Himachal Pradesh University  
Department of Physics  
(NAAC Accredited ‘A’ Grade University)  
Proposed Course of Study and Syllabi  
M. Phil (Physics) and Ph.D. Course work (Physics)  
{Effective from Academic Session 2017-18 onwards}  

M. Phil (Physics) Programme {One year programme}  

Semester-I  

<table>
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<tr>
<th>S. No.</th>
<th>Course code</th>
<th>Course</th>
<th>Marks</th>
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<tbody>
<tr>
<td>1.</td>
<td>PHYMPHIL-101</td>
<td>Research Methodology</td>
<td>100</td>
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<tr>
<td>2.</td>
<td>PHYMPHIL-102</td>
<td>Mathematical Physics</td>
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<td>3.</td>
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<td>Elective-I</td>
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<td>4.</td>
<td>PHYMPHIL-104</td>
<td>Seminar</td>
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Semester-II  

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<td>1.</td>
<td>PHYMPHIL-201</td>
<td>Seminar</td>
<td>Gradation</td>
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<tr>
<td>2.</td>
<td>PHYMPHIL-202</td>
<td>Dissertation</td>
<td>Gradation &amp; Report</td>
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Ph.D. Course work (Physics) Semester -I  

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Semester-II  

Proposed Research work plan for Research Degree Committee for approval  

Note:  
1. The elective papers shall be offered by the Departmental Council with the consultation of teaching staff and students.  
2. Dissertation work will be distributed over both semesters for M. Phil. programme  
3. Both the theory papers and dissertation are to be completed within one year, for M. Phil course.  
4. Gradations are A (Excellent), B (Very Good), C (Good), D (Satisfactory).  
5. Before the dissertation is submitted candidate will be required to give two seminars on the  
   a) Plan of Research work in semester-I: PHYMPHIL-104/ PHYPHD-104  
   b) Pre- dissertation submission seminar in semester-II: PHYMPHIL-201
COURSE CODE: PHYMPHIL-101/PHYPHD-101

Name of the Course: Research Methodology

Max Marks: 100 Time: 3 hrs.

Instructions for paper setters and candidates: Seven questions will be set in all; Question No. 1 is compulsory, covering whole syllabus of the course and consist of 5-10 part of short answer type question. Question No. 2 to 7 shall be set as, two questions from each Section A, Section B and Section C. Candidates will be required to attempt four questions in all, taking atleast one question from each section.

Section A


Section B


Section C

Concepts of deterministic and stochastic simulation methods, limitations of simulational physics, percolation, percolation threshold, cluster labeling, critical exponents, fractal dimension, regular fractals and self similarity, fractal growth processes. One particle system moving in a spring potential.

Random walk on one, two and three dimensional latices, self-avoiding walk, micro-canonical ensemble Simulations of molecular dynamics, Monte Carlo simulations: Metropolis algorithm for equilibrium statistical mechanics, classical models of magnetism, Ising model; isothermal-isobaric ensemble montecarlo method, grand-canonical ensemble montecarlo method and exact diagonalization of many-body Hamiltonian
Recommended Books

2. Computational Physics, T. Pang Cambridge University press
3. Computational Physics, S.E. Koonin, Addison Welsey.

COURSE CODE: PHYMPHIL-102/PHYPHD-102

Name of the Course: Mathematical Physics

Max Marks: 100          Time: 3 hrs.

Instructions for paper setters and candidates: Seven questions will be set in all; Question No. 1 is compulsory. covering whole syllabus of the course and consist of 5-10 part of short answer type question. Question No. 2 to 7 shall be set as, two questions from each Section A, Section B and Section C. Candidates will be required to attempt four questions in all, taking atleast one question from each section.

Section A


Section B


Section C

Transform Methods: Fourier and Laplace transforms. Their properties and applications to solve differential and integral differential equations.

