COURSE NAME AND CODE:	Calculus for Scientists and Engineers (MATH1185)
LEVEL:	I
SEMESTER:	II
NUMBER OF CREDITS:	3
PREREQUISITES:	CAPE or GCE A-Level Mathematics, or M08B/MATH0100 and M08C/MATH0110, or equivalent.

RATIONALE:

The laws of nature, as expressed in physics and applied in engineering are generally stated in a concise manner and constitute a consistent framework. Hence, the language and methods of mathematics have proven to be an invaluable tool in the investigation, construction and development of physics and engineering analyses and a solid mathematics foundation is therefore essential to the training of physicists and engineers. Calculus provides a framework to propel oneself from a static view of the world to a more dynamic model, opening up a much wider array of scenarios and associated problem solving techniques. This course is the second course in the traditional calculus sequence for mathematics, science and engineering students. The approach allows the use of technology and the rule of four (topics are presented geometrically, numerically, algebraically, and verbally) to focus on conceptual understanding. At the same time, it retains the strength of the traditional calculus by exposing the students to the rigor of proofs and the full variety of traditional topics: limits, differentiability, integration, and techniques of integration, applications of integration, functions of several variables, infinite series and ordinary differential equations.

COURSE DESCRIPTION:

This is a Level I compulsory course for a major in Physics and Engineering. This course will give students the basic knowledge of mathematical analyses which in turn will develop the student's ability to understand and work with continuous variables. It will prepare the student to formulate and solve problems requiring the use of calculus.

Therefore, the course will allow them to successfully study Level II courses in Physics and engineering with greater appreciation and insight into the physical relationships. Furthermore, students will be exposed to modern mathematical software (Math Lab, Maple or Mathematica) to explore the concepts encountered in the course.

CONTENT:

Limits, Continuity and Differentiability; Application of derivatives; Integration; Ordinary differential equations; Functions of several variables; **multiple integrals; series.**

OBJECTIVES:

At the end of the course, students will be able to:

- Translate a problem statement into an integral over a single variable and solve the integral;
- Use definite integrals to determine areas of regions between curves and lengths of plane curves;
- Explain and solve problems involving first and second order homogenous differential equations with constant coefficients where different mathematical and real-world interpretations of the derivative occur (slope, velocity, acceleration, exponential growth and decay);
- Apply partial differentiation to determine the maximum and/or minimum points for functions of two variables;
- Translate a problem statement into a double integral where appropriate and solve problems requiring double integrals such as moment of inertia, center of mass and area of a surface;
- Develop the ability to reason logically and rigorously;
- Develop techniques for solving problems that may arise in everyday life.

SYLLABUS:

Limits, Continuity and Differentiability: [2 hours]

Limits: properties relating limits with addition, subtraction, multiplication, and division; the squeezing process; Definition of continuous functions; Derivatives: definition, geometrical interpretation, derivatives of sums, products and quotients, derivability versus continuity, the Chain Rule and implicit differentiation.

Application of derivatives: [4 hours]

Rate of change, critical points of a function; intermediate value theorem; increasing and decreasing functions, Rolle's theorem, Mean value theorem, L'Hospital rule, Taylor's formula, Taylor's polynomials and estimate for the reminder; Applications to real-world problems.

Integration: [4 hours]

Indefinite integral, tables of some indefinite integrals using information obtained about derivatives, Upper and Lower sums, Partitions of an interval, the definite integral as a Riemann sum, the Fundamental Theorem of Calculus, properties of the integral (sums and inequalities), and improper integrals.

Techniques of integration: substitution and elimination of extra constants by substitution, integration by parts, partial fraction decomposition, exponential substitutions. Trigonometric integrals and integration of expression containing radicals, integration of expressions containing hyperbolic functions.

Applications of integration: length of curves, the hanging cable, area in polar coordinates, parametric curves and their length, surface of revolution, work, moments and center of gravity.

Ordinary differential equations: [3 hours]

Differential equations of the first order: method of separation variables, exact equations, integrating factors; Solutions of homogeneous linear equations with constant coefficients and example of applications to physics and engineering problems.

