using rules of differentiation (e.g. product rule and chain rule).	b
7	Use the derivatives to establish linear approximations, estimate changes and solve nonlinear equations (by Newton’s method).	a, b
8	Use the derivatives to assist in curve sketching and solving optimization problems.	a, b
9	Evaluate integrals by using integration formulae, rules of algebra and substitution techniques.	a, b
10	Evaluate more complicated integrals by using “integration by parts”, “trigonometric substitutions”, “partial fractions”, “reduction formulae” and special techniques for integrands involving quadratic or trigonometric expressions.	a, b
11	Evaluate definite integrals by using trapezium & Simpson’s rules and perform error analysis.	a, b
12	Evaluate improper integrals of the first, second & third kinds, and test for convergence.	a, b
13	Interpret the meaning of integration by using the concept of Riemann sum.	a, b
14	Use integration to find areas between curves (by dividing into vertical or horizontal strips) and volumes of solids (slicing & cylindrical shells methods).	a, b
15	Use integration to find volumes of solids of revolution (slicing & cylindrical shells methods).	a, b
16	Use integration to find lengths of plane curves and areas of surfaces of revolution.	a, b
17	Use mean value theorem, fundamental theorem of calculus and Leibniz’s rule to evaluate expressions involving differentiation and integration.	a, b

***Legend:**

● Fully consistent (contributes to more than 75% of Student Learning Outcomes)
◐ Partially consistent(contributes to about 50% of Student Learning Outcomes)
○ Weakly consistent (contributes to about 25% of Student Learning Outcomes)
[Blank]Not related to Student Learning Outcomes

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 the limitations.
f. **The engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
g. **Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for the sustainable development.
h. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the 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, such as, being 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 the 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 and in multidisciplinary envir onments.
l. **Life-long Learning:** Recognise the need for, and have the preparation and ability to engage in independent and life-long 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.

Learning and Teaching Approach

Lectures (26 hours)	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. Problem solving: Develop competence in solving related problems. Peer Instruction: Develop communication skills and competence in mathematics. You also have an opportunity to work with your peers during lectures and tutorial sessions.
Tutorials (12 hours)	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. Problem solving: Develop competence in solving related problems. Peer Instruction: Develop communication skills and competence in mathematics. You also have an opportunity to work with your peers during lectures and tutorial sessions.

Reading and References

Text book:

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

Reference:

Calculus (International Student Edition), 6th edt, James Stewart, Thomson, 9780495482826 Brooks/Cole

Course Policies and Student Responsibilities

Absence Due to Medical or Other Convincing Reasons
If you are unable to attend a common test with a valid reason, you have to:
1. Send an email to the instructor regarding the absence.
2. Submit the original Medical Certificate* or documents (if it is not due to medical reason) to administrator (in School Office).

* The medical certificate mentioned above should be issued in Singapore by a medical practitioner registered with the Singapore Medical Association.

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
Tang Wee Kee (Dr)	SPMS-MAS-05-07	6513 8654	weekeetang@ntu.edu.sg
Wang Huaxiong (Assoc Prof)	SPMS-MAS-05-26	6513 7472	hxwang@ntu.edu.sg
Wang Li-Lian (Assoc Prof)	SPMS-MAS-05-20	6513 7465	lilian@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course ILO	Readings/ Activities
1	Complex numbers, Argand Diagram, Polar & Euler form form, Conjugate of a complex number, The Fundamental Theorem of Algebra, De Moivre's Theorem, Findinf nth root	1, 2	Lecture
2	Vectors, Dot and cross products, applications of vectors	2, 3	Tutorial 1
3	Matrix, operations on matrix (multiplication, inverse and power etc)	2, 3	Tutorial 2
4	Determinants, cofactors, Cramer's rule	3	Tutorial 3
5	Limits, one-side limit, Limit theorems, continuity at points, one-side continuity,	4	Tutorial 4
6	Squeeze theorem, Limit Laws for Infinite Limits, Limits at Infinity for Rational Functions	4	Tutorial 5
7	Continuous Functions, Intermediate Value Theorem, Extreme Value Theorem.	4	Tutorial 6
8	Derivative: Definition and Basic Rules	5, 6	Tutorial 7
9	Differentiation Rules and Linearisation	6, 7, 8	Tutorial 8
10	Close Interval Method, Mean Value Theorem and L'Hospital's Rule	7, 8	Tutorial 9
11	Indefinite and Definite Integrals: Definition and Riemann Sum	9, 13	Tutorial 10
12	Fundamental Theorem of Calculus, Basic integration techniques	10, 11	Tutorial 11
13	Substitution, by-parts, partial fractions for rational functions and Applications	12, 13, 14, 15, 16, 17	Tutorial 12

Appendix 1: Assessment Rubrics

Rubric for Mid-semester Quiz: Take Home Test (9%)

1. This take home test aims to test all topics after the midterm that reflect the learning outcomes.

2. To prepare for this test, the students should understand the learning objectives of each lecture and practise the tutorial questions/exercises in lecture slides.

Rubric for Examination: Final Examination (60%)

1. This examination aims to test all topics that reflect the learning outcomes.

2. To prepare for this examination, the students should understand the learning objectives of each lecture and practise the tutorial questions/exercises in lecture slides.