Department of Physics
University of Dhaka

Syllabus for M.S Courses

Effective from session: 2015-2016.

1. Total number of credits is thirty (30) spread over one year of which Twenty (20) credits will comprise theoretical courses. There will be Six (6) credits of practical (4), practical class assessment (2) /thesis work (4 Thesis+2 Viva), and four (4) credits of general oral examination (viva- voce).

2. The credit is defined as follows:

(i) For theoretical courses, 15 one-hour class lecturer = 1 credit.
For example existing full unit course is equivalnt to 4 credits.

(ii) For practical 30 hours of laboratory work will constitute one (1) credit.

For non-thesis students

3. For practical, 4 credits will be awarded on final practical examination and 2 credits for practical class assessment.

Total : 6 credits

For thesis students

4. There will be an oral examination based on the thesis work which will carry 2 credits and 4 credits will be allocated for the evaluation of the written thesis submitted by the student. Total : 6 credits

Credit Distribution

1. Theory	:	5 X 4 = 20 credits
2. General viva	:	1 X 4 = 04 credits
3. Non-thesis (practical) group /Thesis group*	=	6 credits
Total :		= 30 credits

Non-thesis Group *		Thesis Group*	
Practical exam	4 credits	Thesis evaluation	4 credits
Class Assessment	2 credits	Oral exam	2 credits
Total : 6 credits		Total : 6 credits	

Rules regarding the M.S. Examination

There will be10% marks for attendence and 90% for the final examination on Theory papers.

The rules regarding examinations, fees etc. will remain the same as the usual University rules.

Students will take any 5 (five) subjects from this following:

PG 521: General Relativity and Cosmology
PG 522: Group Theory, Differential Geometry and Topology
PG 541: Quantum Field Theory I
PG 542: Quantum Field Theory II
PG 543: The Electroweak and Strong Interaction
PG 544: Astroparticle Physics
PG 545: Advanced Laser Physics
PG 550: Advanced applications of Lasers
PG 551: Equilibrium Statistical Mechanics
PG 552: Non-equilibrium Statistical Mechanics
PG 560: Condensed Matter Physics and Materials Science
PG 561: Computational Physics
PG 563: Biomedical Physics
PG 571: Nuclear Physics
PG 580: Atmospheric Physics
PG 581: Atmospheric Physics and Meteorology I
PG 582: Atmospheric Physics and Meteorology II
PG 583: Optical Spectroscopy
PG 585: Reactor Physics
PG 587: Biophysics & Medical Imaging
PG 588: Polymer Physics
PG 589: Health and Radiation Physics

Detailed Syllabus

PG 521: General Relativity and Cosmology **4 Credits**

1. Preamble: 3 lect
Review of special relativity and its Limitations, non-intertial frames Einstein's equivalence principle.

2. Elements of Tensor Calculus: 10 lect
Tensor fields, metric tensor, covariant derivatives and connections, parallel transport and Christoffel connection, geodesics. Riemann curvature tensor and its symmetries, Bianchi identities. Ricci, Einstein and Wey1 tensors, Geodesic deviation.

3. Gravitation: 12 lect
Equivalence principles, gravitational redshift, gravitation as spacetime curvature. Einstein's equation. Hilbert action. Energy-momentum tensor.

Weak field limit and linearized Einstein equations.

4. The Schwarz schild solution and Blackholes: 10 lect
a) Spherically symmetric metrics and Birkhoff's theorem. Schwarzschild solution.

b) Event horizon, Blackholes, Kruskal coordinates. Blackhole formation. Conformal infinity and Penrose Diagrams.

6. Cosmology: 25 lect
a) Cosmological principle-homogeneity and isotropy. Friedman-Robertson-Walker metric. Energy-Momentum tensor for various forms of matter. Friedmann equations. Evolution of the scale factor, redshift, Hubble law. Cosmic Microwave Background Radiation.

b) Horizon problem in big bang model. Inflationary Universe. Vacuum transition. Old Inflation and the New inflation models.

References:

1.Bernard F. Schutz-A First Course in General Relativity (Cambridge Univ. Press, 2009).
2. Bernard F. Schutz-Geometrical Methods in Mathematical Physics (Cambridege Univ. Press, 1982).
3. I. S. Sokolnikoff-Tensor Analysis: Theory and Applications (John Wiley and Sons, Inc. 1951).
4. James B. Hartle-Gravity: An Introduction to Einsteins's General Relativity (Addison Wesley Publishing Co., 2003).
5. M. P. Hobson, G. P. Efstathiou and A. N. Lansenby-General Relativity: An Introduction for Physicists (Cambridge Univ. Press, 2006).
6. S. Caroll-Spacetime and geometry: An Introduction to general Relativity (Addison Wesley Publishing Co., 2003). [A free version on the web is available as the lecture note gr-qc/9712109].
7. Ray d!Inverno-Introducing Einstein's relativity (Oxford Univ. Press, 1992).
8. R.Wald General Ralativity (Change University Press, 1984).

PG 522: Group Theory, Differential Geometry and Topology **4 Credits**

1. Mathematical Preliminaries:
Maps, Homomorphism, Isomorphism, Equivalence relation and equivalence class, Examples, Vector space, Basis, Linear Maps, Image, Kernel, Dual Vector space, Dual Basis, Inner Product, Tensor Product [2 lec]

2. Introduction to Groups:
Symmetry in Physics, Definition of Group, Properties of Group, Representation, Reducible and Irreducible representations, Schur's Lemma, Subgroup, Coset, Normal Subgroup, Quotient group, Examples, Permutation Group [2 lec]

3. Topological Space:
a. Definition of topological space, Neighborhood, Hausdorff space, Compact space, Covering, Connectedness, Homeomorphism, Topological Invariants, Euler Characteristic [2 lec]

b. Path and Loops, Homotopy, Fundamental Group, General properties of Fundamental group, Examples of Fundamental groups, Introduction to Higher Homotopy groups, Examples in Physics [8 lec]

4. Manifold, Differential Form and Exterior Calculus
a. Manifold, Co-ordinate system, Examples of manifolds, Product Manifold, Submanifold, Tangent vector and Tangent vector space, Cotangent vector space and one-form, Tensor and Tensor fields, Examples in Physics, Flow and Lie Derivative, Lie Bracket [6 lec]

b. k-form, Wedge product, Properties of Wedge product, Exterior Derivative, Properties of Exterior Derivative, Volume Form, Orientable manifolds, Dual Map (Hodge star operation), Properties of dual map, Inner products of k-forms, Codifferential (adjoint exterior derivative), Laplacian, Electromagnetism in terms on differential forms [15 lec]
c. Integration of differential forms, Stokes's Theorem, Properties of integrals, deRham's theorem, Electromagnetism with Integral calculus of forms [10 lec]

5. Lie Groups and Lie Algebras:
a. Lie group, Examples of Lie group, Lie Algebras, Generators and structure constants, Exponentiation, Fundamental and Adjoint representation, Irreducible representations of SU(2), Product representations of SU(2), SU(3) group, Gell-mann matrices [5 lec]

b. Cartan generator and Subalgebra, Rank, Weight and Weight vectors, Root and Root space, Raising and Lowering operators, Weights and Roots of SU(3), Positive weights, Simple Roots, Construction of the algebra, Dynkin diagram, Cartan Matrix, Examples [10 lec]

References:
1. Geometry, Topology and Physics by M. Nakahara
2. Topology and Geometry for Physicists by C. Nash and S. Sen
3. Tensor Analysis on Manifolds by R. L. Bishop and S. I. Goldberg
4. Geomtry, Particles and Fields by B. Felsager
5. Lie Algebras in Particle Physics by H. Georgi
6. Group Theory-A Physicist's Survey by P. Ramond
7. Lie Groups, Lie Algebras and Some of Their Applications by R. Gilmore
8. Topology by K. Janich

PG 541: Quantum Field Theory – I 4 Credits

1. Need for Quantum Fields:
Action functional, Action for strings and Membranes, Relativistic generalization [2 lec]

2**. Lorentz and Poincare Symmetries:**
Lie group and Lie algebras, The Lorentz Group and Lorentz Algebra, Spinoral and Tensor representations of Lorentz group, Field representations: Scalar, Weyl, Dirac, Majorana and Vector fields, Poincare group and Poincare Algebra, Representations on fields, Representations on one-particle states [10 lec]

