BTech EP 2020 Curriculum

Semester	Course No	Course Name	Credits	Offered by…	
1	MA1110	Calculus-I	1	MA	BS
1	MA1220	Calculus-II	1	MA	BS
1	EP1108	Modern Physics	2	PH	BS
1	CY1018	Environmental Chemistry	2	CY	BS
1	SSxxxx	English communication	2	SS	SS
1	ID1063	Introduction to Programming	3	CSE	BE
1	EP1128	Basic Electric Circuits	2	PH	DC
1	EP1118	Maths for Physics	2	PH	DC
Total			**15**		
2	MA1140	Elementary Linear Algebra	1	MA	BS
2	MA1150	Differential Equations	1	MA	BS
2	MExxxx	Introduction to Mechanical Engg	3	ME	BE
2	EP1031	EP Lab - 1	2	PH	BS
2	EP1208	Electricity and Magnetism	2	PH	DC
2	SSxxxx	Life Skills	1	SS	SS
2	BTxxxx	Life Sciences	1	BS	BS
2	FExxxx	Free elective	3	FE	FE
2	LAxxxx	LA/CA	3	LA/CA	LA/CA
2	SSxxx	Introduction to Entrepreneurship	1	SS	SS
Total			**18**		
3	CS2233	Data Structure	3	CSE	BE
3	XXxxxx	Personality Development	1	LA	SS
3	CY1031	Chemistry Lab	2	CY	BS
3	MA2110	Introduction to Probability	1	MA	BS
3	EExxxx	Digital Circuits	3	EE	BE
3	EP2108	Special Relativity	2	PH	DC
3	EP2118	Analog Electronics	2	PH	DC
3	EP2100	Classical Mechanics	3	PH	DC
Total			**17**		
4	MA2140	Introduction to Statistics	1	MA	BS
4	AI3217	Introduction to AI	1	AI	BE
4	EP3227	Nonlinear dynamics	1	PH	DC
4	EP3208	Advanced Mathematical Physics	2	PH	DC
4	EP2200	Thermodynamics	3	PH	DC

4	EP4210	Computational Physics	3	PH	DC
4	EP2418	Electronic Device Physics	2	PH	DC
4	EP2041	Core EP lab-2	2	PH	DC
4	EP3220	Modern Optics	3	PH	DC
Total			**18**		
5	EP3100	Quantum Mechanics-1	3	PH	DC
5	EP3105	Project-1	3	PH	DC
5	EP3110	Electrodynamics	3	PH	DC
5	EP3120	Statistical Mechanics	3	PH	DC
5	EP4071	Core EP lab-3	2	PH	DC
5	LAxxxx	LA elective	3	LA	LA
5	EExxxx	Linear Systems & Signal Processing	3	EE	BE
Total			**20**		
6	EP3200	Solid State Physics	3	PH	DC
6	EP3210	Quantum Mechanics-II	3	PH	DC
6	EP3230	Atomic and Molecular Physics	3	PH	DC
6	EP3205	B.Tech Project II	3	PH	DC
6	EPxxxx	Elective-I	3	PH	DE
6	EP5101	Core EP lab-4	2	PH	DC
Total			**17**		
7	EP4108	Nuclear Physics	2	PH	DC
7	EP4710	Particle Physics	3	PH	DC
7	EPxxxx	Elective-II	3	PH	DE
7	EP5201	Core-EP Lab-5	2	PH	DC
7	FExxxx	Free Elective	3	FE	FE
Total			**13**		
8	EPxxxx	Elective-III	3	PH	DE
8	XXxxxx	Free Elective	3	FE	FE
8	FExxxx	Free Elective	3	FE	FE
8	LAxxxx	LA	3	LA	LA
Total			**12**		
			130		

*Internship Students: Waive Btech Project+Departmental Elective OR Two Departmental Electives.

Course Type	Credits	%age
BS	16	12
BE	15	12
SS	4	3
LA/CA	9	7
FE	12	9
DC	74	57
TOTAL	**130**	**100**

2credit 3credit

Sem	BS	BE	SS	LA	FE	DC	Total
1	6	3	2	0	0	4	**15**
2	5	3	1	3	3	2	**17**
3	3	6	2	0	0	7	**18**
4	1	1	0	0	0	16	**18**
5	0	3	0	3	0	14	**20**
6	0	0	0	0	0	17	**17**
7	0	0	0	0	3	10	**13**
8	0	0	0	3	6	3	**12**
Total	**15**	**16**	**5**	**9**	**12**	**73**	**130**

