MANONMANIAM SUNDARANAR UNIVERISTY,
TIRUNELVELI-12

# SYLLABUS

**PG - COURSES – AFFILIATED COLLEGES**

Course Structure for M.Sc. Physics

(Choice Based Credit System)

(with effect from the academic year 2021-2022 onwards )

| Semester-III | | | | |
|---|---|---|---|---|
| **Part** | **Subject Status** | **Subject Title** | **Subject Code** | **Credit** |
| 3 | Core | QUANTUM MECHANICS - I | ZPHM31 | 4 |
| 3 | Core | ATOMIC AND MOLECULAR SPECTROSCOPY | ZMAM32 | 4 |
| 3 | Core | CONDENSED MATTER PHYSICS | ZMAM33 | 4 |
| 3 | Core | NUMERICAL METHODS & PROGRAMMING C++ | ZMAM34 | 4 |
| 3 | Practical | ADVANCED PHYSICS EXPERIMENTS - I | ZMAL31 | 3 |
| 3 | Practical | MICROPROCESSOR EXPERIMENTS | ZMAL32 | 3 |

**Total Marks: 100 Internal Exam: 25 marks + External Exam: 75 marks**

A. **Scheme for internal Assessment**:
Maximum marks for written test: **15 marks**
**3 internal tests**, each of **I hour** duration shall be conducted every semester.
To the average of the **best two** written examinations must be added the marks scored in. The **assignment** for 5 marks and Seminar for 5 marks

The break up for internal assessment shall be:
Written test- 15 marks; Assignment -5 marks; Seminar-5 Marks Total - 25 marks

**B. Scheme of External Examination**
**3 hrs.** examination at the end of the semester
A – Part : 1 mark question two - from each unit
B – Part : 5 marks question one - from each unit
C – Part : 8 marks question one - from each unit

- **Conversion of Marks into Grade Points and Letter Grades**

| S.No. | Percentage of Marks | Letter Grade | Grade Point | Performance |
|---|---|---|---|---|
| 1 | 90 - 100 | O+ | 10 | Outstanding |
| 2 | 80 - 89 | O | 9 | Excellent |
| 3 | 70 - 79 | A+ | 8 | Very Good |
| 4 | 60 - 69 | A | 7 | Good |
| 5 | 55 - 59 | B+ | 6 | Above Average |
| 6 | 50 - 54 | B | 5 | Pass |
| 7 | 0 - 49 | RA | - | ReAppear |
| 8 | Absent | AA | - | Absent |

- **Cumulative Grade Point Average (CGPA)**

$$\mathbf{CGPA} = \frac{\mathbf{\Sigma\,(GP \times C)}}{\mathbf{\Sigma C}}$$

- **GP** = Grade point, **C** = Credit
- CGPA is calculated only for Part-III courses
- CGPA for a semester is awarded on cumulative basis

- **Classification**
  a) First Class with Distinction : CGPA $\geq$ 7.5*****
  b) First Class : CGPA $\geq$ 6.0
  c) Second Class : CGPA $\geq$ 5.0 and $<$ 6.0
  d) Third Class : CGPA $<$ 5.0

# QUANTUM MECHANICS-I

**Preamble** : This course imparts knowledge about solving Eigen value problems and perturbation. It also gives exposure on matrix formalism and its applications in LHO and angular momentum.

**UNIT I: Wave mechanical Concepts and general formalism of quantum mechanics**

Shortcomings of classical and old quantum theories – wave particle duality – de Broglie concept – Heisenberg uncertainty principle – Illustration of uncertainty relation –Principle of complementarity – Applications of uncertainty principle – Phase and group velocities – Time dependent and independent Schrodinger wave equations and solutions – Eigen value problem; degeneracy – Physical interpretation of wave function – admissibility conditions on the wave function – Normalization and Probability interpretation – Box normalization – Expectation values: Ehrenfest's theorem – Postulates of quantum mechanics.

**UNITII: Exactly solvable eigen value problems**

One dimensional Square well potential; rigid and finite walls – One dimensional Harmonic oscillator: Schrodinger and Abstract Operator methods – Schrödinger equation for spherically symmetric potentials – Condition on solutions and eigen values – Spherical harmonics – Rigid rotator – Radial equation of Central potential and solution – Hydrogen atom; eigen values and eigen functions – Three dimensional square well potential.

