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}

A. 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 Viva-Voce	Gradation Gradation

B. 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 candidates who have completed M.Phil as per the course given above shall be exempted from the Ph.D. Course work as defined under B.
2. The elective papers shall be offered by the Departmental Council with the consultation of teaching staff and students.
3. Dissertation work will be distributed over both semesters for M. Phil. Programme.

4. Both the theory papers and dissertation are to be completed within one year, for M. Phil course.
5. Gradations are A (Excellent), B (Very Good), C (Good), D (Satisfactory).
6. 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

Error Estimation , Minimising the Total Error, Pitfalls and Precautions, **Iterative Solution of Linear Equations;** Need and Scope, Jacobi Iteration Method, Gauss- Seidel Method, Convergence of Iteration Methods, Condition for convergence, Rate of convergence. **Curve Fitting Interpolation;** Introduction, Polynomial Forms, Linear Interpolation, Lagrange Interpolation Polynomial, Spline Interpolation, Cubic Spline, **Curve Fitting Regression**; Introduction, Fitting Linear Equations, Least Squares regression, Ill- Conditioning in least-squares methods, **Numerical Differentiation**; Differentiating Tabulated Functions, Error analysis , Higher order derivatives, Richardson Extrapolation, **Numerical Integrations;** Simpson's 1/3 rule, error analysis, Composite Simpson's 1/3 rule, Simpson's 3/8 rule Gaussian Integrations, Changing limits of integration, Higher order Gaussian formulae, **Numerical Solution of ordinary Differential Equations**: Euler's Method, Accuracy of Euler's method, program EULER, Runge – Kutta Methods, Determination of weights, Fourth order Runge Kutta methods.

Recommended Books

Text Books:

1. Radiation Detection and measurement (3^{rd} edition), Gleniff. Knoll John Wiley & Sons, INC
2. Numerical Methods, E. Balagurusamy Tata McGraw -Hill

Reference Books:

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

Partial differential equation: Importance of partial differential equations; wave equations: the diffusion equation, Laplace's equation, Poisson's equation, Schrodinger's equations. General form of solution, General and particular solutions; First order equations: inhomogeneous equations and problems, second order equations. The wave equation, The diffusion Equation, Characteristics and the existence of solutions; First order equations, Second order equations, Uniqueness of Solutions. Separation of variables; the general method, Superposition of separated solutions, Separation of variables in polar coordinates, Laplace's equation in polar coordinates; spherical harmonics, other equations in polar coordinates, solution by expansion; separation of variables for inhomogeneous equations. Integral transform methods, Inhomogeneous problems- Green's functions, Similarities to Green's functions for ordinary differential equations, general boundary -value problems; Dirichlet problems.

Section B

Calculus of variations : The Euler – Lagrange equation , Special cases , F does not contain y explicitly: F does not contain X explicitly, Some extensions, Several dependent variables, several independent variables; higher- order derivatives ; variable end points; Constrained variation, Physical variational principles, Fermat's principle in optics: Hamiltion's principle in mechanics, General eigenvalue problems, Estimation of eigenvalues and eigenfunctions, Adjustment of parameters.

Section C

Group Theory: Groups, definition of a group: examples of groups, Finite groups, Non – Abelian Groups, Permutation groups , Mappings between groups , Subgroups, Subdividing a group, Equivalence relations and classes; congruence and cosets: conjugates and classes, Exercises, Hints and answer. **Representation Theory:** Dipole moments of molecules, Choosing and appropriate formalism, Equivalent representations, Reducibility of a representation, The orthogonality theorem for irreducible representations, Characters, orthogonality property of characters, Counting irreps using characters , Summation rules of irreps, Construction of a character table, Group nomenclature , Product representations, Physical applications of group theory, Bonding in molecules: matrix elements in quantum mechanics ; degeneracy of normal modes breaking of degeneracies.

Recommended Books

Text Books:

1. Mathematical methods for physics and engineering by K. F. Riley, M. P. Hobson, and S. J. Bence, third edition, Cambridge University Press 2006
   ISBN: 978-0-521-13987-8

Reference Books:

1 Mathematics of classical and Quantum Physics, Frederick W. Byzon and Robat W. Fuller.
2. Mathematical methods for Physicists, 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. K. L. G. Heyde, The Nuclear Shell Model, (Springer-Verlag, 1994)
3. A. R. Edmonds, Angular Momentum in Quantum Mechanics, (Princeton University Press, 1957
4. D. M. Brink and G. R. Satchler, Angular Momentum, (Clarendon Press, Oxford, 1968).
5. D. Vautherin and D. M. Brink, Phys. Rev. C 5, 626 (1972)
6. T. R. H. Skyrme. Philos. Mag. 1, 1043 (1956); Nucl. Phys. 9, 615 (1959); 9, 635 (1959)
7. W. Kohn and L. J. Sham, Phys. Rev. 140 A1133 (1965).
8. P. J. Brussaard and P. W. M. Glaudemans, Shell Model Applications in Nuclear Spectroscopy, (North Holland, 1977).