2: 2 Credit

	Nr. of Course	Credits	%age
3 cr	16	48	55
2 cr	12	24	41
1 cr	1	1	3
TOTAL	29	73	100

Odd Semester	Even Semester
Advance Solid State Physics	Advanced Functional Materials
CFT	Advance Particle Physics
Advanced Imaging Techniches	Data Science Analysis
Ultrafast Lasers and Applications	Spintronics
Solar Cells and Technology	Plasma Physics and Applications
GTR	Accelerator Physics and Megnetohydrodynamics
Computational Solid State Physics	Introduction to Astrophysics
Adv. Stat. Mech	Laser spectroscopy
Fluid Mechanics	
QFT	
Introduction to Nanomagnetism	

DEPARTMENT OF PHYSICS

Courses for Approval

EP1108: Modern Physics Credits: 2

Photoelectric Effect, Atomic Structure, Bohr's Theory, X-Rays Generation and Interaction with Matter, de Broglie wavelength, Moseley's Law, Nuclear physics, Special Relativity

Reading Material:

- Concept of Modern Physics by Arthur Beiser
- Modern Physics by Kenneth S Krane

EP1118: Maths for Physics Credits: 2

Vectors and scalars, Vector differentiation, Gradient, Divergence and Curl, Multiple integrals, Vector integration- ordinary integrals of vectors, Line integrals, surface integrals, Volume Integrals Divergence Theorem, Stokes Theorem, Curvilinear Coordinates, Orthogonal Curvilinear coordinates, cylindrical coordinates, spherical polar coordinates- unit vectors, Arc length, Gradient, divergence and Curl in Curvilinear systems, Analytic functions- Introduction to complex numbers, complex powers, topology of the complex plane, complex functions and limits, elementary functions, analyticity and the Cauchy Riemann relations, Cauchy's theorem - contour integration and Cauchy's theorem, harmonic functions Series representation of analytic functions- convergent series of analytic functions, Taylor series, zeros and singularities, Calculus of residues - calculation of residues, residue theorem

Reading Material:

- P. Dennery and A. Krzywicki; Mathematics for Physicists; Dover Publications
- Vector Analysis - Murray. R. Spiegel
- Arfken and Weber; Mathematical methods for Physicists; Academic Press

EP1128: Basic Electric Circuits Credits: 2

Circuit Concept, Circuit laws, Circuit Analysis concept, Amplifier and Operational Amplifier Circuits, Waveform Signal, EM, EM Induction, Hysteresis, Power sources, Electrical Instruments and Measurements

Reading Material:

- Electrical Technology by Theraja and Theraja
- Theory and Problems of Electric Circuits by Mehmood Nahvi and Joseph A Edminister

PH5120: Mathematical Physics-1 Credits: 3 (OLDER APPROVED)

Linear vector space, Metric space, Function space, Hilbert space, linear operators, N-dim. Vector space, Tensors, Transformation of basis, Invariant subspaces, Hermitian and Unitary matrices. Analytic functions, Cauchy theorem, Cauchy’s integral representations, Taylor and Laurent series, Calculus of residues, Analytic continuation, conformal mapping, Fourier series, Fourier transforms, Convolution theorem, Laplace transforms, Applications of Fourier and laplace transforms, Series solution, separation of variables, Sturm-Liouville theory, Bessel equation and function, Legendre equation and function, Spherical harmonics, Green function and Nonhomogeneous differential equations, Special functions such as hermite, Laguerre, Chebyshev etc.

Reading Material:

- P. Dennery and A. Krzywicki; Mathematics for Physicists; Dover Publications
- Arfken and Weber; Mathematical methods for Physicists; Academic Press
- J. D. Jackson; Classical Electrodynamics

EP2117: Photonics Credits: 1

Photonics and light technology, Properties of photons, Geometrical Optics, Optical components and Instrumentation, Working of a Laser, Introduction to Fiber Optics Communications.

Reading Material:

- Photonics by Menzel
- Optics by Hecht and Ganesan

EP1208: Electricity and Magnetism Credits: 2

Vector and Scalar Fields, Electric Field, Charge, Dipoles, Electromagnetic fields and forces, Line and Surface Integrals, Gauss' Law, Magnetic Field and Force, Ampere's Law, Faraday's Law, Traveling and Standing Waves, Electromagnetic waves, Maxwell's Equations.

Reading Material:

- Introduction to Electrodynamics, 3rd Edition, by David J. Griffiths.