Recommended Books

1. Mathematics of classical and Quantum Physics, Frederick W. Byzon and Robat W. Fuller.
Elective-I: PHYMPHIL103/PHYPHD103; Common for both M. Phil. and Ph.D. course. The candidate has to choose one course from following list of courses)

List of Elective-I for M. Phil. & Ph.D. Course

a) Advanced Nuclear Physics
b) Advanced Particle Physics
c) Advanced Topics in Nuclear Astrophysics
d) Advanced Topics in Condensed Matter Physics
e) Advanced Quantum Mechanics
f) Advanced Techniques for Materials Characterization
g) Quantum computational and Quantum information

COURSE CODE: PHYMPHIL-103/PHYPHD-103

Name of the Course: Advanced Nuclear Physics

Max Marks: 100  Time: 3 hrs.

Instructions for paper setters and candidates: Seven questions will be set in all; Question No. 1 is compulsory covering whole syllabus of the course and consist of 5-10 part of short answer type question. Question No. 2 to 7 shall be set as, two questions from each Section A, Section B and Section C. Candidates will be required to attempt four questions in all, taking atleast one question from each section.

Section A


Nuclear Decays: Decay widths and lifetimes. Alpha Decay: General Properties and theory of alpha decay, Barrier penetration of alpha decay, alpha decay spectroscopy Spontaneous fission decay Beta Decay: General Properties, Neutrinos and Antineutrinos, the Fermi theory of beta decay, Angular momentum and selection rules of beta decay, electron capture, beta spectroscopy. Gamma decay, reduced transition probabilities for gamma decay, Weisskopf units for gamma decay.

Section B

The Fermi gas model, The one body potential General properties, The harmonic oscillator potential separation of intrinsic and centre-of-mass motion, the kinetic energy and the harmonic oscillator. Conserved quantum numbers, angular momentum, parity and isospin, Quantum number for the two nucleon system, two proton or two neutron, and proton and neutron.
The Hartree Fock Approximation  Properties of single Slater determinants, Derivation of the Hartree-Fock equations, examples of single particle energies, Results with Skyrme Hamiltonian: Binding energy, single particle energies, Rms charge radii and charge densities.

Section C

**The Shell Model:** Ground state spin of nuclei, Static electromagnetic moments of nuclei, Electromagnetic transition probability on shell model, Exact treatment of two-nucleons by shell model, two-nucleon wave function, matrix elements of one-body operator and two-body potential, Shell model diagonalization, Configuration mixing, relationship between hole state and particle state, State of hole-particle excitation and core polarization, Seniority and fractional percentage by second-quantization technique.

**Recommended Books**


**COURSE CODE: PHYMPHIL-103/PHYPHD-103**

**Name of the Course: Advanced Particle Physics**

Max Marks: 100 Time: 3 hrs.

*Instructions for paper setters and candidates:* Seven questions will be set in all; Question No. 1 is compulsory. covering whole syllabus of the course and consist of 5-10 part of short answer type question. Question No. 2 to 7 shall be set as, two questions from each Section A, Section B and Section C. Candidates will be required to attempt four questions in all, taking at least one question from each section.

**Section A**

Symmetries and Conservation Laws, Noether’s theorem, U(1) gauge invariance baryon and Lepton Number Conservation Global and Local Gauge Invariance, Spontaneous Breaking of
Global gauge invariance, Goldstone Bosons, Higgs Mechanism, Generalized Local gauge invariance, Abelian and Non Abelian gauge invariance.

Section B

Weinberg- Salam Theory of Electroweak Unification, the matter fields, the gauge fields, The gauging of SU (2) X U (1), the Vector Bosons, the fermion sector, Helicity States, Fermion Masses, Fermion Assignments in the electroweak model, Spontaneous Symmetry Break down, Fermion Mass Generation, the Color gauge theory of Strong interactions.

Section C

SU (5) Grand Unified Theory, the generators of SU (5), The Choice of fermion representations, Spontaneous Breaking of SU (5) Symmetry Fermion Masses and Mixing Angles, the Classic Predictions of SU(5) Grand Unified Theory Quark-lepton Mass Relations in SU(5).