3. Symmetries, Noether's Theorem and Conservation laws:
Action Principle, Global and Local symmetries, Noether's Theorem, Energy Momentum tensor, Conserved currents and charges, Topological conservation laws [4 lec]

4. Gauge theory:
Gauge invariance, Covariant Derivative, Vector potential, Aharonov-Bohm effect, Use of different gauges, Covariant form of Maxwell's equations, Geometrical interpretation [3 lec]

5. Quantization of Free fields:
a. Scalar Fields: Fock Space, Creation and Annihilation operators, Normal ordering, Time Ordered product, Contraction, Real scalar fields, Complex scalar fields, anti-particle and charge operator, Causality, Feynman Propagator [5 lec]
b. Fermion Fields: Creation and annihilation operators for the Dirac fields, Anticommutation relations, Creation and annihilation operator for the Weyl and Majorana fields, Spin-statistics Connection, Feynman propagator for Dirac, Weyl and Majorana fields [6 lec]
c. Electromagnetic field: Quantization in Radiation gauge, Covariant quantization: Gupta-Bleuler prescription, Vacuum Fluctuation, Casimir Effect [5 lec]

6. Perturbation Theory and Feynman Diagrams:
S-matrix, LSZ reduction formula, Perturbative expansion, Wick's Theorem, Feynman Diagrams, Feynman rules for Scalar, Fermion and gauge fields, Examples: Yukawa theory, Scalar Electrodynamics and Quantum Electrodynamics [8 lec]

7. Cross Sections and Decay rates:
Relativistic and Nonrelativistic normalization, Decay rates, Cross sections, Tree-level processes in Yukawa theory and Scalar Electrodynamics [5 lec]

8. Quantum Electrodynamics:
A. QED Lagrangian, Pair Production and annihilation, Electron-electron scattering, Compton Scattering [5 lec]
B. One loop divergences, Dimensional Regularization, Renormalization prescription, Photon polarization graph, Vertex Correction, Electromagnatic Form factors, Bremsstrahlung Process [7 lec]

References:
1. An Introduction To Quantum Field Theory by M. Peskin and D. Schroeder
2. Quantum Field Theory and the Standard Model by M. Schwartz
3. Quarks and Leptons by F. Halzen and A. Martin
4. Quantum Field Theory by M. Kaku
5. A Modern Introduction to Quantum Field Theory by M. Maggiore
6. Quantum Electrodynamics by V. B. Berestetskii, E. M. Lifshitz and L. P. Pitaevskii
7. Quantum Field Theory by Itzaykson and Zuber

PG 542: Quantum Field Theory – II **4 Credits**

1. Path Integrals in Quantum Mechanics:
Feynman Path Integral, Partition Function, Green's function, Evaluation of the Partition function for a free particle, Simple harmonic oscillator and Forced harmonic oscillator [5 lec]

2. Functional Methods in Field Theory:
a. Functional Calculus: Differentiation and Integration, Generating Functional for the free scalar field, Generating functional for interacting scalar field, Example: Phi^4 theory, Connected and Disconnected graph, 1-particle Irreducible graphs, Proper vertex function [8 lec]
b. Effective Action, Evaluation of Path Integral, Zeta function evaluation [2 lec]
c. Path Integral over Grassmann variables, Functional methods for the Fermions. [2 lec]

3. Non-Abelian Gauge Fields and Path Integrals:
A. Summary of Lie Algebras and Gauge Fields, Construction of Lagrangian and Action for the Gauge fields, Pure Yang-Mills Theory, Gauge Invariant Wilson Loop [3 lec]
B. Path Integrals for Gauge fields, Gauge Fixing and Faddeev-Popov Method, Ghost Fields, Feynman Rules for Yang-Mills Theory in Covariant Gauge, Ghost and Unitarity, , Becchi-Rouet-Stora (BRS) transformation [10 lec]

4. Renormalization and Renormalization Group:
A. Power counting and Superficial Degrees of Divergences, Weinberg's Theorem, Divergences in lambda phi^4 theory, Dimensional Regularization, Renormalization of lambda phi^4 theory, Wilson's Approach to Renormalization group, Callan- Symanzik equation, Evolution of coupling constant [10 lec]
B. Renomalization of QED, Ward-Takahashi identities for QED, Renormalization of Yang-Mills Theory and QCD, Slavnov-Taylor Identities, Beta functions for QED, Pure Yang Mills theory and QCD. [10 lec]
C. Effective Potential, Background Field Method, Beta function for Yang-Mills theory in Background field method [2 lec]

5. Spontaneous Symmetry Breaking:
Degenerate vacua in Quantum Mechanics and Quantum Field theory, Spontaneous symmetry breaking of Global symmetry, Nambu-Goldstone boson, Non-linear realization of symmetry, Spontaneous symmetry breaking of Gauge symmetries, SSB and Superconductivity, Brout-Englert-Higgs-Kibble-Guralnik-Hagen Mechanism, Stueckelberg Formalism, Renormalization and SSB, Coleman-Weinberg Mechanism [8 lec]

References:

1. An Introduction To Quantum Field Theory by M. Peskin and D. V. Schroeder
2. Quantum Field Theory and the Standard Model by M. Schwartz
3. Field Theory-A Modern Primer by P. Ramond
4. Quantum Field Theory by M. Srednicki
5. The Quantum Theory of Fields Vol-I and II by S. Weinberg
6. Gauge Field Theories by S. Pokorski
7. Foundations of Quantum Chromodynamics by T. Muta

PG 543: The Electroweak and Strong Interactions **4 Credits**

1. Group Theory and Quarks:
Symmetries in Physics, Elements of Group theory, Lie Group and Lie Algebra, SU(2) group, SU(3) group, The Quark Model [8 lec]

2. Chiral Symmetry and Strong Interaction:
Global Symmetries and their realizations, Current Algebra and sum rules, Spontaneous Symmetry Breaking of Global symmetries, Nambu-Goldstone boson, Sigma Model and Chiral Symmetry breaking, Soft Pion Theorems, Flavor symmetry of the Strong interactions [10 lec]

3. Spontaneous Symmetry Breaking:
Spontaneous symmetry breaking of Local symmetries, Brout-Englert-Higgs-Guralnik-Hagen Mechanism, Examples, Stueckelberg Method [4 lec]

4. Weak Interaction:
Weak Interaction, Parity violation, Fermi's Four Fermion Interaction model, Charged and Neutral currents, Pion Decay, Muon Decay, Nuclear beta decay, Neutrino electron scattering, Neutrino quark scattering, Limitation of Four-fermion interaction model [8 lec]

5. The Standard Model:
Construction of the Standard Model (SM), Gauge structure, Matter content, SM Lagrangian: Gauge sector, Fermion Sector, Higgs sector, Mass of W and Z vector bosons, Fermion Mass Generation, Weak Mixing angles [10 lec]

6. Phenomenology of the Standard Model:
Decay of W and Z bosons, CP violation, GIM mechanism, Higgs Particle [6 lec]

7. The Structure of Hadron and Parton Model:
Electron Proton scattering, Form factors, Deep Inelastic lepton hardon scattering, Bjorken scaling, Parton Model. [4 lec]

8. Introduction to Quantum Chromodynamics:
Gluons, QCD Lagrangian, e^+ e^- to Hadrons, Scaling Violation, Altarelli-Parisi Equations, Fragmantation functions, Jet, Drell-Yan Processes [10 lec]

References:
1. Gauge Theory of Elementary Particle Physics by T. P. Cheng and L. F. Li
2. Quarks and Leptons by F. Halzen and A. D. Martin
3. Modern Particle Physics by M. Thompson
4. Gauge theories of Strong, Weak and Electromagnetic interactions by C. Quigg
5. An Introduction to the Standard Model of Particle Physics by D. A. Greenwood and W. N. Cottingham