PH6708/EP3208: Advance Mathematical Physics-2 Credits: 2

Special functions, Class, Cosets, Factor group, Character table, Reducible and Irreducible representations, Lie groups, Applications of group theory in Physics

Reading Material:

- J. F. Cornwell; Group theory in Physics; Academic Press

PH6128/EP2108: Special Relativity Credits: 2

Tensor Analysis, Pseudo and Dual tensors, Tensors in general coordinates, Jacobians, Differential forms: Differentiating and integrating forms. Galilean transformations, postulates of special theory of relativity, Lorentz transformations, length contraction, time dilation, relativistic mass, relativistic energy and momentum, notion of space, time and space-time, space-time diagram, Lorentz group, equivalence principle and general theory of relativity

Reading Material:

- Electrodynamics by D J Griffiths
- Mathematical Physics by Arfken
- Relativity by Resnick
- Differential forms by David Bachman and notes by Donu Arapura

EP2118: Analog Electronics Credits: 2

Introduction, Thevenin's Theorem, Norton's Theorem, Diode Theory, Rectifiers, Optoelectronics devices (LED, Photodiode, Laser Diode), Transistors and their frequency response (BJT, JFET, MOSFET), Voltage and Power amplifiers, Differential Amplifiers, Operational amplifiers

Reading Material:

- Albert Paul Malvino, Electronic Principles – latest Edition, Tata McGraw Hill
- L.Floyd, Electronic Devices, "Pearson Education" New York

EP2100: Classical Mechanics Credits: 3

Brief introduction to Newtonian mechanics, Constraints, Generalized coordinates, Degree of freedom, Virtual work, D'Alembert's Principle of virtual work, Lagrangian formalism, Hamilton's equation, Central force problem (equation of orbits, motion of planets and satellites), Rigid body dynamics, Hamilton's principle, Galilean invariance, Lagrangian and Lagrangian density, symmetry and conservation laws, scattering, small oscillations, rigid body dynamics, canonical equations, canonical transformations, action-angle variables, Hamilton-Jacobi.

Reading Material:

- Rana and Joag, "Classical Mechanics"
- Goldstein, "Classical Mechanics"

EP3217: Introduction to ML in Physics Credits: 1

Basics of Machine Learning. Supervised Learning; Clustering, Classification and Data Mining; Machine Learning metrics; Multivariate analysis; Hands-on experience in Python with applications to Physics;

Reading Material:

- Introduction to Machine Learning using Python by Andreas Mueller and Sarah Guido
- Python Data Science Handbook by Jake Van Der Plas

PH5200/EP2200: Thermodynamics Credits: 3

Laws of thermodynamics, entropy, Clausius theorem, approach to equilibrium, stability conditions; random variables, probability distributions, central limit theorem, information and uncertainty, entropy maximization under constraints.

Reading Material:

- H B Callen, “Thermodynamics and an introduction to Thermostatistics”
- Mehran Kardar, “Statistical Physics of Particles”

PH5207/EP2207: Astroparticle Physics and Cosmology Credits: 1

Natural system of units, elementary particles of nature, Fundamental forces of nature, Physics of Particle and Radiation detection, Acceleration mechanism and Cosmic rays, Concepts of metric, Particle kinematics and dynamics in FRW Universe, redshift, thermodynamics in the early universe, neutrino decoupling, matter-radiation equality, photon-decoupling and recombination, baryon number of the Universe, horizons.

Reading Material:

- The Early Universe by E.W. Kolb and M. S. Turner
- Gravitation and Cosmology by S. Weinberg
- Astroparticle Physics by Claus Grupen

PH5170/EP4210: Computational Physics Credits: 3

Introduction to programming (Python/MATLAB/C++/C/Fortran95), Numerical differentiation and integration, Monte carlo methods, Curve fitting, Linear and nonlinear regression, Roots and optimization of multivariable functions, Solution of nonlinear equations, Numerical matrix computing, Numerical Fourier analysis, Numerical solutions of ordinary and partial differential equations, Numerical solution of Physics problems (Wave equation, Poisson equation, heat equation, Laplace equation, Schrodinger equation, Nonlinear dynamics, Ising model, Statistical mechanics, molecular dynamics etc.)

Reading Material:

- Computational Physics by Tao Pang
- Computational Physics by R. H. Landau, M. J. Paez and C. C. Bordeianu

EP2418: Electronic Device Physics Credits: 2

Basics of Semiconductors: band structure, effective mass, carrier statistics. Junctions: formation of p-n junctions, I-V characteristics, tunnel diodes, p-i-n diodes, semiconductor heterostructures, Transport: Diffusion equations, Boltzmann transport equations, scattering mechanisms, calculation of mobility, carrier dynamics under illumination condition, Generation and recombination of carriers, rate equations, different recombination processes. MOSFETs: MIS structures, C-V characteristics, MOSFET Band diagram, operation regimes, surface charge density, surface potential, charge and field distribution, principle of operation of MOSFETs, Current-Voltage characteristics. Single Electron Transistors: SET structure, Equivalent circuit, coulomb blockade effect, coulomb diamond, Current-Voltage characteristics. Optoelectronic devices: Semiconductor under EM field, absorption, reflection, refraction, transmission, basic operation principle of Solar cell, Quantum well LEDs and Laser diodes (LDs).