**UNIT III: Operator formalism and Matrix theory in Quantum Mechanics**

Definition of an operator – Commuting and non – commuting operators – Different types of operators – Hermitian operators and properties – Projection operators – Dirac's bra and ket notations – Linear vector space and Hilbert space – Poisson brackets and equation of motion – Transformation theory; unitary matrix – Transformation of Hamiltonian with unitary matrix U, V and W – Matrix theory of the Linear Harmonic Oscillator – Physical meaning of matrix elements.

**UNIT IV: Theory of Angular Momentum**

Introduction – Angular momentum operators – Components of orbital angular momentum L – Commutation relations among the components of L, L2 and Lz – Ladder operators L± and commutation relations – Total angular momentum J and its commutation relations – Eigen values and eigen functions of L2 and Lz – Spectrum of eigen values of J2 and Jz – Angular momentum matrices – Construction of angular momentum matrices for j = 3/2 – Coupling of two angular momenta – Clebsch

– Gordan coefficients – Evaluation of CG coefficients for j=½ and 1 – Coupling of three and four angular momenta – Racah coefficients – 6j and 9j symbols.

**UNIT V: The Perturbation theory**

Time Independent Perturbation Theory: – Theory for non – degenerate case – Application – the perturbed harmonic oscillator – Theory for degenerate levels – First order Stark effect in Hydrogen atom – Time Dependent Perturbation Theory: – Dirac's theory–Transition probability – Constant perturbation – Harmonic perturbation – Transition to a discrete state – Transition to a continuum state (Fermi's Golden Rule) – Selection rules for dipole transition – Adiabatic perturbation – Sudden approximation –Application to semi classical theory of radiation – Calculation of Einstein coefficients.

**Books for Study:**


1. A Text book of Quantum Mechanics – P. M. Mathews and K. Venkatesan, Tata Mc Graw Hill
1. Edn. Pvt. Ltd. Publications, New Delhi, 2011.
2. Quantum Mechanics – Leonard I. Schiff, McGraw-Hill International Publication, NewYork,1996.
3. Quantum Mechanics – G. Aruldhas, Printice Hall of India publications, New Delhi, 2009.


**Books for Reference:**


1. Quantum Mechanics I: Fundamentals – S. Rajasekar and R. Velusamy, CRC Press,Taylor and Francis group – Boca Raton, London.
2. Quantum Mechanics – S. Devanarayanan, Sci. Tech. Publications Pvt. Ltd., Chennai,2005.
3. Quantum Mechanics – Satya Praash, Kedar Nath Ram Nath & Co., Meerut, 2012.
4. Quantum Mechanics – V. Devanathan, Narosa Publishing House, New Delhi, 2005.
5. Quantum Mechanics – Theory and Applications, A. K. Ghatak and Lokanathan; (5thEdition) – Macmillan India Ltd. Publication.
6. Quantum Mechanics – Eugen Merzbacher (3rd Edition), John Wiley and Sons, New York, 2004.
7. Quantum Mechanics – S. L. Gupta, V. Kumar, H.V. Sharma, R.C. Sharma, Jai Prakash Nathand Co., Meerut, India, 2005.
8. Quantum Mechanics – G. R. Chatwaland S. K. Anand, Himalaya Publishing House, New Delhi, 2011.
9. Quantum Mechanics – V. K. Thankappan, Wiley Eastern Ltd., New Delhi, 1985.
10. Principles of Quantum Mechanics, R Shankar, 2nd Edition, Springer, 1994.

**Related online resources:**
1. https://youtu.be/7I3cqOk0t-4
2. https://youtu.be/jb8XvtEgAyk

# ATOMIC AND MOLECULAR SPECTROSCOPY

**Preamble:** The scope of this course is to provide sufficient knowledge on most common atomic and molecular spectroscopic methods and properties derived from them and also to provide an over view of microwave, IR, Raman, electronic and resonance spectroscopic techniques.

