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

S. No.	Course code	Course	Marks
1.	PHYMPHIL-101	Research Methodology	100
2.	PHYMPHIL-102	Mathematical Physics	100
3.	PHYMPHIL-103	Elective-I	100
4.	PHYMPHIL-104	Seminar	Gradation

Semester-II

S. No.	Course code	Course	Marks
1.	PHYMPHIL-201	Seminar	Gradation
2.	PHYMPHIL-202	Dissertation	Gradation & Report

Ph.D. Course work (Physics) Semester -I

S. No.	Course code	Course	Marks
1.	PHYPHD-101	Research Methodology	100
2.	PHYPHD-102	Mathematical Physics	100
3.	PHYPHD-103	Elective-I	100
4.	PHYPHD-104	Seminar	Gradation

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

Scintillation Detector Principles:- Organic Scintillators, Inorganic Scintillators, Light Collection and Scintillator Mounting ; **Photomultiplier Tubes and Photodiodes:-** Introduction, The Photocathode, Electron Multiplication, Photomultiplier Tube Characteristics, Photodiode as substitute for photomultiplier tubes, Scintillation Pulse Shape Analysis, Hybrid Photomultiplier tubes, Position Sensing Photomultiplier Tubes, Photoionization Detectors; **Radiation Spectroscopy with Scintillators:-** General Consideration in Gamma-Ray Spectroscopy, Gamma-Ray interactions, Predicted response functions, Properties of scintillation gamma ray spectrometers, response of scintillation detectors to neutrons, electron spectroscopy with scintillators, specialized detector configurations based on scintillations.

Section B

Semiconductor Diode Detectors: - Semiconductor Properties, The Action of ionization radiation in Semiconductors, Semiconductors as radiation detectors Semiconductor Detector Configurations, Operational Characteristics, Application of Silicon Diode Detectors; **Germanium Gamma-Ray detectors:-** General considerations, configuration of Germanium detectors, Germanium detector operational characteristics, Gamma ray spectroscopy with Germanium detectors; **Other Solid State Detectors:-** Lithium –Drifted Silicon Detectors, Avalanche detectors, Photoconductive Detectors, Position sensitive semiconductor detectors

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 lattices, 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 diagnonalization of many-body Hamiltonian

Recommended Books

1. Radiation Detection and measurement (3rd edition), Gleniff. Knoll John Wiley & Sons, INC
2. Computational Physics, T. Pang Cambridge University press
3. Computational Physics, S.E. Koonin , Addison Welsey.
4. Monte carlo Methods in statistical in Physics, K. Binder Springer 1986

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

Green's Functions: Green's functions and boundary value problem for ordinary differential equation. Self adjoint differential form. Equivalence of integral and differential equations.Green's function for the partial differential equation and applications to physical problems.

Section B

Integral Equations: Linear integral equations. Iterative techniques. Degenerate's and symmetric Kernels Hilbert – Schmidt theory. Ferdhom theory. Volterra integral equation.

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.
2. Mathematical methods for Physicsts, GB Arfken HJ Weben and FE Harris, Academea Press, 2000.

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

Angular Momentum Theory: Angular momentum coupling: coupling of two angular momenta, coupling of three angular momenta, coupling of four angular momenta Racah coefficients. Tensors and reduced matrix elements of irreducible operators, Product of tensor operators. Application: Spherical harmonics between orbital angular momentum states, Spin operator between spin states, Angular momentum J between momentum states, Matrix elements element of compounded states and Matrix elements between angular momentum coupled state.

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 instrinsic 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 shall model, two-nucleon wave function, matrix elements of one-body operator and two-body potential, Shell model digonalization, 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

1. M.K. Pal Theory of Nuclear Structure, Affiliated East-West, Madras-1992.
2. Y. R. Waghmare, Introductory Nuclear Physics, Oxford-IBH, Bombay, 1981.
3. K. L. G. Heyde, The Nuclear Shell Model, (Springer-Verlag, 1994)
4. R. D. Lawson, Theory of the Nuclear Shell Model, (Clarendon Press, 1980).
5. A. R. Edmonds, Angular Momentum in Quantum Mechanics, (Princeton University Press, 1957
6. D. M. Brink and G. R. Satchler, Angular Momentum, (Clarendon Press, Oxford, 1968).
7. R. D. Lawson, Theory of the Nuclear Shell Model, (Clarendon Press, 1980)
8. D. Vautherin and D. M. Brink, Phys. Rev. C 5, 626 (1972)
9. T. R. H. Skyrme. Philos. Mag. 1, 1043 (1956); Nucl. Phys. 9, 615 (1959); 9, 635 (1959)
10. W. Kohn and L. J. Sham, Phys. Rev. 140 A1133 (1965).
11. P. J. Brussaard and P. W. M. Glaudemans, Shell Model Applications in Nuclear Spectroscopy, (North Holland, 1977).
12. A. De Shalit and I. Talmi, Nuclear Shell Theory, (Academic Press, 1963).

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 atleast 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, Ablian 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 (I), the Vector Bosons, the fermion sector, Helicity States, Fermion Masses, Fermon 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 fermoin 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)
6. Gauge Field theories J. Leite Lopes, Pergamon Press.

