12998 - 254 (16) Electromagnetism, Waves and Introduction to Quantum Physics (3L, 3P)

2020

Course summary:

Electrostatic fields; magnetic fields; electromagnetic induction and alternating currents, Maxwell's equations and electromagnetic waves. Quantum properties and wave-particle duality.

Schrödinger equation in one dimension, eigenvalues and eigenfunctions for piecewise constant potentials and the harmonic oscillator. Time dependence, wave packets and tunneling.

Method of assessment: Flexible assessment

Prerequisite modules:

- *Mathematics 114, 144*
- *Physics 224*

Language policy:

Afrikaans and English in the same class groups:
During each lecture, all information is conveyed at least in English. Summaries and/or explanation of the core concepts will also be given in Afrikaans. Questions in Afrikaans and English will, at the least be answered in the language of the question. Students will be supported in Afrikaans and English during a combination of appropriate facilitated learning opportunities.

Module relevance in programme:

Electromagnetism can be considered one of the basic pillars in physics, together with mechanics (classical and quantum) and statistical physics. The first part of this module builds on the 144 introduction to electric and magnetic fields. This module on electrodynamics introduces Maxwell equations which describe all of electrodynamics and introduces the concept of electromagnetic waves. Hence the module prepares the student for the further study of electromagnetic waves, optics, special relativity and further study of electric and magnetic fields in matter.

The second part of the module (quantum mechanics) builds on the classical mechanics from 114 and the 224, introducing quantum physics. The wave mechanics and physical optics from 224 prepare the introduction to wave mechanics in quantum mechanics. The introduction to the basics of quantum mechanics in this module prepare the foundation for the course in quantum mechanics in the third year (334)

Outcomes of course:

This course exposes the student to electromagnetism and quantum mechanics on an introductory level.

The electromagnetism component of the course will enable the student to understand and appreciate the most important equations of electromagnetism, namely the Maxwell equations. It also prepares the student for further applications and generalization of these equations. The main goal is to show that the properties of electromagnetic waves can be derived from the Maxwell equations.

The quantum mechanics component of the course establishes an understanding of the background to physical observations and arguments which lead to the introduction of quantum mechanics as the basic description of the microscopic world. Students will understand the motivation for and status of the Schrödinger equation and will be able to solve this equation for simple one-dimensional systems. The foundation for more general interpretation aspects of the measurement of physical observables is established. Students will also be able to solve and interpret the simplest quantum mechanical scattering processes which serve as an entry to how the bulk of information on the microscopic level is obtained.

Lecturers:

Prof. EG Rohwer
Telephone number: (021) 808-3372
E-mail address: egr@sun.ac.za
Office: Room 1003 in the Merensky Physics Building.

Dr. JN Kriel
Telephone number: (021) 808-3658
E-mail address: hkriel@sun.ac.za
Office: Room 1014 in the Merensky Physics Building.

Mentor:

The Department of Physics has appointed a staff member as mentor for each year of its physics programme to be available to students for consultation. Students should feel free to discuss general issues related to the physics programme or specific modules in the programme with the relevant mentor, in addition to usual consultations with their individual lecturers of modules.

The mentor for second year programme and its modules is Dr P Southey southey@sun.ac.za .

Course content:

Formal lectures
The course is split into two term components in the second semester: the third term component focuses on electromagnetism and builds on the Physics 144 course. Topics covered includes: *Electrostatic fields*; *magnetic fields*; *electromagnetic induction* and *alternating currents*, *Maxwell's equations*, *electromagnetic waves in vacuum* and the *properties of the waves.*

The fourth term component comprises a first course in quantum mechanics. The Bohr atom and evidence for discrete energy levels are discussed as background material, followed by wave properties of particles with emphasis on the double slit experiment as discussed in the Feynman Lectures. This is followed by further motivation for the Schrödinger equation and applications to one-dimensional systems, including the infinite and finite square wells and the harmonic oscillator. Time-dependent states are discussed with emphasis on the superposition principle and the interpretation of measurements. Scattering from one-dimensional potential barriers is discussed in the time-independent framework.

Laboratory work
A program of practicals and tutorials will be provided.

Practical (Tutorials):

A program of practicals and tutorials will be provided.

Study material:

Prescribed texts:
DJ Griffiths, **Introduction to electrodynamics** (Prentice Hall, 1999 Fourth edition)

Recommended for students who intend to continue with physics:
DJ Griffiths, **Introduction to quantum mechanics** (Second edition)
All books are on reserve in the Physics library for the duration of the course

Learning opportunities:

Tutorials
Homework

Assessment:

Methods of Assessments
Continuous Evaluation.

Venue and time of assessment opportunities
Physics Merensky Building

See *timetable* on Physics home page.

Availability of marks:
Papers are returned as soon as possible.

Calculation of final mark for the module:
Electromagnetism:
Tutorial test 1 - 5%
Tutorial test 2 – 15%
Tasks – 15%
Practical work 30%
Test 1 – 35%

Quantum mechanics:
Class test 2 – 50%
Homework problem sets, practicals, tutorial tests and class quizzes – 50%

Note: If a student commits plagiarism in a homework assignment then none their homework will be taken into account in the calculation of the final mark. In such a case the test marks will make up the full final mark for this section.

Final mark: Quantum mechanics 50% Electromagnetism 50%