PG 544: Astroparticle Physics **4 Credits**

1. The Early Universe:

a. Background of Cosmology: The Friedmann-Roberston-Walker metric, Friedmann Equation, Nature of the solutions of the Friedmann Equation. [2 lect]

b. Thermodynamics of the Early universe: Equilibrium thermodynamics-Number, energy and entropy densities, Equations of State, Decoupling, Boltzmann Equation, Freeze-out process, Out-of-equilibrium decay. [10 lect]

c. Big-Bang Nucleosynthesis (BBN): Ingredients of BBN, Initiation of BBN era, Neutron-to-proton ratio, Neutrino decoupling, Positron annihilation and Neutron decay, Synthesis of light Nuclei, Constraints on the number of neutrino families [2 lect]

d. Baryon asymmetry of the universe: Experimental evidence of Baryon asymmetry, Size of the Baryon asymmetry, Sakharov conditions, Mechanisms of Baryongenesis [2 lect]

e. The Cosmic Microwave Background Radiation (CMB): Formation of the CMB, Basic properties of the CMB, CMB anisotropies [2 lect]

2. The Stars and Galaxies:

Stellar structure and Evolution, Hydrogen and Helium burning in the stars, Heavy element production, Stellar stability, White Dwarfs, Stellar Collapse, Supernova, Type-1 and Type-2 Supernova, Neutron stars and Pulsars, Black Holes, Galaxy and galaxy clusters, Impact of novel particles in stellar dynamics [10 lect]

3. Dark Matter:

Dark matter (DM) in galaxies and clusters, Evidence of DM, Possible DM candidates, Relic density of DM from the Boltzmann Equation, Weakly Interacting Massive Particle (WIMP) as DM candidates, Experimental searches of DM, Direct and Indirect detections [15 lect]

4. Cosmic Rays:

Composition of cosmic rays, Origin of Cosmic rays, Primary and Secondary Cosmic rays, Acceleration of Cosmic rays, Passage of charged particles and radiation through matter, Air shower, Gamma-ray sources, Ultra High Energetic Cosmic Rays (UHECR), GZK cut-off, Possible sources of UHECR [8 lect]

5. Neutrino:

Solar and Atmospheric neutrinos, Neutrino oscillation in the vacuum and matter, Neutrinos from astrophysical source-Supernove neutrinos, Cosmological origin of neutrinos, High energetic neutrinos-IceCube neutrino observatory [9 lect]

References:

1. The Early Universe by E. Kolb and M. Turner
2. Astroparticle Physics by C. Grupen
3. Stars as Laboratories of Fundamental Physics by G. Raffelt
4. Particle Astrophysics by D. Perkins
5. Cosmic Rays and Particle Physics by T. K. Gaisser

PG 545 : Advanced Laser Physics **4 Credits**

1. Overview of Laser physics: 6 lect

Basic idea of absorption, spontaneous emmission and stimulated emission the laser idea, rate equation formalism for 4-level and 3-level lasers, theshold inversion output power and effciency.

2. Advanced properties of Laser Beams: 14 lect

Monochromaticity, Theoretical limit to laser monochromaticity, first-order cherence, complex representation of polychromatic fields, first-order correlation functions, spatial and temporal coherence, mutual correlation fuction, Measurement of spatial, temporal and mutual correlation functions Relation between temporal coherence and Monochromaticty, directionslity, diffraction-limited divergence of a laser beam, measurement of beam divergence, Brightness, comparison between brightness of thermal light sources and laser beams, higher-order coherence functions measurement of higher-order coherence.

3. Nonlinear Optics: 16 lect

The nonlinear wave equation, Manley-Rowe relations, Three-wave mixing, Second Harmonic generation, analytic treatment Experimental techniques, nonlinear materials, Phase-matching, parametric oscillation, four-wave mixing and phase conjugation, analytic treatment experimental methods.

4. Untrashort Laser techniques and Applications: 13 lect

Methods of ultrashort pulse generation ; Q-switching and mode-locking. Colliding-pulse and Kerr-lens mode-locking, applications in femtosecond dye and Ti; sapphire lasers, group velocity and group-delay dispersion, pulse compressaion, pulse compresion by prism and grating pairs, chirped-pulse amplification (CPA), experimental applications of ultrashort laser pulses in physics and chemistry.

5. New Developments in Lasers: 11 lect

New types of lasers free-electron lasers, chemical lasers, tunable solid-state lasers: alexandrite laser. Tirsapphire laser short-wavelength semiconductor lasers, new semiconductor laser materials and laser structures, quantum cascade lasers, use of semiconductor lasers in information technology and teleconmunications.

References:

1. O. Svelto Principles of Lasers (4th ed.) Plenum Press.
2. Hooker and Web, Laser Physi, Oxford University Press.
3. E. Hecht Laser Guidebook (2nd ed.) McGraw-Hill
4. Y. R. Shen The Principles of Nonlinear Optices McGraw Hill
5. P. W. Milonni and J. H. Eberly, Lasers, Wiley.

PG 550 : Advanced applications of Lasers **4 Credits**

1. Atom- Matter Iteraction and Laser Theory : 14 lect

Elements or quantum electrodynamics creation and annihilation operators, quanization of the electromagnelts field, zero point energy,QED treatment of interaction of radiation with matter,laser eavity mods, polarigation of the cavity medium complex electric susceptibility, first order theory, threshold inversion higher order theory.

2. Multiphoton Processes: 10 lect.

Multiphoton photolectric effect, two-photon procsses, experiments in two-photon procsses, Multiphoton procsses. Multiphoton Absorption and emission, second harmonic generation as gener a three-photon procsses, stimulated scattering processes : procsses. Raman effect, stimulated Brilliouin effect and Coherent Anti- Stokes Raman(CARS) effecet and their applications, Raman laser.

3. Fiber-Optic Communications: 14 lect.

Fundamentals of optical fiber communications, advantages over coventional techiques, optical waveguides, characteristic equations. Waveguides modes, propagation losses and their sources maltimode and single-mode ffibers and their characteristcs, model and material disperston, optical transmitters, mudulators and receivers, optical repeaters and fiber amplefiers, wavelength-division multiplexing (WDM), switching,different generations of fiber-optic systems and their perfomance chracteristics measurements, optical time-domain reflectometers (OTDR).

4. Laser Speckle Matrology and Interferometry: 14 lect.

Origins of laser speckle, calculation of speckle size-subjective and objective speckles, speckle pattern photography, : Inplane, out of plane and shearing peckle pattern inferometers, electronic peckle pattern interferometer (ESPI) the video pattern system and its perfomance, optical disign of electronic speckle paittern video interferometrs. ESPI in shape measurement, applications of ESPI : measurement, of stresses, temperature distributions, prevention and restoration of art works, nondestructive sesting (NDT).

5. Laser Remote Seusing: 12 lect.

Advantages of laser remote sensing. Fundamental.processes : Mie and Rayleigh scattering, Resonance and absorption, LIDER, differential absorption laser, (DIAL) range equation, sources of noise and singal to noise (S/N)ratio, lasers systems : Nd : YAG, excimer and trunable lasers,detection systems, signal and data processing, measurement of NO_X, SO_2, CO_2,OH concentrations, ozone hole detection, water quantity monitoring and chlorophyll mapping.

References :

1. P.W. Milonni and J.H. Eberly, Lasers Wiley.
2. Pantell and Puhoff, Quantum Electronics.
3. Johnes and Wykes, Holographic and Speckle Interferometry (2nd Edition), Cambridge University Press.
4. J. Gower, Optical Communication Systems (2nd Edition.) Prentice-Hall.
5. J.M. Senior, Optical Fiber Communications, Prentice-Hall.

PG 551: Equilibrium Statistical Mechanics **4 Credits**

1. Ensemble: 7lect

Micro Canonical, Canonical and Grand Canonical ensembles; Ensemble and Time average, Ergodicity. Ensembles for systems with indefinite number of particles for systems in uniform motion.

2. Partition Function: 8 lect

Calculation of partition functions for non-interacting systems and interacting systems. Relation of partition function with thermodynamics. Equation of states. Some applications.

3. Virial Equation of State: 7 lect

Equation of state; virial coefficients: Scaling properties of different gases. Virial coefficeient calculation for hard-sphere and Lennard-Jones potentials.

4. Quantum Statistics: 6 lect

Density matrix; Quantum mechanical ensembles: canonical and grand canonical ensembles; Applications spin-1/2 particle in magnetic field; Systems of non-interacting particles.

5. Classical Theory of Liquids: 10 lect

i) Pair correlation functions. Yvon-Born-Green function. MSA, HNC, MHNC, VMHNC.
ii) Gibbs-Bogoliubov variation scheme.

