COURSE NAME:	MECHANICS OF INTERACTING PARTICLES
COURSE CODE:	MATH6629
# of CONTACT HRS.:	One Semester (13 weeks - 36 hours of lectures and 24 hours of tutorials)
NUMBER OF CREDITS:	4
LEVEL:	Graduate
PREREQUISITES:	MATH6627, MATH6628

RATIONALE:

In a broad sense Mechanics is the branch of science concerned with the behavior of physical bodies when forces act upon them. This discipline separates into analytical mechanics and quantum mechanics. Historically, classical mechanics came first, while quantum mechanics is a comparatively recent invention. There is also the "theory of fields" which is closely interwoven with the mechanics of classical and quantum fields. Thus, for instance, forces that act on particles are frequently derived from fields (electromagnetic and gravitational), and particles generate fields by acting as sources. In fact, in quantum mechanics, particles themselves are fields, as described theoretically by the wave function.

COURSE DESCRIPTION:

The course gives an up-to-date and modern overview of the main concepts in the Mechanics of interacting particles. Starting with an introduction to Newtonian mechanics and the Lagrangian/Hamiltonian formalism the course continues with an axiomatic approach to Quantum Mechanics. Path integrals and path integral quantization of Bosonic and Fermionic particles are also treated. A short introduction to Gauge Theories and the Higgs field is given at the end of the course.

LEARNING OUTCOMES:

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

Explain rigorously the meaning of Lagrangian and Hamiltonian formalism of classical mechanics;

- Construct the Lagrangian and Hamiltonian of systems of interacting particles;

- Discuss the implications of the canonical quantization;
- Construct the partition functions of a Bosonic and Fermionic oscillator ;
- Construct the quantization of a Dirac and scalar field;
- Construct coherent states;
- Use examples to explain the significance of Abelian and non-Abelian gauge theories;
- Explain the Higgs field.

CONTENT:

Analytical Mechanics: Newtonian mechanics, Lagrangian and Hamiltonian formalisms, applications. [5 hrs i.e. 4 hrs lecture + 2 hrs tutorials]

Quantum Mechanics: Axioms of canonical quantization, Heisenberg equation, Heisenberg picture and Schroedinger picture, harmonic oscillator. [10 hrs i.e. 8 hrs lecture + 4 hrs tutorials]

Path integral quantization of Bose and Dirac particles: Path integral quantization, imaginary time and partition function, time-ordered product and generating functional, Fermionic harmonic oscillator, calculus of Grassmann numbers, coherent states and completeness relation, partition function of a Fermionic oscillator. [17 hrs i.e. 12 hrs lecture + 10 hrs tutorials]

Quantization of a Dirac and scalar field: Free Dirac and scalar fields, interacting Dirac and scalar fields. [11 hrs i.e. 8 hrs lecture + 6 hrs tutorials]

Gauge theories: Abelian gauge theories, non-Abelian gauge theories, Higgs fields. [5 hrs i.e. 4 hrs lecture + 2 hrs tutorials]

Total contact hrs = 48 i.e. 36 hrs lecture + 24 hrs tutorials

TEACHING METHODOLOGY

The abstract concepts, illustrated with examples, will be presented during the lectures. The course is designed in such a way to maximize the extent to which students discover the main concepts by themselves. This is achieved through class participation in discussions during the lectures and tutorial periods. The tutorial periods will include problem solving sessions which will ensure that the students are able to understand, appreciate and apply the concepts learnt in the course. Homework problems will be divided into two types: *practice problems*, and *challenging problems*, whose resolution will be fundamentally more involved. The total estimated 48 contact hours may be accounted for as follows: 36 hours of lectures and 12 hours of tutorials.

Course material, including practice problems, will be posted on the webpage

http://ourvle.mona.uwi.edu/

ASSESSMENT

The course assessment has two components consisting of coursework (40%) and a final exam (60%):

One in-course test - 20% of overall grade;

One group project - 20% of overall grade;

Final exam - 60% of overall grade will be three hours duration.

REFERENCE MATERIAL:

Prescribed books:

Srednicki, M. (2007) Quantum Field Theory, Cambridge University Press, ISBN-10: 0521864496

Recommended books:

D. Griffiths, D (1987). *Introduction to Elementary Particles*, John Wiley & Sons, ISBN-10: 3527406018

Landau, L. D. & E. M. Lifshitz (1989). *Quantum Mechanics*, 3rd edition, Pergamon Press, ISBN-10: 0131118927

Arnold V. I. et al. (1989), *Mathematical Methods of Classical Mechanics*, Springer Verlag. ISBN-10: 0387968903

Online Resources:

http://www.freebookcentre.net/Physics/Mechanics-Books-Download.html

This section contains free e-books and guides on Analytical Mechanics, some of the resources in this section can be viewed online and some of them can be downloaded.