Recommended Books

1. Modern Elementary Particles Physics, G.L.Kane (Addison Wesley).
2. Gauge Theories of Strong, Weak and Electromagnetic Interactions C. Quigg (Addison-Wesley)
3. Grand Unified Theories Graham Ross (Addison Wesley)
4. Gauge theory of Elementary Particles Physics, P.P. Cheng and Ling Fong Li.
5. Gauge Field Theories, Paul H. Frampton (Addison Wesley)

COURSE CODE: PHYMPHIL-103/PHYPHD-103

Name of the Course: Advanced Topics in Nuclear Astrophysics

Max Marks: 100 Time: 3 hrs.

Instructions for paper setters and candidates: Seven questions will be set in all; Question No. 1 is compulsory, covering whole syllabus of the course and consist of 5-10 part of short answer type question. Question No. 2 to 7 shall be set as, two questions from each Section A, Section B and Section C. Candidates will be required to attempt four questions in all, taking atleast one question from each section.

Section A

Element abundances and Big Bang Nucleosynthesis, Cosmology: Baryons, the Cosmic Microwave Background, and Dark Matter/Energy, Nuclear reactions in stars, hydrogen burning: pp chain, CNO cycles, red giant evolution: 3alphareaction and 12C(alpha,alpha)

Section B

Solar neutrinos, neutrino oscillations, matter effects, neutrino-nucleus reactions detectors, neutrino oscillations and the MSW effect, neutrino properties and open questions, Core-
collapse supernovae, Nova and supernova nucleosynthesis in novae, the s-process, the r-process, neutrino process

Section C

Neutron stars, Cosmic rays, composition and sources, very high energies and the GZK cutoff, atmospheric neutrinos, gamma-ray lines, and gamma-ray bursts

Recommended Books

2. D. Clayton, Principles of Stellar Evolution and Nucleosynthesis

COURSE CODE: PHYMPHIL-103/PHYPHD-103

Name of the Course: Advanced Topics in Condensed Matter Physics

Max Marks: 100

Instructions for paper setters and candidates: Seven questions will be set in all; Question No. 1 is compulsory, covering whole syllabus of the course and consist of 5-10 part of short answer type question. Question No. 2 to 7 shall be set as, two questions from each Section A, Section B and Section C. Candidates will be required to attempt four questions in all, taking atleast one question from each section.

Section A

Interacting electrons (Many-body problem, Hartree-Fock approximation in second quantization, Brief overview on Density Functional Theory); Linear response theory (Fluctuation-dissipation theorem, Scattering, Sumrule); Physics of disorder (Kubo formula for conductivity, Scaling theory of localization, Quantum hall effect);

Section B

Magnetism (Local moment magnetism, exchange interaction, Band magnetism- Stoner theory, spin density wave, Anderson model, Kondo problem); Fermi liquid theory (Electron spectral function, Quasi-particles and Landau interaction parameter, Fermi liquid in Kondo problem);

Section C

Origin of attractive interaction: Reminder on Green functions, Coulomb interaction, Electron phonon interaction, Effective interaction between electrons, Cooper instability and BCS ground state: Cooper instability , The BCS ground state, BCS Theory: BCS mean filed theory , Isotope effect , Specific heat, Density of states and single particle tunneling , Ultrasonic attenuation and nuclear relaxation , Ginzburg – Landau Gor’klov theory, Josephson effects: The Josephson effects in Ginzburg- Landau theory, Dynamics of Josephson junctions, Bogoliubov- de Gennes Hamiltonian, Andreev reflection, Unconventional paring: The gap equation for unconventional paring, Cuprates,
Recommended Books

1. Advanced Solid State Physics – Phillip Phillips

COURSE CODE: PHYMPHIL-103/PHYPHD-103

Name of the Course: Advanced Quantum Mechanics

Max Marks: 100 Time: 3 hrs.

Instructions for paper setters and candidates: Seven questions will be set in all; Question No. 1 is compulsory. covering whole syllabus of the course and consist of 5-10 part of short answer type question. Question No. 2 to 7 shall be set as, two questions from each Section A, Section B and Section C. Candidates will be required to attempt four questions in all, taking atleast one question from each section.