6. Transport theory: 12 lect

The relaxation time approximation, Boltzmann semi-classical equation and its solution for electrical and thermal conductivity; Ziman’s theory from time-dependent perturbation theory.

7. Brownian Motion: 10 lect

Calculation of mean square displacement. Relation between dissipation and fluctuation force. Correlation functions and friction constants. Velocity correlation function. Fokker-Planck equation and its solution on sager relations.

References:

1. F. Reif, Fundamentals of Statistical and Thermal Physics, MeGraw-Hill, NY.
2. K. Huang-Statistical Mechanics, John Wiley and Sons, NY.
3. D.A. Mc Quarrie, Statistical, Mechanics, Harper and Row, NY.
4. J.P. Hansen and I Mc Donald, Theory of Liquid Metals.
5. M. Shimoji. Liquid Metals. Academic Press London.
6. R. Balescu. Equilibrium and Non-equilibrium Statistical Mechanics, John Wiley and Sons NY.

PG 552 : Non-equilibrium Statistical Mechanics **4 Credits**

1. **Scaling, Scale-invariance and self-similarity:** 8 Lect.
Dimensions of physical quantity, Power-law monomial nature of dimensions, significance of power-law monomial nature of dimensional function, Buckingham π-theorem, Examples to illustrate significance of π-theorem, Similarity, Illustrative examples of similarity phenomena, Self-similarity, Dynamic scaling and its link to π-theorem, Finite-size scaling and its link to π-theorem, Scale invariance: Homogeneous functions, Scale invariance: Generalized Homogeneous functions, Dimension functions are scale-invariant, Notes on power-law distribution, Examples of Power-law Distributions, Questions, Exercise.

2. Stochastic process, random walk and diffusion: 10 lect.
Stochastic Process, Essential Nomenclatures and Definitions: Markov Process, Chapman-Kolmogorov Equation, Markov Chains, Master Equation, Random walk (RW) problem, Master equation for RW problem, Diffusion equation for RW problem, Mean and root mean-square displacement, Diffusion and Fick's Law, Brownian motion, diffusion and random walk, Solutions of diffusion equation, Exact solution, Scaling solution, Scaling Properties of the RW problem, Scale-free first return probability, Extensive numerical simulation to verify power-law first return probability, Exercise.

3. Stochastic theory of fragmentation: 5 Lect.
Master equation for binary Fragmentation Process, Properties of the daughter distribution function, Ternery fragmentation, Fragmentation into an Arbitrary Number of Particles, Definition of function c (x, t) and of its various moments, Model I: Sum Kernel: F (x, y)= $(x+y)^{X-1}$, Model II: Product Kernel, Fragmentation of d dimensional objects, Solution to stochastic planar fragmentation, Multiscaling, Numerical simulation of the planar fragmentation, Algorithm of the planar fragmentation, Deterministic planar fragmentation, Exercise.

4. Fractal and Multifractal: 14 Lect.
Introduction, Euclidean geometry, Hausdorff-Besicovitch Dimension, Fractal, Recursive cantor set (RCS) Triadic Koch Curve, Sierpinski gasket and carpet, Similarity Dimension, Mass-length relation for fractal geometry, Truth about natural fractal, Dyadic Cantor Set (DCS), Kinetic DCS, Stochastic Dyadic Cantor set, Data-collapse in kinetic DCS, Multifractality, Theory of Multifractality, Legendre transformation of τ_s (q):$f(\alpha)$ spectrum, Cut and paste model on Sierpinski carpet, Stochastic Sierpinsky carpet, Discussions, Questions.

5. Complex network theory: 8 Lect.
Introduction, What is network, Observables, Tree network and Complete graph, Degree κ and degree distribution P (κ), Clustering co-efficient C, Mean geodesic (shortest) distance ι, Random network: Erdos-Renyi model, Small-world network, Watts and Strogatz model, Scale-free complex network, The World Wide Web (WWW), The Internet, Movie actor collaboration network, Scientific collaboration network, Barabasi-Albert model, Dynamic scaling and universality, Stochastic Planar Lattice, Kinetic square lattice, weighted planar stochastic lattice by two cracks (WPSL2), Algorithm of the model Topological Properties of WPSL2, The role of group in the growth of BA network, Weighted planar stochastic lattice by a single crack: WPSL1, Small-world properties of WPSL, Multi-multifractal properties of WPSL, WPSL2, WPSL1.

6. Phase transition, critical phenomena and percolation theory: 15 lect.
The thermodynamic state functions: E, A, G, and H, The Legendre Tansformation, Thermodynamic Potentials, Response functions: Specific heat, compressibility and susceptibility, Non-magnetic systems, Magnetic Systems, Magnetic system, Stability and convexity relations and their geometric interpretation, Classification of phase transition, Critical Point exponent and universality, Widom Scaling, Percolation transition, Ovservable quantities in percolation, Spanning probability W (Ƥ), Percolation probability P, Cluster size distribution function n_s, Mean cluster size S , Connection to thermal phase transition, Exact solution in one dimension, Mean cluster Size S, Correlation function g(ɤ) and the correlation Length ε, Percolation in the Bethe lattice: Exact solution, properties of the Bethe lattice, Percolation threshold, Percolation Strength P, Mean Cluster size S, Correlation function g(ɤ), Cluster size distribution, Scaling theory, Cluster geometry, Finite-size scaling, Monte Carlo simulation, Hoshen-Kopelman algorithm, Newman-Ziff Algorithm.

References:

1. V. Privman-Non-equilibrium Statistical Mechanics in One Dimension (Cambridge University Press, 1997).
2. J.Feder Fractals (Plenum, NY, 1988).
3. G.I. Barenblatt (Translation form Russian by M. Van Dyke) Similarity. Self- Similarity and Intermediate Asymptotic.
4. D. Stauffer-Introduction to Percolation Theory(Taylor and Francis 1985).
5. H. Stanley-Introduction of Phase Transition and Critical Phenomena (Oxford Univ. Press, NY. 1971).
6. S.K. Srinivasan, Stochastic Theory and Cascade Processes (El. evier, 1969).

PG 560: Condensed Matter Physics and Materials Science **4 Credits**

1. Superconductivity:

(a) Phenomenology of Superconductors: Theory of superconductivity, Thermodynamics of superconductors, Surface energy, Ginzburg-Landau theory, Coherence length, Penetration depth, Josephson Effect, SQUID,
(b) Microscopic theory of Superconductors: Electron-ion interaction, Electron-Phonon interaction, Electron-electron interaction, Cooper Pairs, Cooper problem, BCS theory of the Superconducting ground state, Elementary excitations: the Bogoliubov-Valatin transformation, thermodynamics properties, High T_C superconductors,

2. Topological insulators:

General theory of topological insulators, Topological excitations, Topological band theory, topological superconductors and superfluids.

3. Interactions with Photons:
Photons, Polaritons, Polarons, Complex dielectric constant, Electron-Phonon interaction, Direct transitions, Indirect transitions, Plasmons, Metal-insulator transitions, Exciton.

4. Non-crystalline Solids:

(a) Glasses, Polymers, Amorphous semiconductors, Amorphous Ferromagnets, Low energy excitation in amorphous solids.
(b) Liquid crystal, Symmetry, textures, microscopic and optical properties of different types of nematic, smectic and cholesteric liquid crystal; Electrical and dielectric properties of liquid crystal; electro-hydrodynamics instability of liquid crystal; Chiral liquid crystals; Ferroelectric liquid crystals; Electro-optic and magneto-optic effect of liquid crystals; display and memory devices; Applications of liquid crystals.

5. Introduction to nanomaterials and nano-composites:

(a) Electronic transport in 1D, 2D and 3D, Size Effects and nanoscale properties, Quantum confinement, Quantum dots, quantum well, Drude condition and mean free path in 3D, Manufacturing of nanomaterials, structural mechanics of nanomaterials; structure-property relationships, Compound semiconductors, superlattices, Nanotubes, Nanohorns, Nanowires, applications
(b) Characterization of nanomaterials: SEM, STM, TEM, Raman spectroscopy
(c) Nano-fiber reinforced composites; application of nanocomposites for lightweight structures, thermal protection and nanoelectronics.