Reading Material:

- Physics of semiconductor devices, Michael Shur (Prentice-Hall)
- Quantum Heterostructures: Microelectronics and Optoelectronics, V. V. Mitin, V. A. Kochelap and M. A. Stroscio
- Physics of Low dimensional Semiconductors : An Introduction. J.H. Davies

PH5210/EP3110: Electrodynamics Credits: 3

Electric field, Divergence and curl of electrostatic fields, electric potential, work and energy in electrostatics, conductors, Special techniques to solve Laplace’s equations, separation of variables and Multiple expansion, Polarization, Field of a polarized object, Electric displacement and linear dielectrics, Lorentz force law, Biot-Savart Law, magnetic vector potential, magnetization, field of a magnetized object, linear and nonlinear media. Electromotive force, Electromagnetic induction, Maxwell’s equations, conservation laws, Poynting theorem, Maxwell’s stress tensor, conservation of momentum, Electromagnetic waves, Electromagnetic waves in vacuum and matter, Absorption and Dispersion, Wave Guides, Potentials and fields, Gauge transformations, Dipole radiation, Power radiated by point charge, Maxwell’s equations in matter, Boundary conditions, Poynting’s theorem, Newton’s third law in Electrodynamics, Maxwell’s stress tensor, Conservation of Momentum, Electromagnetic waves in vacuum, and matter, absorption and dispersion, Guided waves.

Reading Material:

- Introduction to Electrodynamics, 3rd Edition, by David J. Griffiths.
- Classical Electrodynamics : John David Jackson

PH5310/EP5310: Electrodynamics-2 Credits: 3

Postulates of special theory of relativity, Lorentz transformations, length contraction, time dilation, relativistic mass, relativistic energy and momentum, notion of space, time and space-time, Lorentz group, equivalence principle and general theory of relativity. Covariance and contravariance, Metric and invariant scalar products, Second rank 4-tensors: symmetric and antisymmetric, Higher-rank 4-tensors. Tensor Calculus,

Reading Material:

- Introduction to Electrodynamics, 3rd Edition, by David J. Griffiths.
- Classical Electrodynamics by John David Jackson
- Classical theory of fields by Landau lifshitz

PH5130/EP3100: Quantum Mechanics-1 Credits: 3

Classical to quantum cross-over, basic principles of quantum mechanics, wave function and uncertainty principle, Schrodinger formalism, time-independent and time-dependent Schrodinger equations, Dirac formulation of quantum mechanics, completeness and orthonormalization of basis vectors, basis sets, eigenstate and eigenvalues, Schrodinger Equation in one dimension, probability current density, equation of continuity, Free particle solution of Schrodinger equation, box and delta function normalisation of free particle solution, potential step, potential barrier, particle in an infinite potential box, square well potential and tunnelling, linear harmonic oscillator. Orbital and spin angular momentum operators, angular momentum algebra, eigenstates and eigenvalues of angular momentum, addition of angular momenta, Clebsch-Gordon coefficients, spin-orbit interaction and applications, central potential, solutions of schrodinger equation in a central potential, Hydrogen-like atom, 3 dimensional harmonic oscillator. Time independent perturbation theory for non-degenerate and degenerate energy levels, variational method, WKB approximation and applications, time dependent perturbation theory, Fermi-golden rule, adiabatic approximation, sudden approximation.

Reading Material:

- Quantum Mechanics by Stephen Gasiorowicz
- Principles of Quantum Mechanics by R. Shankar
- Quantum Mechanics by Bransden and Joachain
- Quantum Mechanics I, II by JJ Sakurai

PH5230/EP3210: Quantum Mechanics-2 Credits: 3

Scattering experiments and cross-sections, general features of scattering in presence of a potential, partial wave analysis, scattering by square well, scattering by hard sphere potential, born approximation, applications. Schrodinger and Heisenberg pictures, interaction picture, unitary transformations, symmetry principle and conservation laws, translation along spatial and temporal directions, spatial rotation and conservation of angular momentum, space reflection and parity conservation, time reversal invariance. Elements of relativistic quantum mechanics, the Klein-Gordon equation, the Dirac equation, Dirac matrices, spinors, positive and negative energy solutions, physical interpretations, non-relativistic limit of Klein-Gordon and Dirac equations, equation of continuity and probability current density.

