09720PHYS587000　雷射物理與應用一(Laser Physics and Applications (I))

課程目標(Objective): After taking this course, the student is expected to acquire knowledge on the following:

1. The Nature of Laser Light
    a. Explain what characteristics make laser light different from ordinary light
    b. Define the terms: monochromaticity, directionality, brightness, coherence, and polarization
2. Basic Laser Principles
    a. State the three interactions possible between atoms and optical waves in terms of photons and discrete energy levels of the atoms
    b. Use the Einstein relations to determine the net rate of stimulated emission from a collection of excited atoms
    c. Understand different pumping schemes
3. Gaussian Beams and Laser Cavities
    a. Analyze the optical stability of various types of laser cavity configurations in terms of the mirror spacing and focal lengths
    b. Describe optical beams both inside and outside the laser cavity in terms of spot size and divergence characteristics
4. Laser Output Characteristics
    a. Explain the difference between homogeneous and inhomogeneous broadening, including mathematical descriptions, and give examples of each type
    b. Determine the axial mode spacing for a laser, and describe transverse mode patterns
    c. Show the relationship between laser output power and pumping rate
    d. Understand how to obtain single-mode operation, frequency stabilization, and short pulse output from a laser
5. Types of Lasers
    a. Understand the unique characteristics (e.g., wavelength, output power, size, and so on) of different types of lasers: gas -- HeNe, argon, metal vapor, CO2, N2, and chemical; solid state – Ti :Sapphire, Nd:YAG, and ruby; semiconductor; dye; Free-electron, etc.
    b. Given a certain type of laser medium, design a practical laser, including tube size, cavity dimensions, modes, and pump power
6. Applications of the Laser
    a. Understand how the laser is used in the field of optical communications in terms of beam directivity, modulation, fiber optics, and detection

b. Show how the laser's unique output power characteristics allow it to be used to drill small holes, weld, scribe, and be employed in medical application.

課程綱要(Outline)：

I. Introduction
II. Gaussian Beams and Beam Propagation – Chapter 3 (Review of Wave Optics and Ray Matrix)
III. Optical Cavities and Resonators – Chapter 9
IV. Interaction of radiation with matter (spontaneous emission, stimulated emission and absorption, line broadening mechanisms) – Chapters 11 and 12
V. Light-Matter Interaction – Chapter 12
VI. Optical amplification (population inversion, gain and gain saturation, pumping requirements and techniques) – Chapter 13
VII. Theory of laser oscillation - cw and transient behavior (Q-switching and mode-locking)Lasers – Chapter 14
VIII. Characteristics of selected laser systems
IX. Selected topics (time permitting)
Ultrafast Optics
Manipulating Laser Light
Laser Applications

參考書目(Textbook and References)：

Lecture will be based on the textbook but at a level appropriate for advanced undergraduates and graduate students in science and engineering. The student should consult the other reference books listed below as well.

Textbook:

Bahaa E. A. Saleh and Malvin Carl Teich,
Fundamentals of Photonics
1st Edition, Copyright © 1991, John Wiley & Sons, Inc.
http://www3.interscience.wiley.com/cgi-bin/bookhome/88511919
available as an e-book at the NCTU library. 2nd Edition© 2007 (recommended)