References:
1. Superconductivity-Ketterson & Song (Cambridge University Press, 1999)
2. Solid State Physics- M. S. Rogalski & S. B. Palmer (Gordon & Breach Science Publishers, 2001)
3. Introduction to Solid State Physics- C. Kittel (John Wiley & Sons, 2004)
4. The Physics of Liquid Crystals- P. G.de Gennes, J. Prost (International Series of Monographs on Physics, 2005)
5. Topological insulators and Topological superconductors- B. A. Bernevig, T. L. Hughes (Princeton University Press, 2013)
5. Carbon Nanotubes- A Jorio, G. Dresselhaus, and M. S. Dresselhaus (Spinger, Heidelberg, 2008).
6. Carbon Nanotubes-Polymer composite- B. P. Grady (John Wiley & Sons, 2011)

PG 561: Computational Physics 4 credits

This course would constitute two parts namely theoretical part which will comprise of 30 lectures and will be examined in a 2.5 hour long exam carrying 50 marks and the remaining part will be consist of a weekly 3 hour hands on practice session using computers. The practical part will be graded based on in course evalution carrying 20 marks and a final in-lab practical exiamination carrying 30 marks.

The syllabus for the theoretical part will be as follows:

I. Chaos and Non-linear Equation: 5 lect

a) Solution using fixed point iteration
b) Logistic maps. Period doubling. Feigenbaum indices.
c) Lorentz equation and Chaos.

II. Solution of Linear Equations: 8 lect

a) Gauss-Jordan Elimination Method
b) LU decomposition
c) Singular Value Decomposition
d) Conjugate Gradient Methods

III. Numerical Integration: 3 lect

a) Gaussian Quadrature for Integrations.
b) Monte Carto Method for Evalution multidimensional integrals.

IV. Boundary value Problems in one dimension: 4 lect

a) The shooting method
b) Finite difference method-Raleygh-Ritz, Collocation, Galerkin method.
c) Eigenvalue Problems.

V. Partial Differntial Equations: 7lect

a) Parabolic, Hyperbolic and Elliptic equations.
b) FTCS method, Lax method, Staggered Leapfrog, Crank-Nicholson method for solving initial value problems.

VI. Approximation of Functions: 3 lect

a) Chebyshev Polynomials and Pade approximation
b) Sampling theorems and Fast Fourier transformation.

References:

1. C.Gerald and P. Wheatley –Applied Numerical Analysis, Addison Wesley.
2. W. Press et.al – Numerical Recipes, Cambridge Univ. Press.

PG 563: Biomedical Physics **4 Credits**

Section A: Biophysics

1. Structure of Macromolecules : Atomic and Molecular force, Behaviour of macromolecules, Physics techniques for structure determination (e.g. X-ray diffraction, Spectroscopy and NMR).
2. Properties and Structure of Nucleic Acid: DNA, RNA, Viruses, Methods of replication.
3. Protein Structures: Amino acids; Primary,secondary and tertiary structure.
4. Basic Enzyme Behaviour: Michelis Menten Mechanism and MWC model, Haeornoglobin.
5. The Cell Membrane: Basic membrane properties, Duffusion and transport, chemical pump and membrane potential, membrane model.
6. Physics of-Nervous System: Electrical activity of the central nervous system, Huxley-Hodgkin Theory, neurotransmitters, Physics of vision and hearing.
7. Physics of Muscles: Smooth, striated and cardiac muscle, muscle action potential.
8. Cardio-Vascular System: Mechanics of fluids and its application to blood flow.

Section B: Medical Physics

1. Ultrasound Imaging: Nature, production and detection of ultrasounds, A-scan, B-scanner, Clinical application.
2. Other Imaging Techniques: Rectilinear Scanner, Gamma camera, Cat scanner, Clinical application.
3. Vascular Measurements: Blood pressure, Blood flow, Blood velocity.
4. Cardiac Measurements: ECG, ECG planes, Einthoven's triangle, Elementary ideas on heart disorders, Defibrillators, patient safety.
5. Bio-electric amplifiers, patient safrty.
6. Radiation and Health: Radiopharmaceuticals, Radiotherpay, Radiation Protection, Radiation Dosimetry.

References:

1. W.T. Hughes, Aspects of Biophysics, John Wiley and Sons.
2. B.H. Brown and R.H.Smallwood, Medical Physics and Physiological Measurements, Black-well Scientific Publications.
3. J.R. Cameron and J.G.Skofronick, Medical Physics, John Weley & Sons.
4. D. Hughes, Notes on Ionising Radiation, Quantiles, Units, Biologional Effects and Permissible Doses, Science Reviews IA, London and H. Scientific Constants Limited.
5. Antonini and Brunori, Haemoglobin and Myoglobin in their Reactions with Ligands. North Holland.
6. N.C. Hilyard and H.C. Biggin, Physics for Applied Biologists, University Park Press, Maryland.
7. P.Davidovits, Physics in Biology and Medcine, Prentice-Hall.
8. Ruch and Patton, Physiology and Biophysics, Saunders.
9. H. Cember, Introduction of Health Physics, Pergamon Press.

PG 571: Nuclear Physics **4 Credits**

1. Nuclear Shell Model : 10 lect

Single Particle model, Total spin J for various configurationa, Nordheim's rules, Independent particle model, L-S coupling, J-J coupling, Applications of the shell model in stripping, pick-up reactions, beta decay and nuclear isomerism, configuration mixing and fractional parentage.

2. Collective model : 10 lect

Nuclear deformation, Collective vibrational excitations, collective oscillations liquid drop model. Quardrupole deformation Electromagnetic properties, reduced transition probnability and the expression for B(E2) value in the case of a symmetric rotor for Coulomb excitation, Nielson potential. Core potential.

3. Compound Nucleas and structure: 10 lect

(a) Crossection, Breit-Wigner resonance formala for 1=0. The compound, Nucleus, Continum theory of cross section. Statistical theory of nuclear reactions, Evaporation model.

4. Optical Model: 8 lect

Kapur-Peierls dispersion formula and giant resonance, Lane Thomas and Wigner model.

5. Direct Reaction: 10 lect

Transfer reactions, The DWBA theory and its application.

6. Intermediate energy nuclear Physics: 12 lect

Covariant Direr equation, Chiral symmetry. Meson exchange NN potential-pi, rho, omega exchange.

Pion-nuclear system, isospin symmetry,
Pion-nuclear scattering, pion-nucleus scattering.

References:

1. H. Feshbach-Theoretical Nuclear Physics (Nuclear Reactions).
2. Nuclear Physics, Roy and Nigam. John Wiley and Sons.
3. Structure of the Nucleus, Preston and Bhaduri. Addision-Wesley.
4. Nuclear Physics, Blatt and Weiskoff. John Wiley ans Sons.
5. A. Bohr and B.R. Mottelson-Nuclear Structure.
6. G.R. Satchler: Direct Nuclear Reactions.
7. J.P. Davidson-Collectine models of the Nrclide.
8. Introduction to Nuclear physics, H.A. Enge. Addison-Wesley.

PG 580: Atmospheric Physics **4 Credits**

Structure of the atmosphere, Elementary ideas about the sun and the laws of radiation, Definition and units of solar radiation. Depletion of solar radiation in the atmosphere.Terrestrial radiation. Radiation transfer, heat balance in the atmosphere heat budget. Vertical temperature profile, Radiation charts and the their uses.

Composition of the atmosphere, mean molecular weight, humidity, mixing ratio, density and saturation vapour pressure.

Dynamic Meteorology: units and dimension of parameters used in dynamic meteorology. Fundamental forces governing the motion of the atmosphere. Pressure gradient force, gravitational force, frictional force. Apparent forces in non-inertial frame of reference, centrifugal force, Coriolis force. Structure of the static atmosphere. Hydrostatic equation.

Different frames and coordinates. Physical meaning of total and partial differentiation in meteorology. The basic conservation laws. The vector from of momentum equation in spherical coordinates.The component equation in spherical coordiates. Continuity equation. The thermodynamic energy equation. Thermodynamic of dry atmosphere. Application of the basic equations. Balanced flow. Trajectories and streamlines. Thermal wind. Vertical motion circulation and vorticity. Elementary ideas of planetary boundary layer.

Condensation, precipitation and atmospheric electricity. Microphysical processes: condensation nuclei, curvature and solute effects, cloud classification, general features.

The general circulation of the atmosphere, elementary ideas, fronts, cyclones.