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, Corecollapse supernovae, Nova and supernova nucleosynthesisin 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

1. E. Kolb and M. Turner, The Early Universe Addision-Wesly Publication company
2. D. Clayton, Principles of Stellar Evolution and Nucleosynthesis
3. Christian Iliadas, Nuclear Physics of Stars, Wiley –VCH Verlay GmbH & Co. 2007

COURSE CODE: PHYMPHIL-103/PHYPHD-103

Name of the Course: Advanced Topics in Condensed Matter 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

Interacting electrons (Many-body problem, Hartree-Fockapproximation in second quantization, Brief overview on Density Functional Theory); Linear response theory (Fluctuation-dissipation theorem, Scattering, Fsumrule); 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'kov 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, Pnictides , Triplet superconductors and He-3.

Recommended Books

1. Advanced Solid State Physics – Phillip Phillips
2. Solid State Physics, by N W Ashcroft and N D Mermin, Harcourt College Publishers. (College Ed.)
3. Theory of Quantum liquid, Pines and Nozieres, Westview Press
4. Theory of Superconductivity. J. Robert Schrieffer, Westview Press
5. Theory of Superconductivity. Carsten Timm, Institute of theoretical Physics

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

Path Integral Formulation of Quantum Mechanics: The quantum mechanical law of motion classical action, quantum mechanical amplitudes, the sum over paths. Events occurring in succession, wave function. Application to free particle and harmonic and forced harmonic oscillator. Path integral as a functional and its evaluation. Schrodinger equation, time independent Hamiltonian, perturbation expansion, transition elements. Propagator and scattering matrix.

Section C

Interacting Fields: Interaction Lagrangian for the fields. S. Matrix and its reduction, chronological product and wick's theorem. Covariant perturbation theory. Lagrangian for quantum electrodynamics. Feynman diagrams and rules for QED in configuration and momentum space. Radiation theory, absorption and emission. Furry's theorem, Coulomb scattering, election- positron annihilation. Bhabha scattering and Compton scattering.

Recommended Readings

1. L.I. Schiff; Quantum Mechanics (McGraw Hill)
2. L.H. Ryder: Quantum Field theory (Cambridge Univ. Pr)
3. J.Bjorken and S.D. Drell: Ralativistic Quantum Mechanics Quantum Mechanics (McGraw Hill)
4. R.P. Feynmn 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 **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

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: megnetometry – vibrating sample magnetometer (VSM), thermo-magnetic 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

1. An introduction of X-ray crystallography: by M.M.Woolfson.
2. Characterization of Materials: by John B. Watchman.
3. X-ray and Neutron Reflectivity: by J.Daillant and A.Gilaud (Ed) Springer (2009).
4. Modern Techniques for Surface Science: by D.P. Woodruff and T.A.Delchar- Cambridge University Press, 1994
5. Methods of Surface Analysis: by J.M. Walls- Cambridge University Press, 1989.
6. X-ray Flurorescence Spectroscopy: R. Jenkins – Wiley Interscience, New York, 1999.
7. The SQUID Handbook: Fundamental and Technology of SQUID and SQUID systems: by John Clarke and Alex I.Braginski, Wiley-VCH (2004).
8. Solid State Magnetism: by John Crangle&Edward Arnold- UK (1991).
9. The Principles and Practice of Electron Microscopy: by Ian. M. Walt-Cambridge University Press, 1997.
10. Physical Principles of Electron Microscopy: An introduction to TEM, SEM and AFM: by R.F.Egerton Springer(2005).
11. Material Characterization Techniques: by S. Zhang, L. Li and A. Kumar, CRC press (2009).

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:

Linear algebra, Bases and linear independence, Linear operators and matrices, The Pauli matrices, Inner products, Eigenvectors and eigenvalues, Adjoints and Hermitian operators, Tensor products, Operator functions, The commutator and anti commutator, The polar and singular value decompositions.

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 puri¯cations, 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

The Quantum Fourier Transform and its Applications: The quantum Fourier transform, Phase estimation, Performance and requirements, Applications: order-¯nding and factoring, Application: order-¯nding, Application: factoring, General applications of the quantum Fourier transform, Period-¯nding, Discrete logarithms, The hidden subgroup problem, Other quantum algorithms?

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 °ip and phase °ip 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:
Introduction, The three qubit bit °ip code, Three qubit phase °ip code, The Shor code, Theory of quantum error-correction, Discretization of the errors, Independent error models, Degenerate codes, The quantum Hamming bound, Constructing quantum codes, Classical linear codes Calderbank{Shor{Steane codes, Stabilizer codes**,** The stabilizer formalism, Unitary gates and the stabilizer formalism, Measurement in the stabilizer formalism, The Gottesman{Knill theorem, Stabilizer code constructions, Examples, Standard form for a stabilizer code, Quantum circuits for encoding, decoding, and correction, Fault-tolerant quantum computation, Fault-tolerance: the big picture, Fault-tolerant quantum logic, Fault-tolerant measurement, Elements of resilient quantum computation

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 amplication and

information reconciliation, Quantum key distribution, Privacy and coherent information, The security of quantum key distribution

Recommended Books:

1. Quantum Computation and Quantum Information, Michael. A. Nielsen and ISSAAC L. Chuang, Cambridge University press

2. Classical and Quantum Computation A.Yu Kitaev, A.H.Shen and M.N.Vyalyi .

3. Quantum Information Theory , Mark M. Wilde Cambridge Press .