Reading Material:

- Quantum Mechanic by Stephen Gasiorowicz
- Principles of Quantum Mechanics by R. Shankar
- Advanced Quantum Mechanics by J.J. Sakurai
- Quantum Mechanics by Bransden and Joachain

PH5260/EP3230: Atomic-Molecular Physics Credits: 3

Quantum states of an electron in an atom. Electron spin. Spectrum of helium and alkali atom. Relativistic corrections for energy levels of hydrogen atom, hyperfine structure and isotopic shift, width of spectral lines, LS & JJ couplings. Zeeman, Paschen-Bach & Stark effects. Electron spin resonance. Nuclear magnetic resonance, chemical shift. Frank-Condon principle. Born-Oppenheimer approximation. Electronic, rotational, vibrational and Raman spectra of diatomic molecules, selection rules. Experimental techniques in atomic and molecular physics: Absorption, Fluorescence, Raman, Two-photon, Doppler-limited and Doppler-free spectroscopy, X-ray and photoelectron spectroscopy, Cooling and trapping of atoms/ions.

Reading Material:

- Physics of atoms and molecules by Brensden and Joachain
- Atomic and molecular spectroscopy by Svanberg
- Fundamentals of Molecular Spectroscopy by C.N. Banwell and E.M. McCash

PH5167/EP3367: Experimental Techniques Credits: 1

Vacuum Techniques, Optical techniques, Magnetic characterization techniques, Data Analysis, Error Analysis

Reading Material:

- The Laboratory Companion by Gary Coyne
- Building Scientific Apparatus by Moore, Davis, Coplan and Greer
- Introduction to Error Analysis, J. R Taylor

PH5250/EP3220: Modern Optics Credits: 3

Propagation of Light, Fermat's Principle, Lens and Aberration, Interference, Coherence of Light, Diffraction Theory, Polarization, Fourier Optics, Linear Interaction between Light and Matter, Non-linear Interaction between Light and Matter and basics of nonlinear optics, LASERs basics, Gaussian Optics, Fundamentals of Optical Engineering

Reading Material:

- Principles of Optics, Max Born and Emil Wolf
- Optics by Hecht and Ganesan
- Fourier Optics by Goodman

PH5240/EP3120: Statistical Mechanics Credits: 3

Introduction to statistical methods; Statistical description of a physical system; Microcanonical ensemble; Canonical ensemble, Grand canonical and pressure ensemble, Quantum statistical mechanics, The ideal quantum gas, Thermodynamics of ideal Fermi and Bose gases, Bose-Einstein condensation, Phase transition and critical phenomena, Exact solution of 1D Ising model, Ising model (mean field, Bragg-Williams, Bethe-Peierls approximation)

Reading Material :

- Statistical Physics of Particles by M. Kardar
- Statistical Mechanics by R. K. Pathria
- Statistical Physics - Landau and Lifshitz
- Statistical Mechanics by K. Huang

PH5110/EP3140: Classical Mechanics Credits: 3

Constraints, Generalized coordinates, D'Alembert principle, Lagrangian, Euler-Lagrange equations, Hamilton's principle, Galilean invariance, Symmetry and Conservation laws, Motion in one dimension, Two body problem, Kepler Problem, Scattering in central field, Small oscillations, Normal modes, Rigid body dynamics, Canonical equations, Canonical transformations, Action-angle variables, Hamilton-Jacobi equation.

Reading Material:

- Landau and Lifshitz, "Mechanics"
- Hand and Finch, "Analytical Mechanics"
- Goldstein, "Classical Mechanics"
- Pars, "A Treatise on Analytical Dynamics"
- Percival and Richards, "Introduction and Dynamics"
- Arnold, "Mathematical Methods of Classical Mechanics"

PH6200/EP3200: Solid state Physics Credits: 3

Crystal structure, Wave diffraction and Reciprocal lattice, Free electron Fermi gas, Band theory of solids, Lattice Vibrations and phonons, Thermal properties, Semiclassical theory of transport, Magnetism and magnetic systems, Dielectrics and Ferroelectrics, Semiconductors, Optical processes and excitons, Superconductivity, Nanostructures

Reading Material:

- C. Kittel, Introduction to Solid State Physics, 8th Edition,
- Solid state Physics by N. W. Ascroft and N. D. Marmin
- Condensed Matter Physics by M. P. Marder

PH6108/EP4108: Nuclear Physics Credits: 2

Basic nuclear properties: size, shape and charge distribution, spin and parity. Binding energy, semi empirical mass formula, liquid drop model. Nature of the nuclear force, form of nucleon-nucleon potential, charge-independence and charge-symmetry of nuclear forces. Deuteron problem. Evidence of shell structure, single-particle shell model, its validity and limitations. Rotational spectra. Elementary ideas of alpha, beta and gamma decays and their selection rules. Fission and fusion. Nuclear reactions, reaction mechanism, compound nuclei and direct reactions.

