University of the Witwatersrand
Physics IIE (Engineering) : PHYS284 - 2006
Course Co-ordinator : Dr SH Connell

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Lectures : Mondays periods 3,4 and Fridays periods 1,2 in the Physics Building P114.

Tutorial period : Tuesdays period 5 in SH312X

Laboratory :

1. Set Labarotories : Four praticals, Wednesdays periods 6-9.
   (Performed during weeks 2-9 of the course)
   (a) Statistics.
   (b) X-ray Structure determination.
   (c) e/m ratio of the electron.
   (d) The Hall effect.
2. Construct a Laser, Wednesdays periods 6-9.
   (Performed during weeks 10-14 of the course)

Notes : The notes provided during the course *must be supplemented* by your own notes taken during the lectures, study of the text books and proficiency with the tutorial problems.

Required Reading(*) :

A Beiser*	*Concepts of Modern Physics*	Chap's 1,5-7,9,10
R Serway & R Beichner	*Physics for scientists and engineers (with modern physics)*	as appropriate
L Solymar And D Walsh	*Lectures on the electrical properties of materials*	

Semester 1 : 25 double lectures

Lecturers	Dr SH Connell	University of the Witwatersrand	Sections 1-5, 7
	Dr A Forbes	National Laser Centre	Section 6

1. **Relativistic Mechanics** [8 lectures]
   (a) Relativity, reference frames
   (b) The Galilean Transformation
   (c) The failure of the Galilean Transformation
   (d) Special Relativity
   (e) The Lorentz Transformation
   (f) Time Dilation, The Doppler Effect
   (g) Length Contraction
   (h) The Twin Paradox

(i) Electricity and Magnetism

(j) The Relativity of Mass

(k) Mass and Energy

(l) Massles particles

(m) General Relativity

(n) Applications - GPS systems

2. **Introduction to Quantum Mechanics** [8 lectures]

(a) Young's double slit experiment - Quantum mechanical behaviour

(b) Wave Functions, Operators

(c) Schrödinger's Time-Dependent Wave Equation

(d) Calculating Observables

(e) Schrödinger's Time-Independent Wave Equation

(f) Simple Quantum Systems

i. The particle in a box

ii. The finite potential well

iii. Barrier penetration, tunneling

(g) Applications : The STM microscope, alpha decay, the quantum limit for the miniturisation of the classical computer

3. **Quantum Mechanics of Atoms** [8 lectures]

(a) Introduction

(b) A full Quantum Mechanical Model of the Atom

(c) Solving the Schrödinger equation for hydrogen-like atoms,

(d) Quantising intrinsic electron spin

(e) Quantum numbers

(f) Probability densities

(g) Radiative transitions

(h) Many-electron atoms

(i) Symmetric / antisymmetric wave functions

(j) Pauli's exclusion principle

(k) Applications : Understanding the Periodic Table

4. **Statistical Mechanics** [5 lectures]

(a) Introduction

(b) Maxwell-Boltzmann Statistics

(c) The Ideal Gas

(d) Indistinguishability of particles and Quantum Statistics

(e) Boson Statistics

(f) Black-body radiation and Planck's Radiation Law

(g) Fermion Statistics

(h) Applications : Electrons in a metal - Ohm's Law, switches

5. **Modern materials** [1 lectures]

(a) Nanomaterials

(b) Superconductors

6. **Lasers** [5 lectures]

(a) Introduction

(b) Applications

7. **From Semiconductivity to Micro-electronics** [14 lectures]

(a) Introduction, history, highlights, the future

(b) Quantum Mechanical review

(c) Crystal lattices, periodic potentials, surprising results

(d) Band structure, mobility, effective mass, holes

(e) Fermi statistics, charge carrier concentrations, dopants

(f) Diffusion and drift of charge carriers

(g) Junctions, depletion regions, band bending, Fermi levels.

(h) Applications : Devices (diodes, transistors, solar cells, CCD's ...)

(i) Applications : Beyond Moore's law ... Quantum Computing and Communication