Teaching Experience

I have taught almost all core courses at the Undergraduate, Postgraduate and Ph.D. levels and courses related to the Particle Physics specializaion of the M.Sc. program. These courses are listed below. I have taught all the courses, except a few ,several times. The undergraduate courses were taught at IIIT Hyderabad and in Five Year Integrated M.Sc. program of the University of Hyderabad.

List of Undergraduate Courses Taught

1. Physics-I : Mechanics(Both Theory and Lab Courses)
2. Electromagnetic Theory
3. Thermodynamics
4. Waves and Oscillations
5. Quantum Physics

List of M.Sc. Courses Taught

1. Quantum Mechanics-I
2. Quantum Mechanics-II
3. Quantum Mechanics-III
4. Classical Mechanics
5. Electromagnetic Theory-I
6. Electromagnetic Theory-II
7. Mathematical Physics-I
8. Mathematical Physics-II
9. Statistical Mechanics
10. Atomic Physics
11. Nuclear Physics
12. Quantum Field Theory
13. Elementary Particle Physics
14. Lie Groups and Lie Algebras

15. General Relativity and Gravitation

16. Quantum Information and Quantum Computing

List of Ph.D. Courses Taught

1. Advanced Quantum Mechanics

2. Mathematical Physics

3. Electromagnetic Theory

1 Syllabus and Lecture Plan of a Few Courses

Mathematical Physics-I

1. *Ordinary Differential Equations:* The method of series solution, Fuchs's theorem. Application to important differential equations of Mathematical Physics.

   Partial Differential Equations: Method of separation of variables for partial differential equations. Application to wave equation, heat conduction, Laplace and Poisson equations. Use of Fourier series and Fourier transform for boundary value problems. Dirac Delta function

   Special functions: Orthogonal Polynomials, Associated Legendre functions, Spherical harmonics,

   Linear Vector Spaces: Fields and vector spaces, Subspace, Linear functional Linear independence and dimension, Basis
   Quotient, Direct Product and Tensor Product of Vector Spaces
   Linea Operators; Vector space of linear operators,Commutator, Inverse of an Operator.
   Vector spaces with inner product, Cauchy Schwarz inequality, orthogonality, Grahm Schmidt orthogonalization, Hermitian and unitary operators; Spectral theorem

Mathematical Physics-II:

1. *Complex Variables:* Algebra of complex numbers; Roots of unity; Differentiation of function of a complex variable, Cauchy Riemann equations, analytic functions, harmonic functions; Integration in complex plane, bound on integrals Cauchy fundamental theorem; Cauchy integral formula Taylor and Laurent expansion; Classification of singular points,residue at a singular point. Cauchy residue theorem, contour integration.

2. *Group Theory:* Basic definitions, Example of groups, multiplication table, permutation group, Cosets aand conjugacy classes. Class multiplication. Representations, reducible and irreducible representations. Schur's lemma. Characters and character table. Orthogonality theorems. Applications of group theory to physical problems.

Mechanics-I
Five Year Integrated M.Sc. Program, University of Hyderabad

This course is the first course at the undergraduate level in first semester of the five year integrated M.Sc. program of the University of Hyderabad. The class strength was 45 students. The students' background varied a lot. About half the class did not have any course on calculus and a very little introduction to trigonometry and vector algebra. Their Physics background also varied a lot. This course is conceived as a course to bring them at a uniform introductory level in mechanics.

Most of the course material is available on the School of Physics, course site.

1. General introduction. Plan of the course and references. Evaluation rules. Prerequisites.

2. A critical review of Newton's Laws.

3. The structure of Newtonian formalism.

4. A brief review of mathematics needed. Vector algebra, Calculus and Trigonometry.

5. Kinematics of linear and rotatory motion. Properties of rotations. Acceleration in rotating frames.

6. Systems with a few degrees of freedom. Rotations About an Axis, Kinetic Energy and Angular Momentum. Angular momentum of a system of point particles.

7. Solved Examples on Rotations Solved Problems on Rotations Rotational Motion of Point Particle; Proof of the Main Results Simple problems in rotational dynamics.

8. Solved Examples on Equilibrium of Three Coplanar Forces Solved Examples on Kinematics.

9. Work Energy Theorem, Conservative Forces, Potential Energy Examples from the Physics Lab: Flywheel and Katers Pendulum

10. Simple Harmonic Motion, Solved Problem. Small Oscillations in one dimension. Bifilar Pendulum
Small Oscillations, Two Dimensional Problems.

11. Solved Examples on Work and Energy.
Conservation of Momentum, Centre of Mass.
Conservation of Linear Momentum.

12. Motion in non-inertial frames. Solved Examples on motion in non-inertial frames.

13. Concluding remarks

Electricity and Magnetism
B.Tech. Program, International Institute of Technology, Hyderabad

This is first course on Electromagnetic Theory in the second semester of B.Tech. Program of International Institute of Technology, Hyderabad. The class strength grew from 50 to 180. over a period of four years. The students had a good exposure to the basic concepts of electrostatics and magnetostatics only. They also had an introduction to vector calculus.

The course material was uploaded on the course site of IIIT Hyderabad and is not available any more. The part of the material for the integrated program of University of Hyderabad is available on the School of Physics course site.