Reading Material:

- Introductory Nuclear Physics, by Kenneth Krane
- Nuclear Physics, by S.B Patel

PH6270/EP4710: Particle Physics Credits: 3

Basic constituents of matter, Forces in nature, Accelerators: Cosmic and Manmade, Detectors, Exotic Matter. Classification of particles, Quark contents of Hadrons, Particle quantum numbers, Gell-Mann Nishijima formula, Relativistic kinematics, scattering amplitudes, Cross sections, decay rate and life-time. Breight-Wigner formula, Continuous symmetries and conservation laws. Discrete symmetries. CPT theorem, Weak processes, pion decay, GIM mechanism, Parity violation, Quark mixing, CKM matrix, Neutrino Physics, Elements of Quantum Chromodynamics, Electroweak interaction, Symmetry breaking and Higgs mechanism, Standard Model of Particle Physics and Physics beyond the standard model.

Reading Material:

- F. Halzen and A. Martin, Quarks and Leptons, John Wiley
- R. Phillips and V Barger, Collider Physics, Frontiers in Physics, AP
- Gauge theory of elementary Particles Cheng and Li
- Particle Physics by Kerson and Huang
- D. H. Perkins, Introduction to High Energy Physics, Oxford Univ. Press

PH5227/EP3227: Nonlinear dynamics Credits: 1

Nonlinear methods and chaos, stability, logistic map, nonlinear differential equations, bifurcations, chaos

Reading Material:

- Strogatz, “Nonlinear dynamics and Chaos”

PH6297/EP5297: Classical Field Theory Credits: 1

This is a one credit advanced elective intended to be an introduction to classical dynamics of (relativistic) fields at the postgraduate/advanced undergraduate level. This course will prepare the student for a more advanced course on quantum field theory. Topics covered will include a review of continuum mechanics/field concept, review of special relativity, the introduction to functional methods for Lagrangian version of classical field theory, Noether's theorem and applications, and Hamiltonian (symplectic) methods in field theory. I will restrict myself to scalar and spin-1 (Maxwell) fields. If time permits we will also cover canonical and path integral quantization of scalar fields. Topics covered are to be found in the classical field theory sections of quantum field theory textbooks.

Reading Material:

- Landau and Lifshitz: The Classical Theory of Fields

- S. W. Weinberg: General Relativity and Cosmology
- V.P. Nair: Quantum Field Theory: A Modern Perspective
- J.J. Sakurai: Advanced Quantum Mechanics
- Itzykson and Zuber: Quantum Field theory

PH6450/ EP4250: Gravitation and Cosmology Credits: 3

This is an intermediate-to-advanced course in Einstein's general relativity theory and its application to the universe at the largest scales (cosmology). The course can be roughly imagined to consist of two halves. The first half of the course is dedicated to elementary topics in general relativity: special relativity, the equivalence principle and differential geometry (tensor calculus), Einstein's field equations and few simple solutions of the Einstein field equations: gravitational waves and gravitational radiation and the Schwarzschild black hole. The second half of the class is dedicated to application of general relativity to the large scale structure of the universe: we will review basics of big bang cosmology accounting for the (1) the expansion of the universe as measured by galactic redshifts (2) the existence of the cosmic background radiation and (3) the relative amounts of hydrogen, helium and deuterium in the universe. Existence of Dark matter and Dark energy; and if time permits an introduction to inflationary cosmology.