**Unit I: Atomic Spectra**
The hydrogen atom and the three quantum numbers - spectra of hydrogen like ions, alkali metal vapours – forbidden transitions and selection rules – space quantization – magnetic moment and space quantization of angular momentum – the stern – Gerlach experiment.

**Unit II: Atoms in External Fields**
The normal Zeeman effect – the anomalous Zeeman effect – the magnetic moment of the atom and the 'g' factor – emitted frequencies in anomalous Zeeman transitions – the Paschen - Back effect – normal Stark effect – Stark effect in a strong electric field – Width of spectral lines – natural width of a spectral line – the Doppler effect – external effects –hyperfine structure of spectral lines –Zeeman effect of hyperfine structure.

**Unit III: Microwave and Infrared Spectra**
Rotational spectra of rigid diatomic molecules – isotope effect in rotational spectra – intensity of rotational lines–non-rigid rotator– vibrational excitation effect - Vibrational energy of a diatomic molecule – infrared spectra preliminaries – infrared selection rules – vibrating diatomic molecule – diatomic vibrating rotator.

**Unit IV: Electronic Spectra and Resonance spectroscopy**
Introduction – Vibration coarse structure – Franck - Condon principle – intensity of vibrational electronic spectra – rotational fine structure of electronic vibration spectra – magnetic properties of nuclei – resonance condition – NMR instrumentation – relaxation processes – Bloch equations – dipolar interaction – chemical shift – Introduction to ESR –principle of ESR – ESR spectrometer –total Hamiltonian hyperfine structure.

**Unit V: Raman Spectra and Lasers**

Raman Effect – Classical Theory of Raman Effect – Quantum Theory of Raman Effect– Rotational Raman Spectra – Vibration Raman Spectra – Vibration – Rotational Raman Spectra – Intensity Alternation in Raman Spectra – Spontaneous and Stimulated emission, Absorption – Einstein coefficients – The Laser idea – Properties of Laser beams –Rate equations of a two, three and four level Laser – Methods of obtaining population inversion – Laser resonators.

**Books for study:**


1. B. P. Straughan & S. Walker, Spectroscopy: Vol. I, Chapmen and Hall (1976). (Unit I & II)
2. G. Aruldhas, Molecular Structure and Spectroscopy, Prentice Hall of India, New Delhi (2002).
1. (Unit III & IV).
2. Vimal Kumar Jain, Introduction to Atomic and Molecular Spectroscopy, Narosa Publishing House, New Delhi, 2015.


**Books for Reference:**


1. C. N. Banwell, Fundamentals of Molecular Spectroscopy, 4th edition, Mc Graw-Hill, NewYork
1. (2004).
2. G. M. Barrow, Introduction to Molecular Spectroscopy, Mc Graw Hill (1986).
3. E. H. White, Introduction to Atomic Spectra, Mc Graw – Hill (2005).
4. Manas Chanda, Atomic Structure and Chemical Bond, Tata Mc Graw - Hill, New Delhi (2003).


**Related online resources:**

1. https://nptel.ac.in/courses/104/101/104101099/https://nptel.ac.in/courses/115/101/115101003/
2. https://nptel.ac.in/courses/104/106/104106122/

# CONDENSED MATTER PHYSICS

**Preamble:** This course provides knowledge on crystals and gives an idea of vibration of lattice. It also helps to understand electrical and magnetic properties of solids, energy band and the classification of solids.

**Unit I: Crystallography and crystal binding**

Bragg's law – scattered wave amplitude – Brillouin zones – Fourier analysis of the basis – quasi crystals – crystals of inert gases – ionic crystals – covalent

crystals – metals –hydrogen bonds – atomic radii – analysis of elastic strains – elastic compliance and stiffness constants – elastic wave in cubic crystals.

**Unit II: Phonons and thermal properties**

Vibrations of crystals with mono atomic basis – two atoms per primitive basis – quantization of elastic waves – phonon momentum – inelastic scattering by phonons – density of states in 3 dimension – Debye model for density of states – Debye T3law – Einstein model of the density of states – thermal conductivity – thermal resistivity of phonon gas – Umklapp processes.