The Tephigram.
Topical Meteorology: Definition of the region, zones of convergence, vertical structure of the wind trade winds. Monsoons Depressions, tropical cyclones. Elementary ideas about forecasting. Synoptic charts. Satellite meteorology.

References:

1. An Introduction to dynamic meteorology, J.R. Holton.
2. Essentials or Meteorology, D.H. Mclntosh and A.S. Thorn.
3. An Introduction to Atmospheric Physics, R.G. fleagle.
4. Tropical Meteorology, H. Riehl.

PG 581: Atmospheric physics and Meteorology-I **4 Credits**

1. Geophysical Fluid Dynamics: 30 lect

Physical principles: Navier-Stokes equations. Equation of motion relative to a rotating frame-coriolis force. Geostropic, cyclostropic, gradient and thermal wind. Vorticity and Circulation-vorticity and circulation theorems Boundary layers-solution. Eckman pumpngi. Proudman-Taylor theorem. Dynamical similarity.

Atmospheric turbulence-the Reynolds number and Reynolds stress. Mixing length hypothesis. Spectrum of atmospheric turbulence. Boussinesq approximation.

Atmospheric Thermodynamics-entropy and potential temperature. The Tephigram. Total potential energy of an air column: zonal and eddy energy. Radiative transfer. Integral equations of transfer Heating rate due to radiative processes.

2. Dynamics of Atmosphere and Oceans: 20 lect

General circulation of the atmosphere and oceans. Thermal structure of atmosphere and oceans. Eddy flux of sensible and latent heat. Energetics of large scale eddies. Barometric and baroclinic instabilities Transport of angular momentum.

Atmospheric Waves: Sound and gravity waves. Rossby Waves.

Waves in the ocean –Kelvin and Poincare waves.

Storm Surges: Storm surges equation. Vorticity integrated equation. Analytical and numerical solution Effect of storm surges.

Cloud Physics: Thermodynamics of dry and moist air. Static stability and parcel buoyancy-formation and growth of cloud droplets. Precipitation Process. Severe storms and hail. Numerical cloud models.

3. Mathematical and Numerical methods: 10 lect

Harmonic function solution of Laplace’s equation. Basic statistical method, Normal, F, t, x^2. distributions. Tests of significance. Multiple regression analysis. Theory of probability. Anti-correlation function. stochastic methods.

Time series analysis-Fourier analysis, filtering, spectrum analysis.

Numerical analysis-finite difference and finite element and spectral methods in fluids.

References:

1. Holton –Introduction to Dynamic meteorology.
2. John M. Wallace, Peter V. Hobbs- Atmospheric Science (Academic Press).
3. C.S. Ramage Monsoon Meteorology (Academic Press).
4. Horace Robert Byers-General meteorology (Mcgraw-Hill).
5. J.T. Houghton, F.W. Taylor, C.D. Rodgers, Remote Sounding of Atmosphere (Cambridge Univ. Press).
6. Joseph J. Von Schwind-Geophysical Fluid Dynamics for Oceanographers (Prentice-Hall Inc).
7. George J. Haltiner, Roger Terry William Numerical Prediction and Dynamic Meteorology.
8. Glenn I. Trewartha, Lyle H. Horn-An Introduction to Climate (McGraw- Hil).

PG 582: Atmospheric physics and Meteorology-II 4 Credits

1. Tropical meteorology: 15 lect

Survey of Meteorological phenomena in the tropics. Zonal symmetric and asymmetric tropics. Synoptic disturbances in the tropics. Cumulus convection. Tropical cyclone-its structure and movement. Norwester and tornadoes. Tropical easterly jet streams.

Numerical model. The Monsoon-monsoon lows and depression. Land-ocean interaction.

2. Meteorological Analysis: 15 lect

Analysis of meteorological and synoptic charts-Ground and Upper air observations. Air mases, Fronts, Depressions, Cyclones and anti-cyclones. Analysis of 500, 300 and 200 mb charts. Pressure and temperature changes. Stability analysis. Streamline and Jsotach analysis. Determination of divergence and vorticity. Cloud analysis.

3. Satellite Meteorology and Remote Sensing of Earth's Resources: 10 lect

Spectral signature, weather and environmental satellite, Quantitative measurement of cloud, wind, temperature and moisture profiles, sea state, convective intensity and tropical rainfall estimation from satellite data. Application in tropical cyclones, monsoon floods, norwesters, thunderstorm, hail etc.

4. Weather Forecasting: 8 lect

Weather prognosis as a mathematical physics problem. Prediction of various weather constituents. Combined analysis of surface wind, pressure, pressure tendencies, temperature, humidity, upper air data using ground, satellite and radar observation.

Numerical weather forecasting-filtering of sound and gravity waves, numberical solution of barotropic vorticity equation. Primitive equation models. Multi-vorticity equation Primitive equation models. Multi-layered models.

5. Climate and Climatic Change: 6 lect

Energy budget of the earth. Short term and long term predictability. Atmospheric feedback processes. Theory of climatic change. Terrestrial and extra-terrestrial causes. Human contribution. Numerical modeling of climate modifications.

6. Instruments and Techniques: 6 lect

Basic meteorological instruments. Surface observations and upper air observations. Sounding balloons, radiosondes and sondes. Measurment with aircrafts, Radar-principles of radar measurement. LIDAR Measurements with rockets and satellites. Principles of remote sensing. Weather modification experiments- artificial rain-making. Hail and thunder suppression.

PG 583: Optical Spectroscopy **4 Credits**

1. Overview of Atomic and Molecular Physics: atomic and molecular energy levels, transition probability and selection rules, electronic, vibrational and rotational spectra, Frank-Condon principle, broadening mechanisms: collisional, Dopper and natural broadening, absorption and emission spectra. 10 Lecture

2. Absorption Spectroscopy : absorption spectra of gases, liquids and solids, Beer-lambert law, absorbance and extinction coefficient, absorption spectrometers (UV-VIS-IR); principle of operation, light sources, gratings and detectors, dual-beam and single-beam spectrometers, atomic absorption spectrometers (AAS), sensitivity and limits of detection (LoD), applications.
8 Lecture

3. Fourier-Transorm Spectroscopy : Principles, Fourier Transform, limitations of dispersion spectrometers, Michelson interferometer, Felgett advantage, signal-to-noise ratio, light sources, beamsplitters and detectors, near-infrared, mid-infrared and far- infrared FT spectrometers, applications of FT-IR: indetification of organic functional groups, chemical indentification, determination of concentration. 12 Lecture

4. Emission Spectroscopy : Emission spectra of atoms and molecules, fluorescence spectrum, line spectra and band spectra, spectrofluorometers, laser-induced fluorescence (LIF), applications. 8 Lecture

5. Raman Spectroscopy : The Raman Effect, vibrational spectra, vibrational modes of diatomic and polyatomic molecules, selection rules polarizability of molecules and molecular symmetry, Stokes and anti-Stokes Raman spectra, molecular group frequencies, Raman instrumentation, dispersive spectrometers, laser excitation sources, transverse and backscattering geometry, Rayleigh filtering, photomultiplier, diode-array and CCD detectors, S/N ratio, FT-Raman spectrometers: advantages over dispersive systems, Resonance Raman, pulsed Raman and surface-enhanced Raman spectroscopy, applications in physics, chemistry, biology and medicine. 12 Lecture

6. Laser-induced Breakdown Spectroscopy (LIBS) : princciples of laser-induced breakdown, plasma formation, properties of laser- induced plasmas, plasma temperature and density, local thermal equilibrium (LTE), plasma cooling and dispersion, emission of atomic lines, line intensities and linewidths, LIBS instrumentation: lasers for LIBS excitation, spectrometers: grating and echelle spectrometers, CCD and ICCD detectors, detector gating and elimination of plasma background, elemental identification, quantitative and quantitative analysis, applications of LIBS. 10 Lecture

Reference:

1. Atomic and Laser Spectroscopy, A. Corney (Oxford).
2. Atomic and Molecular Spectroscopy, S. Svanberg (Springer)
3. Introductory Raman Spectroscopy, Ferraro., Nakamura and Brown (Elsevier)
4. Raman Spectroscopy for Chemical Analysis, R. L. McCreeary (Wiley).
5. Fourier Tranform Infrared Spectroscopy, P. Griffiths and 1. A. Haseth (Wiley).
6. Handbook of Laser-Induced Breakdown Spectroscopy, Cremers and Radziemski (Wiley)

PG 585: Reactor Physics **4 Credits**

Neutrons : Production of neutrons, interactions of neutrons with nuclei, mechanism of nuclear reaction, resonance absorption, Breit-Wigner formula, neutron cross section, determination of cross section by transmission and activation methods, Doppler-broadening of cross section, average cross section for I/V and non-1/v absorbers, variation of cross section with neutron energy, spectrum for reactor neutrons, neutron activation analysis.

2. Nuclear Fission : Mechanics of fission, fission fuels, fission cross section, fission products and assymetric fission, decay of fission products, decay heat calculation, prompt neutrons and prompt gamma rays, delayed neutrons and delayed gamma rays, energy release in fission, reactor power, fuel burn up and fuel consumption.

3. Duffusion of Neutrons : Neutron interaction rates and neutron flux, neutron current density, equation of continuity, Fick's law, diffusion equation, solution of diffusion equation for various source conditions in infinite and finite media, diffusion length, its physical significance and measurement of diffusion length.

4. Slowing Down of Neutrons: Mechanics of elastic scattering, collision density, slowing down density, moderation of neutron in hydrogen, lethargy. Average logarithmic energy decrement, slowing down in infinite media with capture, resonance escape probability, continuous slowing down model, Fermi age equation, physical interpretation of Fermi age and experimental determination of Fermi age.

5. The Critical Equation: Four factor formula, one group and two group critical equations for bare reactor, critical equation based on the continuous slowing down model (age diffusion method), reactors of various shapes, nonleakage probabilities, critical equation for large reactors, reflected reactor, homogeneous and heterogeneous reactor systems and determination of critical reactor parameters.
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6. Reactor Kinetics: Neutron lifetime, reactor kinetic equation, reactor period, one group of delayed neutrons, inhour formula and basic principles of reactor control.

7. Nuclear Heat Removal: Heat transfer by conduction, convection and radiation; heat transmission in clad cylindrical fuel element, and heat transmission in shields and pressure vessel in the form of slab with exponential heat source.

8. Researtch Reactors: Tark-type and swimming pool type reactors. Power reactors: PWR, BWR, CANDU and AGR type reactors. Breader Reactor.

References:

1. S. Glasstone and A. Sessonske, Nuclear Reactor Engineering, Van Nostrand and Reinhold Company.
2. J.R. Lamarsh, Introduction to Nuclear Reactor Theory, Addision-Wesley Publishing Company.
3. J.R. Lamarsh, Introduction to Nuclear Reactor Engineering, Addision-Wesley Publishing Company.
4. Duderstadt and Hamilton, Nuclear Reactor Analysis, John Wiley and Sons.
5. A.F. Henry, Nuclear Reactor Analysis, MIT Press.
6. Foster and Wright, Basic Nuclear Engineering, Allyn and Bacon, Inc.

PG 587: Biophysics & Medical Imaging **4 Credits**

Structure of Macromolecules: Atomic and Molecular forces, Behaviour of Macromolecules,Physics Techniques of Structure determination (B.G. X-ray differaction, Spectroscopy and NMR). 4 Lectures

Propertiles and Structures of Nucleic acid: DNA Structure, Twisting and wrinthing, Dynamics of DNA, RNA forced unfolding and mechanics of DNA and RNA, Viruses, Methods of Replication. 7 Lectures

Protein Structure: Amino Acide: Primary, Secondary and Tertiary Structure. Protein Folding, Hydrophobic/PolarLattic Modle, Energy Landscapes, Ramachandran Plots. Methods for floding Prediction, Structure determination by solution NMR. 7 Lectures

Basic Enzyme behaviour: Remarkable Properties of Enzymes as Catalysts, Active Sides, Three Point Attachment, Mechanism of Enzyme Action, Flexible Enzymes, Inducedfit Hypothesis, Effeciency of Enzymes, Michelis Menten Mechanism and MWC Model, Steady State Kinetics,Transient Phases of Enzyme Reactions, Lineweaver-Burk, Eddie-Hofsteeplot, Wooff Plot, Haemoglobin. 8 Lectures

The Cell Membrane: Basic Membrane Propertiles, Diffusion and Transport, Chemical Pump and Membrane Potential, Membrane Model. 5 Lectures

Neurobiophysics: Central & Perpheral Nervous System, Mylenated & Nerve Cells. Blood Brain Barrier Generating Nerve Impulse, Synaptic Transmission, Physicochemical Basic of Membrane Potential, Resting and Action Potential, Propagation of Action Potential Voltage Clamp and Patch-Clamp Techniques, Hadgkin-Huxley Analysis Motor and Cortical Control, Sleep and Consciousness, Neuromuscular Junction, Excitation Contraction Coupling Neuronal Networks, Processing of Information, Memory and Neuropeptides. 8 Lectures

Physics of Special Senses: Biophysics of Sensory Mechanism and Fuction of Recetor Cells, Cutaneous, Olfactory and gustatory sensations, Vision- Physical aspects, Neurophysiology colour vision, Visual evoked potentials.

Physics of Muscles: Smooth Strained and Cardisc Muscles, Muscle Action Potential.
3 Lectures

Cardiovascular System: Mechnical Principles of the System, Blood Flow in Arteries. Wave Propagation in Blood Vessels, Wave Reflection Phenomena in large Arteries. 4 Lectures

Biophysical Aspects of Lung Expansion Respinatory Mechanics & Gas Exchange Process, Gas Diffusion & Transport, Pulmonary Curculation & Ventilation, Respiratory Control & Response to Stress. 4 Lectures

Medical-Imaging Tecniques: Aspects Medical-Imaging, Principle, Practical System, Medical Utility of X-tay Imaging, Fluoroscopy, Computerized Axial Tomigraphy, Mammohraphy, Angiohraphy, Myelography, Magnetic Resonacnce Imaging, Ultrasonography. 10 Lectures

References:

1. W.T. Hughes, Aspects of Biophysics, John Wiley and Sons.
2. P. Davidovits, Physics in Biology and Medicine, Prentice-Hall.
3. Ruch and Patton, Physiology and Biophysics, Saunders.
4. Y.C. Fung, Biomechanics: Circulation, New York: Springer, 1996.
5. W.R.Hendee and E.R. Ritenour, Medical Imaging Physics 4th Edition, Wiley-Liss Inc. (2002) ISBN: 0-471-38226-4
6. Jerrold T.Buchberg et al., The Essential physics of Medical Imaging 2nd Edition, Lippincott Williams & Wilking (2002) ISBN: 0-683-30118-7

PG 588: Polymer Physics **4 Credits**

1. Introduction to Polymers **[5 lectures]**

(a) History of polymer science
(b) Polymer microstructure
(c) Homopolymers and heteropolymers
(d) Fractal nature of polymer conformations
(e) Types of polymer substances
  i) Polymer liquids
  ii) Polymer solids
  iii) Liquid crystal polymers.
(f) Molar mass distributions
  i) Binary distribution
  ii) Linear condensation polymers
  iii) Linear addition polymers
(g) Molar mass measurements
  i) Measuring M_n by osmotic pressure
  ii) Measuring M_w by scattering
  iii) Intrinsic viscosity
  iv) Size exclusion chromatography

2. Polymer Morphology **[3 lectures]**

(a) Crystalline and semi-crystalline polymers; Liquid crystalline polymers.
(b) Self-assembly by microphase separation of block copolymers.
(c) Morphology of polymer thin films vs. bulk - surface influence.