Reading material:

First Half: General Relativity

- Sean Carroll: Spacetime and Geometry(Lecture notes http://arxiv.org/abs/gr-qc/9712019)
- Hans Stephani: Relativity: An Introduction to Special and General Relativity
- Ray D'Inverno: Introducing Einstein's Relativity. Oxford U. Clarendon Press
- Steven Weinberg: Gravitation and Cosmology. Wiley India Pvt. Ltd.
- Bernard Schutz: A First Course in General Relativity
- James B Hartle: Gravity:An Introduction to General Relativity. Addison Wesley
- Charles W. Misner, Kip S. Thorne, John A. Wheeler: Gravitation

Second Half: Cosmology

- S.W. Weinberg: Cosmology. Oxford University Press 2
- Steven Weinberg: Gravitation and Cosmology. Wiley India Pvt. Ltd.
- Sean Carroll and Mark Trodden: TASI lecture on Cosmology https://arxiv.org/abs/astroph/0401547
- Barbara Ryden: Introduction to Cosmology
- Matt Roos: Introduction to Cosmology

PH7780/EP4780: Group theory in physics Credits: 3

Groups: General Properties (Motivation: Why Group Theory? Definition, Examples, Examples, Subgroups and Cosets, Conjugates, Normal Subgroups, Quotient Groups, Group Homomorphisms, Product Groups), Group representations (General Group Actions, Representations, Unitarity, Reducibility, Direct Sums and Tensor Products, Schur's Lemma, Eigenstates in Quantum Mechanics, Tensor Operators, Wigner–Eckart Theorem), Discrete Groups (The Symmetric Group, Cycles, Order of a Permutation, Cayley's Theorem, Conjugacy Classes, Representations, The Regular Representation, Orthogonality Relations, Characters, Finding Components of Representations, Conjugacy Classes and Representations, Representations of the

Symmetric Group, Reducibility and Projector, Young Tableaux and Young Operators, Characters, the Hook Rule), Lie Groups and Lie Algebras (Definition, Examples,Topology, Some Differential Geometry: Tangent Vectors, Vector Fields, The Lie Algebra, Matrix Groups, The Lie Algebra of Matrix Groups, Lie Algebras of GL(n, K) and Subgroups, From the Algebra to the Group Lie's Third Theorem, The Exponential Map), Representations theory of Lie Algebras (Generalities, Structure Constants, Representations, The Adjoint Representation, Killing Form, Subalgebras, Real and Complex Lie Algebras, Representations of su(2), Diagonalising the Adjoint Representation, Constructing an Irreducible Representation, Decomposing a General Representation, The Cartan–Weyl Basis, The Cartan Subalgebra, Roots and Weights, The Master Formula, Geometry of Roots: Example: su(3), Positive and Simple Roots: Example: su(3), Constructing the Algebra, Representations and Fundamental Weights, Highest Weight Construction, Fundamental Weights, Cartan Matrix, Dynkin Diagrams, Classification of Simple Lie Algebras, The Dynkin Diagrams of the Classical Groups: su(n), so(n), sp(n) ,Complex Representations, Young Tableaux for SU(n): Products of Representation, Subalgebras, Spinors and Clifford Algebra, Casimir Operators.

Reading material:

- H. Georgi, "Lie Algebras In Particle Physics
- R. N. Cahn, "Semisimple Lie Algebras And Their Representations,"
- H. F. Jones, "Groups, representations and physics,"
- J. Fuchs and C. Schweigert, "Symmetries, Lie Algebras And Representations: A Graduate Course For Physicists,"
- R. Slansky, "Group Theory For Unified Model Building," Phys. Rept. 79, 1 (1981)
- M. Nakahara, "Geometry, topology and physics"

PH6410/EP7410: Quantum field theory Credits: 3

This is an introductory course on Quantum Field Theory. It covers quantization of scalar fields in detail and towards the very end of the course also introduces elements of Quantum Electrodynamics. The topics covered are: Free real and complex scalar fields, Canonical quantization, Interacting scalar fields. Feynman propagator, n-point correlation functions and their perturbative expansion, the S-Matrix and its expansion in Feynman diagrams, Kallen-Lehmann spectral representation, LSZ reduction. Cross-section and its connection to the S-Matrix. Renormalization, Dimensional regularization, Phi-4 theory at one-loop. Dirac Equation, Quantization of Electromagnetic fields, Gauge invariance, Elements of quantum Electrodynamics. Feynman rules and Feynman diagram for spinor electrodynamics.

Reading Material:

- M. Peskin & D. Schroeder, "**An Introduction To Quantum Field Theory**"
- M. Schwartz, "**Quantum Field Theory and the Standard Model"**
- M. Srednicki "**Quantum Field Theory**
- S. Weinberg, "**The Quantum theory of fields: Foundations**"**, Volume 1**

PH 6140: Quantum Yang Mills Theory Credits: 3

This advanced elective course will provide the fundamentals of the framework on which our current understanding of particle physics is based. Here they will learn about non-abelian (Yang-Mills) gauge theories and how to quantize them. This course will teach how to calculate 1-loop Feynman diagram, and furthermore how to renormalize these theories. This course, which is a core course for any PhD student pursuing PhD in theoretical particle physics will equip students with the necessary tools to carry out cutting edge research in various fields of particle physics. Course contents: Gauge Invariance, Basics of Lie Algebras, Yang-Mills Lagrangian, Gauge Fixing, Ghosts and Unitarity, Feynman Rules, One loop divergences, The Beta function, Asymptotic Freedom.