Section A

Quantization of Wave Fields: Classical and quantum fields equations, complex fields, Hamiltonian formulation, quantization of non-relativistic Schrodinger equation for a system of bosons and fermions, commutation and anticommutation at unequal times, N-representations (Quantization of complex scalar (spin zero) fields, positive and negative frequency parts. Quantization of Dirac (spin ½) field. Covariant anticommutation relations, interaction between charged particles and electromagnetic fields, quantization of electromagnetic field.

Section B


Section C

Recommended Readings

1. L.I. Schiff; Quantum Mechanics (McGraw Hill)
2. L.H. Ryder: Quantum Field theory (Cambridge Univ. Pr)
4. R.P. Feynman and Hibbs: Path Integrals (McGraw Hill)
5. R. Ramond: Field theory; A Modern Primer (Addision Wesley)

COURSE CODE: PHYMPHIL-103/PHYPHD-103

Name of the Course: Advanced Techniques for Materials Characterization

Max Marks: 100

Instructions for paper setters and candidates: Seven questions will be set in all; Question No. 1 is compulsory, covering whole syllabus of the course and consist of 5-10 part of short answer type question. Question No. 2 to 7 shall be set as, two questions from each Section A, Section B and Section C. Candidates will be required to attempt four questions in all, taking atleast one question from each section.

Section A

X-ray Techniques: X-RAY TECNIQUES: X-ray diffraction principles, scattering and absorption of X-rays, x-ray techniques for orienting crystals, diffraction from regular and faulted closed pack structures, line profile analysis, crystal structure analysis measurements of intensities of X-ray reflection, single crystal powder diffraction, particle size using Scherer formula, microstructure analysis, Rietveld analysis, small angle x-ray scattering (SAXS), X-ray absorption fine structure (XAFS) and X-ray absorption near edge structure (XANES) spectroscopy, X-ray magnetic circular dichroism (XMCD)

Section B

Instrumentation and Applications: Raman spectroscopy, photoluminescence, infrared (IR), UV-visible, Mossbauer spectroscopy, impedance spectroscopy, electron spin resonance (ESR), reflection high energy electron diffraction (RHEED)

Magnetic Measurements: magnetometry – vibrating sample magnetometer (VSM), thermomagnetic analysis, SQUID

Neutron Scattering Techniques: neutron powder diffraction, single crystal neutron diffraction, magnetic neutron scattering, small angle neutron scattering (SANS), phonon and dynamic studies by inelastic and quasi-elastic neutron scattering, neutron reflectrometry for thin films.

Section C

Microscopy: Scanning electron microscopy(SEM) and transmission electron microscopy (TEM), energy dispersive x-ray analysis (EDX) and electron probe micro-analysis, Rutherford back scattering (RBS), low energy electron diffraction (LEED), atomic force
microscopy (AFM) and scattering tunneling microscope (STM), basic principle and different modes of operation, magnetic force microscopy (MFM).

**Recommended Books**


**COURSE CODE: PHYMPHIL-103/PHYPHD-103**

**Name of the Course: Quantum computational and Quantum information**

**Max Marks: 100**

**Time: 3 hrs.**

*Instructions for paper setters and candidates*: Seven questions will be set in all; Question No. 1 is compulsory. covering whole syllabus of the course and consist of 5-10 part of short answer type question. Question No. 2 to 7 shall be set as, two questions from each Section A, Section B and Section C. Candidates will be required to attempt four questions in all, taking atleast one question from each section.

**Section A**

**Introduction and Overview:**
Global perspectives, History of quantum computation and quantum information., Future directions.

**Quantum Bits:**
Multiple qubits

**Quantum computation:**
Single qubit gates, Multiple qubit gates, Measurements in bases other than the computational basis, Quantum Circuits, Qubit copying circuit, Example: Bell states, Example. Quantum teleportation.

**Quantum Algorithms:**
Classical computations on a quantum computer, Quantum parallelism, Deutsch’s algorithm, The Deutsch-Jozsa algorithm, Quantum algorithms summarized

**Experimental Quantum Information Processing :**
The Stern-Gerlach experiment, Prospects for practical quantum information processing
Quantum Information:
Quantum information theory: example problems, Quantum information in wider context

Introduction to Quantum Mechanics:

The Postulates of Quantum Mechanics:
State space, Evolution, Quantum measurement, Distinguishing quantum states, Projective measurements, POVM measurements, Phase, Composite systems, Quantum mechanics: a global view

Application: Superdense Coding:

The Density Operator:
Ensembles of quantum states, General properties of the density operator, The reduced density operator, The Schmidt decomposition and purifications, EPR and the Bell inequality

Introduction to Computer Science:
Models for computation, Turing machines, Circuits, The analysis of computational problems, How to quantify computational resources, Computational complexity, Decision problems and the complexity classes P and NP, A plethora of complexity classes, Energy and computation, Perspectives on computer science

Quantum Circuits:
Quantum algorithms, Single qubit operations, Controlled operations, Measurement, Universal quantum gates, Two-level unitary gates are universal, Single qubit and cnot gates are universal
A discrete set of universal operations, Approximating arbitrary unitary gates is generically hard, Quantum computational complexity, Summary of the quantum circuit model of computation, Simulation of quantum systems, Simulation in action, The quantum simulation algorithm, An illustrative example, Perspectives on quantum simulation

Section B


Quantum Search Algorithms:
The quantum search algorithm, The oracle, The procedure, Geometric visualization, Performance , Quantum search as a quantum simulation, Quantum counting, Speeding up the solution of NP-complete problems, Quantum search of an unstructured database, Optimality of the search algorithm, Black box algorithm limits

Quantum Computers: Physical Realization:
Guiding principles, Conditions for quantum computation, Representation of quantum information, Performance of unitary transformation, Preparation of "ducial initial states, Measurement of output result, Harmonic oscillator quantum computer, Physical apparatus,
The Hamiltonian, Quantum computation, Drawbacks, Optical photon quantum computer, Physical apparatus, Quantum computation, Drawbacks, Optical cavity quantum electrodynamics, Physical apparatus, The Hamiltonian, Single-photon single-atom absorption and refraction, Quantum computation, Ion traps, Physical apparatus, The Hamiltonian, Quantum computation, Experiment, Nuclear magnetic resonance, Physical apparatus, The Hamiltonian, Quantum computation, Experiment, Other implementation schemes

**Quantum Noise and Quantum Operations:**
Classical noise and Markov processes, Quantum operations, Overview, Environments and quantum operations, Operator-sum representation, Axiomatic approach to quantum operations, Examples of quantum noise and quantum operations, Trace and partial trace, Geometric picture of single qubit quantum operations, Bit 0ip and phase 0ip channels, Depolarizing channel, Amplitude damping, Phase damping, Applications of quantum operations, Master equations Quantum process tomography, Limitations of the quantum operations formalism

**Distance Measures for Quantum Information:**
Distance measures for classical information, How close are two quantum states?, Trace distance Fidelity, Relationships between distance measures, How well does a quantum channel preserve information?

**Section C**

**Quantum Error-Correction:**

**Entropy and Information:**
Shannon entropy, Basic properties of entropy, The binary entropy, The relative entropy, Conditional entropy and mutual information, The data processing inequality, Von Neumann entropy, Quantum relative entropy, Basic properties of entropy, Measurements and entropy, Subadditivity, Concavity of the entropy, The entropy of a mixture of quantum states, Strong subadditivity, Proof of strong subadditivity, Strong subadditivity: elementary applications

**Quantum Information Theory:**
Distinguishing quantum states and the accessible information, The Holevo bound, Example applications of the Holevo bound, Data compression, Shannon's noiseless channel coding theorem, Schumacher's quantum noiseless channel coding theorem, Classical information over noisy quantum channels, Communication over noisy classical channels, Communication over noisy quantum channels, Quantum information over noisy quantum channels, Entropy exchange and the quantum Fano inequality, The quantum data processing inequality, Quantum Singleton bound, Quantum error-correction, refrigeration and Maxwell's demon, Entanglement as a physical resource, Transforming bi-partite pure state entanglement, Entanglement distillation and dilution, Entanglement distillation and quantum error-correction, Quantum cryptography, Private key cryptography, Privacy amplification and
information reconciliation, Quantum key distribution, Privacy and coherent information, The security of quantum key distribution

**Recommended Books:**