1. Maxwell's Equations
Introduce Maxwell's equations in time dependent case, win absence of a medium. Take up the time independent case and discuss relation with the known laws of electrostatics. Superposition principle. Coulomb's Law, Gauss Law. Path independence of work done by the electrostatic forces. Electric potential. Electric field due to different charge distributions.

2. Path independence of work done by the electrostatic forces. Electric potential. Poisson equation. Electric potential due to different charge distributions. Multipole expansion.

3. Properties of conductors. Solving boundary value electrostatic problems in presence of conductors. Method of images. Solution of Laplace equation by the method of separation of variables.

   Energy stored in electrostatic fields. Applications of electrostatics energy to capacitors.

4. Magnetic field, Lorentz force on a charge, Magnetic force on current carrying conductors. Ampere's Law, Biot Savart Law, and relation to the Maxwell's equations. Magnetic field due to current carrying conductors. Vector potential and the gauge invariance.

5. Electromagnetic induction. Laws of induction and relation to the Maxwell's equations. Explanation of induced effects in moving conductors, and when the magnetic field is changing with time. Eddy currents. Applications, examples of electromagnetic induction. Energy stored in magnetic fields.

6. Equation of continuity and Maxwell's fourth equation. Displacement current. What is true in statics and is not true in time varying case. Poynting theorem and the energy momentum of the electromagnetic fields. Angular momentum of the electromagnetic fields.

7. A brief introduction to electromagnetic waves.

8. A short discussion of need for $\vec{D}$ and $\vec{H}$ fields and introduction to the Maxwell's equations in presence of a medium. Some simple boundary value problems in presence of dielectrics.

Quantum Mechanics-I:
M.Sc. Program, University of Hyderabad

This is the first course in Quantum Mechanics in the second semester of the postgraduate, Master of Science, program of University of Hyderabad. The students had an introduction to developments in Physics in the early 20^{th}, such as black body radiation, photoelectric effect, Bohr Model and de Broglie waves etc. Some students had an introduction to quantum mechanics but others did not have any exposure to quantum mechanics. The class strength varied from 15 in the initial years to 60 at present. Most of the course material is available on the School of Physics, course site. For more details visit the course site of School of Physics:
`http://webphys.uohyd.ernet.in/~physics/moodle/`
Login as guest and follow the links
Quantum Mechanics-I (2011) listed in M.Sc. Courses
Quantum Mechanics-I (2010) listed in M.Sc. Courses
The details of the course taught are as follows:

1. Classical Systems of Interest [2 Lecs]
   Waves vs Particles
   Single and Double slit experiments with waves
   Single and Double slit experiments with particles
   Probability in Classical Mechanics

2. Inadequacy of the Classical Theory [3 Lecs]
   Postulates of Quantum Mechanics

3. Discussion of Postulates of Quantum Mechanics [3 Lecs]
   States and Dynamical Variables in Quantum Mechanics

   - Discrete nature of physical processes
   - Indeterminacy and probability in QM
   - Superposition principle of quantum states
   - Quantization of Dynamical Variables
   - Spin as a new dynamical variable
   - Measurement of position and momentum; Simultaneous Measurement and Uncertainty Principle

4. Discussion of Postulates of Quantum Mechanics [3 Lecs]

   - Computation of Probabilities and Average Values
   - Simultaneous Measurement and Commuting Observables
   - Brief Discussion of Measurement Process

5. Canonical Quantization [5Lecs]

   - Canonical Commutation Relations
   - Harmonic oscillator energy levels using algebraic methods
   - Angular momentum eigenvalues using algebraic methods.

6. Time Development [3 Lecs]

   - Superposition Principle, Conservation of Probability and Unitary Time Evolution
   - Time Development of Averages and Classical Correspondence
   - Identification of Hamiltonian as Generator of Time Evolution
   - Constant of Motion
   - Solution of Time Dependent Schrodinger Equation
   - Stationary States

7. Working with representations [2 Lecs]

   - Coordinate Representation
   - Momentum Representation

- Transition from one representation to another
- Physical Interpretation

8. Time Dependent Schrodinger Equation [4 Lecs]
    - Time dependent Schrodinger equation
    - Probability current and conservation of probability
    - Time reversal in quantum mechanics
    - Schrödinger equation for a system of charged particles in E.M. fields
    - Gauge invariance
    - Free particle motion in one, two, and three dimensions
    - Wave Packets
9. Energy eigenvalues and Eigenfunctions [7 Lecs]
    - Step Potential
    - Particle in a Box with Rigid Wall
    - Square Well
    - Dirac Delta Function Potential
    - Harmonic Oscillator Energy Level
    - General Properties of Solution of Motion in One Dimension
10. Reflection and Transmission in One Dimension [3 Lecs]
    - Reflection and transmission from a square well
    - Resonances
    - Tunnelling through a square barrier
    - T+R=1

    - Potential Problems in Two and Three Dimensions [2 Lecs] (Mostly Problems Separable In Cartesian Coordinates)
    - Free Particle in 2 and 3 dimensions
    - Particle in 2 and 3 dimensional boxes
    - Harmonic oscillator in 2 and 3 dimensions
11. Spherically symmetric potentials in three dimensions [8 Lecs]
    - Eigenfunctions of Angular Momentum
    - Radial Equation for Piecewise Constant Potentials
    - Free Particle

- Square Well
- Hydrogen Atom

12. Concluding Remarks