3. Static Properties of Polymers **[8 lectures]**

(a) Conformations of Ideal Chain.
  i. Freely rotating, worm-like, hindered rotation and rotational isomeric state chain models.
  ii. Random walk statistics, radius of gyration, end-to-end distance distributions
  iii. Free energy of an ideal chain.
  iv. Measurement of single chain structure by scattering.
(b) Conformations of Real Chains
  i. Excluded volume and self-avoiding random walks
  ii. Flory theory of polymers in good solvents
  iii. Deformation of real chains by tension and compression
  iv. Adsorption of single chains
  v. Temperature effects on real chains: Temperature dependence of coil size, Flory theory of polymers in poor solvents, Second virial coefficient.
  vi. Dilute solution scattering

4. Thermodynamics of Blends and Solutions **[6 lectures]**

(a) Flory interaction parameter; Flory-Huggins/lattice models for polymer mixing
(b) Experimental investigations of binary mixtures; determination of interaction parameters
(c) Osmotic pressure and osmotic compressibility
(d) Spinodal and binodal decomposition; critical phenomena
(e) Dilute and semi-dilute regimes
(f) Measuring chain conformations in semi-dilute regime
(g) Polymer brushes and multi-chain adsoprtion

5. Gelation and Network Formation **[6 lectures]**

(a) Percolation models of gelation
(b) Mean-field and scaling models for gelation
(c) Rubber elasticity - entangled and unentangled systems:
(d) Linear viscoelasticity
  i. Maxwell and Voigt models
  ii. Stress relaxation; Creep and creep recovery
  iii. Boltzmann superposition
  iv. Oscillatory shear and steady shear deformation

6. Introduction to Scattering and Rheological Methods **[7 lectures]**

(a) Structure and Dynamics via Scattering
    i. Elastic and inelastic scattering
    ii. Rayleigh ratios and mass determination; Zimm plots
    iii. Structure factors and form factors; Debye function
    iv. Guinier and Porod/fractal regimes
    v. Time-correlation spectroscopies
(b) Dynamics via Rheology
    i. Linear and non-linear regimes
    ii. Zero-shear viscosity; Einstein viscosity for hard spheres in solution
    iii. Frequency dependent viscoelasticity

7. Unentangled Polymer Dynamics **[8 lectures]**
(a) Rouse and Zimm models
(b) Intrinsic viscosity
(c) Relaxation modes
(d) Semi-flexible chain modes
    i. Bending energy and dynamics
    ii. Tensile modulus and stress relaxation
(e) Temperature dependence of dynamics
    i. Time-temperature superposition
    ii. Glassy dynamics
(f) Dynamic scattering

8. Entangled Polymer Dynamics **[8 lectures]**
(a) Entanglements and reptation in polymer melts
    i. Relaxation times and diffusion
    ii. Stress relaxation and viscosity
(b) Reptation in semi-dilute solutions
(c) Dynamics of a single entangled chain
(d) Many chain effects - constraint release
(e) Entanglement in worm-like micelles

9. Polyelectrolytes **[4 lectures]**
(a) Introduction;
(b) Debye-Hückel theory;
(c) Donnan equilibrium.

10. Biopolymers **[5 lectures]**
(a) Introduction;
(b) Types and properties
(c) Characterization.

References:

(1) M. Rubinstein and R. C. Colby, *Polymer Physics.*
(2) M.Doi : *Introduction to Polymer Physics*;
(3) P.G. de Gennes: *Scaling Concepts in Polymer Physics*;
(4) M. Doi and S.F. Edwards: *The Theory of Polymer Dynamics*;
(5) John D. Ferry: *Viscoelastic Properties of Polymers.*
(6) P. Flory: *Principles of Polymer Chemistry*;
(7) R. G. Larson: *Constitutive Equations for Polymer Melts and Solutions*;
(8) R. G. Larson: *The Structure and Rheology of Complex Fluids*;
(9) I. Teraoka: *Polymer Solutions: An Introduction to Physical Properties*

PG 589: Health and Radiation Physics **4 Credits**

1. **Overview of the Atomic Nucleus and Radiation:** The Atomic Nucleus, Nuclear Force, Nuclear Models, Nuclear Stability and Radioactivity, Types and Characteristic of Radioactive Decay, The Units of Radioactivity, Natural Radioactive Series, Induced Radioactivity, The Nuclide Chart, Natural and Artificial Radionuclides, Interaction of Radiation with Matter, Penetrating Power of Nuclear Radiations, Radioactive Materials and there peaceful Application. Lect.-7

2. **Radiation Dosimetry and Units:** Absorption of Energy, Ionization Exposure, Radiation Absorbed Dose, Dose Equivalent Submultiples, Effective Dose, Dose Rate, Flux, Relationship of Units, Exposure Measurement, The Free Air Chamber, The Air Wall Chamber, Exposure Dose Relationship, Absorbed Dose Measurement, Brag Gray Principle, Kerma Source Strength, Specific Gamma Ray Emission, Dose from Surface Contamination, Skin Contamination, Internally Deposited Radioisotopes, Effective Half Life, Total Dose, Dose Commitment. Lect.-7

3. **Biological Effects of Radiation:** Introduction, Basic Human Physiology, Cell Biology, Interaction of Radiation with Cell, Somatic Effect of Radiation, Hereditary Effect of Radiation, Acute Effects, Delayed Effects, Radiation Weighting Factors, Tissue Weighting Factor. Lect.-5

4. **External Radiation Hazard:** Source of Radiation Hazard, Background Radiation, External Radiation Hazard Control via Time, Distance, Shielding, Personal Dose Co.itrol, Radiation Monitoring, Method for inverse Square Law, Practical application of Inverse Square Law, Attenuation Law, Buildup Factor, Personal Monitoring, External Hazard in X-ray & Radiotherapy facilities, External Hazard in Industrial Radiation Facilities.
Lect.-6

5. **Internal Radiation Hazard:** Uncontained Radioactivity, Routes of Entry, Food monitoring, Annual Limits of Intake, Control of the Contamination, Laboratory Classifications on the basis of radioactivity, Design of Areas for radioactive wark, Treatment of Radiation Effected Personnel, Contamination Monitoring, Internal Hazard in Nuclear Medicine Facilities. Lect.-6

6. **Nuclear Reactor Health Physics:** Fission, Reactor System Refueling Reactors, Radiation Hazard from Reactor, Fuel Storage Ponds, Fuel Reprocessing, Consequences of Releases of Radioactivity from Reactor, Classification of Radioactive Waste, Management of Radioactive Waste, Storage and Disposal of Radioactive waste.
Lect.-6

7. **Health Physics Instrumentation:** Radiation Detectors; Particle Counting Instruments, Gas-Filled Particle Counters, Resolving Time, Scintillation Counters, Nuclear Spectroscopy, Cerenkov Detector, Semiconductor Detector, Dose- Measuring Instruments: Personal Monitoring, Pocket Dosimeters, Survey Meters, Neutron Measurements: Detection Reactions, Neutron Counting with a Proportional Counter, Neutron Dosimetry Calibration for Gamma Rays, Beta Rays , Alpha Rays, Neutrons, Accuracy, Counting Statistics; Distribution Difference between Means, Minimum Detectable Activity, Optimization of Counting Time, Weighted Means.
Lect.-8

8. **Radiation Safety Guides:** Organizations that Set Standards, International Ccmmission for Radiological Protection (ICRP), International Atomic Energy Agency (IAEA), Nuclear Safety & Radiation Control Guides in Bangladesh, International Commission on Radiological Units and Measures (ICRUM), Philosophy of Radiation Protection, Public Health and Radiation Protection, Dose Limitation System, ICRP Basic Radiation Safety Criteria, Occupational Exposure, Medical Exposure, Effective Dose Equivalent, Exposure of Individuals in the General Public, Exposure of Populations, Annual Limit of Intake, air Borne Radioactivity, Inhaled Radioactive Particles, Dose Conservation Factors, Particle Size and Gaseous Radioactivity, Gastrointestinal Tract, Dosimetric Model ICRP Formulation.
Lect.-8

9. **Evaluation of Protective Measures:** Classification of Radionuclides according to Relative Hazard Potential (Hazard Class I, Hazard Class II, Hazard Class III and Hazard Class IV) Medical Surveillances, Estimation of Internally Deposited Radioactivity, Individual Monitoring, Dose Record System Radiation Contamination Survey, Choosing a Health Physics Instrument, Surface Contamination Survey, Choosing a Health Physics Instrument, Surface Contamination, Leak Testing of Sealed Sources, Air Sampling System, Sampling Considerations, Principle of Control, Control of the Source, Confinement, Environmental Control, Control of the Worker, Protective Clothing, Respiratory Protection, Surface Contamination Limits, Continuous Environmental Monitoring (e.g. Fallout from Nuclear Accident), Quality Management System. Lect.-7

References:

1. An Introduction to Radiation Protection by Arion, A., Harbison, S. A
2. Introduction to Health Physics by Herman Cember and Thomas E. Johnson
3. Principle of Radiation and Protection by Turner, M.