Pre-Req: Quantum phi-4 theory, quantization of Dirac fields, tree and one-loop Feynman diagram calculations.

References:

- S. Weinberg, "**The Quantum theory of fields: Modern Applications**", **Volume 2**
- M. Schwartz, "**Quantum Field Theory and the Standard Model"**
- M. Srednicki "**Quantum Field Theory**"
- M. Peskin & D. Schroeder, "**An Introduction To Quantum Field Theory**"

PH5140: Electronics Credits: 3 (Approved)

Introduction, Thevenin's Theorem, Norton's Theorem, Diode Theory, Rectifiers, Optoelectronics devices (LED, Photodiode, Laser Diode), Transistors and their frequency response (BJT, JFET, MOSFET), Voltage and Power amplifiers, Differential Amplifiers, Operational amplifiers, Binary digits, logic operations, number systems, logic gates, Boolean algebra, K-maps, combinational logic gates, functions of logic gates (adder, comparator etc), Flip flops and its applications (counters, shift registers, memory and storage)

Reading Material:

- Albert Paul Malvino, Electronic Principles – latest Edition, Tata McGraw Hill
- L.Floyd, Electronic Devices, "Pearson Education" New York
- Ben.G. Streetman, Solid state electronic devices, Prentice Hall, Englewood cliffs, NJ
- Thomas L.Floyd, Digital Fundamentals – latest edition, Prentice Hall,
- Albert Paul Malvino Donald P. Leach, Digital Principles and Applications , TataMcGrawHill

PH6308/EP4308: Ultrafast Optics Credits: 2

Laser basics; Pulsed Optics; Principle of Mode-locking-Active and Passive; Femtosecond laser pulses; Ultrafast-pulse measurement methods; dispersion and dispersion compensation; ultrafast nonlinear optics; manipulation of ultrashort pulses; application of ultrashort pulses: time resolved and THz spectroscopy, coherent control; attosecond pulses.

Reading Material:

- Ultrafast Optics by Andrew M. Weiner, Wiley.
- Femtosecond laser pulses: principles and experiments ed. Claude Rullière, Springer.

PH6300/EP4300: Ultrafast Optics with simulation Credits: 3

Laser basics; Pulsed Optics; Principle of Mode-locking-Active and Passive; Femtosecond laser pulses; Ultrafast-pulse measurement methods; dispersion and dispersion compensation; ultrafast nonlinear optics; manipulation of ultrashort pulses; application of ultrashort pulses: time resolved and THz spectroscopy, coherent control; attosecond pulses. Matlab/Python/R Simulation

Reading Material:

- Ultrafast Optics by Andrew M. Weiner, Wiley.
- Femtosecond laser pulses: principles and experiments ed. Claude Rullière, Springer.

PH6318/EP4318: Solar Cells and Technology Credits: 2

Basic principles of Photovoltaics; characteristics of the photovoltaic cell; Silicon solar cells; thin film solar cells; managing light; Thermodynamic limit to efficiency-The Shockley-Queisser limit; Advanced strategies for high efficiency solar cells; Inorganic Solar Cells; third generation solar cells:Organic Solar Cells, Perovskite Solar Cells

Reading Material:

- The Physics of Solar Cells by Jenny Nelson, Imperial College Press-2013.
- Physics of Solar Cells: from basic principles to advanced concepts by Peter Würfel, Wiley-VCH-2009.
- Solar Photovoltaics: Fundamentals, Technologies And Applications,Chetan Singh Solanki, PHI Learning PVT Ltd.

PH7400/EP4400: Optical Engineering and lab Credits: 3

Basics of Geometrical Optics and Diffraction Theory, Optical Components: Mirrors, Lens, Prisms, Thin lens theory, Aberrations, Basic Optical Instruments, Lens Design and evaluation, Introduction to Optical Instrument design. 1 credit Lab/Simulation Matlab/Python/R

Reading Material:

- Optical Engineering Fundamentals, Second Edition, Bruce H Walker, SPIE Press
- Basic Optical Engineering for Engineers and Scientists, Haiyin Sun, SPIE Press
- Modern Optical Engineering, W.J. Smith, McGraw-Hill

PH7408/EP4408: Optical Engineering and lab Credits: 3

Basics of Geometrical Optics and Diffraction Theory, