Physics and Astronomy

General Course Information

PHYS413/323
Laser Physics and Modern Optics

0.125 EFTS 15 Points
First Semester

Course Coordinator and Lecturer
Prof. Jon Wells
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Timetable
Wednesday 12-1 pm (Karl Popper 413) and Thursday 1-2 pm (Karl Popper 413).

Description
The aim of this course is to discuss the physics of the atom-radiation interaction, optical materials, laser physics as well as laser spectroscopy, optical metrology and non-linear optics.

Assessment

Homeworks	40%
Exam	60%

Textbooks – all of the following books are available in the Library
Key textbooks:

[1] Optical Properties of Solids	A.M. Fox
[2] The Quantum Theory of Light	R. Loudon
[3] Lasers	A. Siegman
[4] Elements of Nonlinear Optics	P.N. Butcher and D. Cotter

A selection of the following will also prove useful:

[5] Laser Fundamentals	W.T. Silvfast
[6] Laser Electronics 3e	J.T. Verdeyen
[7] Lasers	P.W. Milonni and J.H. Eberly
[8] Solid State Laser Engineering	W. Koechner
[9] Principles of Lasers	O. Svelto
[10] Quantum Electronics	A. Yariv
[11] Applied Nonlinear Optics	F. Zernike

Goal of the Course
To understand the principles of construction and operation of laser technology. To be familiar with key applications of lasers in non-linear optics, spectroscopy and optical metrology.

Learning Outcomes
Students will:
- Have acquired an understanding of the materials physics that underpins laser development.
- Have mastered the physics required to understand laser operation and the output characteristics of different types of lasers including pulsed and CW lasers.
- Be able to design stable optical cavities

- Be familiar with applications of lasers in spectroscopy and optics

Notes
Electronic copies of the detailed lecture notes will be available on the Learn system after week two: http://learn.canterbury.ac.nz/

Marks and Grades: The following numbers should be considered as a guide to the expected grades under normal circumstances. The School reserves the right to adjust mark/grade conversions, if necessary.

Please note that for all invigilated assessments (tests and exams) worth 33% and above, failure to obtain a mark of at least 40% will result in a final grade no higher than an R at 100 and 200 level, and a C- at 300 level.

Grade:	**A+**	**A**	**A−**	**B+**	**B**	**B−**	**C+**	**C**	**C-**	**D**	**E**
Minimum mark %:	**90**	**85**	**80**	**75**	**70**	**65**	**60**	**55**	**50**	**40**	**0**

Late Work
Late work is not in general acceptable without a medical certificate.

Course Content
Light-Matter Interactions: The classical propagation of light, optical properties of semiconductors, metals and insulators. Quantum mechanics of the atom-radiation interaction, Einstein A and B coefficients, transition rates and optical linewidths. Radiative and non-radiative decay, luminescence centres, transition series ions.

Laser Physics: History of the laser. Density of field modes in a cavity, the Fabry-Perot laser, the cold cavity, cavities with gain, laser gain equation, frequency pulling, laser rate equations, threshold inversion, coupled atomic and cavity equations, gain saturation. Cavity modes, cavity geometries, matrix methods and cavity stability. Resonant frequencies. Short pulsed lasers: Q switching and mode locking. Real lasers: gas lasers, solid-state lasers, free electron lasers.

Non-linear Optics and Spectroscopy: the anharmonic oscillator model, phase matching, second and third order non-linearities. Non-linear spectroscopy: ultrafast time domain spectroscopy- pump-probe and four-wave mixing, high frequency resolution spectroscopy-spectral hole burning.