Functions of several variables: [3 hours]

Vector-valued functions: limits, continuity, and differentiation rules for parameterized vectorial functions; Length and Curvature. Motion in the three-dimensional Euclidean space: velocity and acceleration. Functions of two variables: limits and continuity. Partial derivatives and the Chain rule; Directional derivative, the gradient and the determination of maxima and/or minima for functions of two variables. Lagrange multipliers.

Multiple integrals: [4 hours]

Double integrals and their properties, iterated Integrals, and Fubini's theorem; double integrals over regions; double integrals in polar coordinates; applications: moment of inertia and center of mass; Fubini's theorem for triple integrals; classification of regions; formula for triple integration in cylindrical and spherical coordinates; Jacobian and change of variable formula in a multiple integral.

Series: [4 hours]

Series of numbers: definition of convergent series, and the comparison, ratio, root, and integral tests; absolute convergence, alternating series. Power series: radius of convergence. Differentiation and integration of power series.

Tutorials: [12 hours]

Lab : [10 hours] Problem solving and simulations.

TEACHING METHODOLOGY

This course will be delivered by a combination of interactive lectures and participative tutorials. The total estimated 41 contact hours are broken down as follows: 24 hours of lectures, 12 hours of tutorials and 10 hours of lab (counts as 5 contact hours). The course material will be posted on the webpage http://ourvle.mona.uwi.edu/

Practice problems and assignments will also be available to students via this webpage, as well as the solutions to the assignment questions after the due date.

ASSESSMENT

The course assessment will be divided into two components: a coursework component worth 30% and a final exam worth 70%.

- Two course work exams will take place during weeks 5 and 9. Each will be worth 15% of the student's final grade.
- The final exam will be two hours in length and consist of compulsory questions.

REFERENCE MATERIAL:

Books:

1. S. Lang: A first course in Calculus, Springer Undergraduate Texts in Mathematics, 5th Edition, 2005
   - Serge Lang's text teaches the skills needed to solve challenging calculus problems, while teaching to think mathematically. The text is principally concerned with how to solve calculus problems. Key concepts are explained clearly. Methods of solution are effectively demonstrated through examples. The challenging exercises reinforce the concepts, while enabling to develop the skills required for solving hard problems. Answers to the majority of exercises (not just the odd-numbered ones) are provided in a hundred page appendix.
2. J. Stewart: Calculus Early Transcendentals, Thomson, 6th Edition, 2008.
   - This book is very good at providing lots of real-life examples and problems. Each chapter teases some of the more interesting ones (how fast does a turkey cool after you take it out of the oven?) There are extended problems called "Applied Projects." Particularly challenging are those from the related rates and optimization sections.
3. M. Comenetz: Calculus: the elements. World Scientific Publishing, 2002
   - This is by far the best book grasping and retaining the fundamentals of calculus. It starts a topic by building from the most basic and expands it to a conclusion. The text uses numerous technical applications to help in conveying the concepts. The student reading this book must of course dedicate the time and effort to fully understand the concepts. Proofs are used throughout and provide added value to those so inclined to have a rigorous presentation.

Online Resources:

http://www.math.temple.edu/~cow - A collection of auto-scoring calculus modules organized into books, chapters, and sections, with help and hints for the problems. Modules with asterisks (including chain rule, Taylor polynomials, Riemann sums, and arc length) allow you to change values and see the effect. Book I: functions and geometry; limits and continuity; the derivative; techniques and theory of differentiation; applications of the derivative; and integration. Book II: integration; applications of integration; transcendental functions; methods of integration; geometry, curves, and polar coordinates; and sequences and series. Book III: sequences and series; vectors and analytic geometry; curves; functions; and integration. Registered students can log in for a session in which their work will be recorded and graded.

http://www.sosmath.com/calculus/calculus.html - An online course: learning units presented in worksheet format review the most important results, techniques and formulas in college and pre-college calculus. Logarithms and Exponential; Sequences; Series; Techniques of Integration; Local Behavior of Functions; Power Series and much more; and an Appendix of Mathematical Tables.