**Unit III: Free electron theory, Energy bands and Semiconductor crystals**

Energy levels in one dimension – free electron gas in three dimensions – heat capacity of the electron gas – electrical conductivity and Ohm's law – Hall effect – thermal conductivity of metals – Bloch functions – Kronig – Penney model – band gap – equations of motion of electron and hole – Fermi surfaces – energy band calculation – De Hass – Van Alphen Effect.

**Unit IV: Dia, Para, Ferro and Anti Ferromagnetism**

Langevin diamagnetism equation – quantum theory of diamagnetism – quantum theory of paramagnetism – Hund rules – Paramagnetic susceptibility of conduction electrons ferromagnetic order – magnons–ferromagnetic order – antiferromagnetic order–ferromagnetic domains–origin of domains– nuclear magnetic resonance.

**Unit V: Dielectrics, Ferroelectrics and Superconductivity**

Macroscopic electric field – local field at an atom – dielectric constant and polarizability – structural phase transitions – ferroelectric crystals – antiferroelectricity – ferroelectric domains – piezoelectricity – occurrence of superconductivity – Meissner effect – thermodynamics of superconducting transition – London equation – coherence length – BCS theory of superconductivity – single particle tunnelling – DC Josephson effects – SQUIDS – recent developments and applications of superconductivity.

**Book for study:**

1. Introduction to Solid State Physics, Charles Kittel, Seventh Edition Wiley – India sixth reprint
2007.

**Books for reference:**

1. Solid State Physics – R J Singh, Pearson First Impression 2012.
2. Solid State Physics – Vimal Kumar Jain Ane Books Pvt. Ltd 2013.

3. Solid State Physics – H C Gupta,Vikas Publishing house Pvt. Ltd Reprint 2005.
4. Solid State Physics – S O Pillai New Age International Publishers.

**E-Reference**:

1. https://www.classcentral.com/course/swayam-advanced-condensed-matter-physics-10001
2. http://www.phys.ttu.edu/~cmyles/Phys4309-5304/lectures5.html
3. https://www.eeemadeeasy.com/magnetic-materials-magnetism-types/
4. https://nptel.ac.in/courses/115/106/115106061/

# NUMERICAL METHODS & PROGRAMMING IN C++

**Preamble :** The scope of this course is to study solving problems in Physics using numerical methods and computer programming.

**Unit I: Roots of equations and Solution of linear systems**
Solution of Algebraic and transcendental equations: Bisection Method - Method of false position – Newton – Raphson method – Linear Algebraic Equations: Gauss elimination – Gauss – Jordan – Gauss -Jacobi - Inverse of a matrix by Gauss Jordan elimination method.

**Unit II: Curve Fitting and Interpolation**
Curve fitting: Linear Least square fitting – Nonlinear Fit: Fitting a Polynomial Function, Exponential function – Interpolation: Introduction – forward difference – backward difference - Newton's forward and backward difference formulae – Unequally spaced: Lagrangian interpolation formula.

**Unit III: Numerical differentiation and integration**
Numerical Differentiation: Finding first and second derivatives using Newton's forward & backward difference formulae. Numerical Integration: Trapezoidal Rule, Simpson's 1/3 rule and 3/8 rule- Monte - Carlo evaluation of integral.

**Unit IV**: **Solution to ordinary and partial differential equations**
Solution to ordinary first order Differential Equations - Taylor's Series Method - Euler's Method -Euler's modified method - Runge-Kutta 2nd and 4th Order Methods – Solution to partial differential equations: Introduction – finite difference approximation to derivatives – solution of Laplace's Equation.

**Unit V: C++ Programming applications**

Programme structure: header files, local, global and static variables - Euler's Method: Charging and discharging of a condenser – Runge - Kutta methods: Radioactive Decay- Newton- Raphson method: Finding the equilibrium point in a Logistic map for a particular parameter 'a' between 1and 2 [x*=ax*(1-x*)] - Gauss elimination method: Currents in Wheatstone's bridge - Linear fitting: least square method - Cauchy's constant; Simpson's and Monte-Carlo methods : Evaluation of (integral) area under the curve -Numerical differentiation: Newton's Law of cooling.

**Books for Study:**

1. Introductory methods of Numerical Analysis S. S. Sastry, fifth edition, PHI learning private limited, New Delhi.
2. E. Balgurusamy, Object Oriented Programming with C++, Tata Mc Graw Hill, New Delhi (2000).

