17221 - 772 (8) Optics (1.5L, 1.5P)

2022

Course summary:

Geometrical, physical and quantum formalisms, polarisation (Stokes and Jones vectors), reflection, transmission and dispersion (Fresnel, Brewster, total internal reflection, double refraction), geometric-optical description of paraxial optical systems (matrix optics), diffraction and interference (three-dimensional), interferometry. Diffraction theory. Fourier optics, diffractive optics.

Module relevance in programme:

This course offers a comprehensive look at the interaction between light and matter and as such the topics covered allows for eventual specialization in the field of photonics. It is also envisioned that the course permits a seamless transition of concepts to practice which are the requirements of the various laser based research undertaken at the LRI. The module requires prior knowledge in classical electromagnetism as presented in the undergraduate modules 254 and 342 and 711. The module prepares a student for optical applications in many sub-disciplines in physics, among others laser physics, imaging, microscopy, spectroscopy, atomic and molecular physics and biophysics.

Outcomes of course:

The outcomes of the course are to give the student an understanding of a number of the optical techniques that are available in the application of lasers.
The student should:

- understand the physical principles on which the technique relies,
- be able to apply this knowledge to special cases related to experiments in our research projects,
- have knowledge of how these techniques are applied in research and technology.

The module focusses on linear optics, ie the propagation of electromagnetic radiation in media where only the linear polarization is considered. Topics are addressed from a physics perspective and include the propagation of light in matter, reflection and transmission at boundaries, polarization effects, dispersion, coherence, ray optics and imaging and diffraction. Most examples consider plane waves, in order to illustrate the basic concepts. In considering imaging systems, ray tracing approximations are implemented.

This background in linear optics introduces most of the mathematical tools that are generally required for analysis of more complex problems in optics, and prepares for an introduction into non-linear optics. The introduction to diffraction provides a background for Fourier optics.

Lecturer:

Prof EG Rohwer
Telephone number: +2721 8083372
E-mail address: egr@sun.ac.za
Office: Room number 1003 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 the Honours programme and its modules is Dr P Southey (southey@sun.ac.za)

Course content:

Formal lectures

1st and 2nd QUARTER

Formal lectures

1 Electromagnetic Phenomena

1.1 Gauss' Law

1.2 Gauss' Law for Magnetic Fields

1.3 Faraday's Law

1.4 Ampere's Law

1.5 Maxwell's Adjustment to Ampere's Law

1.6 Polarization of Materials

1.7 The Wave Equation

2 Plane Waves and Refractive Index

2.1 Plane Wave Solutions to the Wave Equation

2.2 Complex Plane Waves

2.3 Index of Refraction

2.4 The Lorentz Model of Dielectrics

2.5 Index of Refraction of a Conductor

2.6 Poynting's Theorem

2.7 Irradiance of a Plane Wave

3 Reflection and Refraction

3.1 Refraction at an Interface

Practical (Tutorials):

Tutorials are scheduled. Students are expected to complete tutorial problems and assignments in their own time.

Study material:

Physics of light and optics, J Peatros and M Ware, Free textbook https://optics.byu.edu/home.

Learning opportunities:

Class discussions and tutorial problems.

Assessment:

Methods of Assessments
Tutorial problems, assignments and tests contribute to the continuous assessment.

Homework and tutorial problems

Written tests

Venue and time of assessment opportunities

As determined by lecturer in consultation with students at beginning of semester and the honours time table.

Availability of marks:

Tutorial problems: marks available within 2 weeks.

Tests: marks available within 2 weeks of the tests.

Calculation of final mark for the module:

Tests 75%, homework and tutorials 25 %