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 in Physics, Charge conjugation, time reversal invariance, parity, G-parity, symmetries and groups, The group SU(2), SU(2) of isospin, combining representations, Flavour SU(3), quark model, τ-θ puzzle, parity violation, CP-violation: the neutral kaon system

Section B:

The standard model (SM) of fundamental interactions, construction of SU(2)XU(1) theory, spontaneous symmetry breaking and Higgs mechanism in the SM, Fermion masses, GIM mechanism, Cabbibo-Kobayashi-Maskawa (CKM) matrix, Quark mixing and CP-violation, Color gauge invariance and QCD, neutrino oscillations, helicity of the neutrino, neutrino mass terms of Dirac and Majorana type, neutrino masses in SU(2)XU(1) theory, the neutrino mixing matrix.

Section C:

Idea of Grand Unification, choice of the gauge group, SU(5) model of grand unified theory, generators of SU(5), Fermion representations, spontaneous symmetry breaking in SU(5), SO(10) grand unified theory, Fermion masses in SO(10), neutrino masses in SO(10).

Recommended Books

1. Particle Physics: An Introduction, M. Leon (Academic Press).
2. Quarks and Leptons: An introductory course in Modern Particle Physics, Francis Halzen and Alan D. Martin (John Wiley & Sons).
3. Introduction to Elementary Particles, David Griffiths, (John Wiley & Sons).
4. Gauge Theory of Elementary Particle Physics, Ta-Pei Cheng and Ling Fong Li (Clarendon Oxford).
5. Gauge, Theories of Strong, Weak and Electromagnetic Interactions, C. Quigg (Addison – Wesley).
6. Modern Elementary Particle Physics, G.L.Kane (Addision- Wieley 1987).
7. Grand Unifield Theories, Graham G. Ross (Oxford University).
8. Neutrino Physics, Kai Zuber (CRC Press, Taylor and Francis Group).
9. Physics of Neutrinos and Applications to Astrophysics, M. Fukugita and T. Yanagida (Springer).
10. Massive Neutrinos in Physics and Astrophysics, Rabindra Mohapatra (World Scientific).

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 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

Second quantization: A single electron, Occupation numbers, Second quantization for fermions, The electron gas and the Hartree- Fock approximation , Perturbation theory, The density operator, The random phase approximation and screening , Spin Wave in the electron gas

Section B

Electron–phonon interaction sand Superconductivity: The Frohlich Hamiltonian,Phonon energies and the Kohn effect, Polarons and mass enhancement, The attractive interaction between electrons, The Nakajima Hamiltonian. The superconducting state, the BCS Hamiltonian, The Bogoliubov- Valatin transformation, The ground state wave function and the energy gap, the transition temperature.

Section C

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);

Recommended Books

1. A Quantum Approach to the Solid State, Philip L. Taylor, prentice –Hall, Inc., Englewood Cliffs, new Jersey.
2. Theory of Quantum liquid, Pines and Nozieres, Westview Press
3. Solid State Physics, by N W Ashcroft and N D Mermin, Harcourt College Publishers. (College Ed.)
4. Theory of Superconductivity. J. Robert Schrieffer, Westview Press
5. 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

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). Grazing Incidence X-ray Diffraction (GIXRD).

Neutron Scattering Techniques: neutron powder diffraction, single crystal neutron diffraction, magnetic neutron scattering, small angle neutron scattering (SANS).

Section B

Basic Principles Instrumentation, working and Applications: Raman spectroscopy, photoluminescence, infrared (IR), FTIR UV-visible, Mossbauer spectroscopy, impedance spectroscopy, electron spin resonance (ESR), reflection high energy electron diffraction (RHEED), low energy electron diffraction (LEED).

Magnetic Measurements: megnetometry – vibrating sample magnetometer (VSM), thermo-magnetic analysis, SQUID.

Section C

Microstructure: Scanning electron microscopy(SEM) and transmission electron microscopy (TEM), energy dispersive x-ray analysis (EDX) and electron probe micro-analysis, Microstructure formulation Mechanism in TEM, 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. Fundamentals of Surface and Thin film Analysis by L.C. Feldman and J.W. Mayer published by Elsevier Science, 1986.
5. Modern Techniques for Surface Science: by D.P. Woodruff and T.A.Delchar- Cambridge University Press, 1994
6. Methods of Surface Analysis: by J.M. Walls- Cambridge University Press, 1989.
7. X-ray Flurorescence Spectroscopy: R. Jenkins – Wiley Interscience, New York, 1999.
8. The SQUID Handbook: Fundamental and Technology of SQUID and SQUID systems: by John Clarke and Alex I.Braginski, Wiley-VCH (2004).
9. Solid State Magnetism: by John Crangle&Edward Arnold- UK (1991).
10. The Principles and Practice of Electron Microscopy: by Ian. M. Walt-Cambridge University Press, 1997.
11. Physical Principles of Electron Microscopy: An introduction to TEM, SEM and AFM: by R.F.Egerton Springer(2005).
12. 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

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 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

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

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:

Text Books:

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

Reference Books:

1. Classical and Quantum Computation A.Yu Kitaev, A.H.Shen and M.N.Vyalyi.
2. Quantum Information Theory, Mark M. Wilde Cambridge Press.