**Books for Reference:**

1. M. K. Venketraman, Numerical Methods in Science and Engineering 2nd Ed., National Publishing Co., Chennai (2010).
2. M. K. Jain, S. R. K. Iyengar, R. K. Jain, Numerical Methods for Scientific and Engineering computation, 3rd edition, New age international (P) Ltd, Chennai (1998).
3. E. Balagurusamy, Computer Oriented Statistical and Numerical Methods, Macmillan India Ltd, New Delhi (2000).

**Related online resources:**

1. https://youtu.be/LbKKzMag5Rc
2. https://youtu.be/Xb9Ypn77LBo
3. https://youtu.be/FfqAIlOxkoY

# ADVANCED PHYSICS EXPERIMENTS - I

**Any FIVE Experiments**

**1. Gouy's Method**

Determination of Magnetic Susceptibility (Volume and Mass) of the given sample (use a specimen in the form of a long rod/tube filled with powder or liquid).

**2. Elliptical Fringes**

Determination of Young's modulus, Bulk modulus, Rigidity modulus, Poisson's ratio and Compressibility of the given material by forming Elliptical fringes.

**3. Equipotential lines**

a) Formation of equipotential lines for different shapes
a) parallel lines b) circular lines c) lines of irregular shape.
b) Determination of Electric field between the equipotential lines.
c) Mapping of Electric field vector between the plates.

**4. Phototransistor Characteristics**

Characteristic Study of Phototransistor using
a) Light sources of different wave length
b) light sources of different intensities
Plots for a) Spectral response b) Sensitivity c) Linearity

**5. Ultraviolet spectral analysis**

a) Draw Tau Plot from the given UV spectrum data.
b) Find the band gap energy.

**6. Calibration of Hall Probe into Gauss meter**

a) Calibration of Hall probe into Gauss meter using a Search coil and
b) Determination of calibration curve for a two axis Hall probe in radial mode

**7. Characteristics of Linear and nonlinear circuit element**

V-I characteristic curve of a two terminal linear resistor and a nonlinear resistor (Chua's diode)

# MICROPROCESSOR EXPERIMENTS

Any FIVE programs with Algorithm and Flow chart

1. **Arithmetic Operations**
    a) Addition of two 8 bit and two 16 bit numbers
    b) Subtraction of two 8 bit and 16 bit numbers
    c) Multiplication of two 8 bit numbers –16-bit result.
    d) Division of 16 bit by an 8-bit number.

2. **Data Manipulation**
    a) Arrange the given data items in Ascending or Descending order
    b) Finding the Minimum and Maximum value in the given data set.
    c) Search of a given character/number in the given data set.
3. **System Call and Counters**
    a) Display a character/number on the 7 segment display of the Kit using Monitor Call.
    b) Calculation of Time delay for a given interval.
    c) Up-Counter to count from 00 upto 'nn' with 1 sec time interval.
    d) Down counter to count from 'nn' to 00 with specified counting interval.
4. **Block Move and Series Generation**
    a) Moving a block of data from memory xxxx to yyyy.
    b) Fibonacci series generation
    c) Tribonacci series generation
5. **System Call and Rolling character**
    a) Calculation of time delay for a given interval.
    b) Display a Character on the 7 segment display of the Kit using Monitor Call.
    c) Roll a given character from Left to Right / Right to Left on the 7 segment displays with the specified time interval.
6. **ADC and DAC conversion**
    a) Interfacing ADC with 8085 – ADC chip Block diagram – 8085 - ADC interfacing diagram
    b) Conversion of analog input to digital – Resolution – Graph between input and output.
    c) Interfacing DAC with 8085 – DAC chip Block diagram –8085 DAC interfacing diagram.
    d) Conversion of digital input to analog – Resolution – Graph between input and output. Generation
7. **DAC interfacing and Wave form generation.**
    Interfacing DAC with 8085 – DDC Chip Block diagram – 8085 - DAC - 8085 interfacing diagram and Wave Form using DAC
    a) Square wave with the specified period
    b) Rectangular wave with the specified perio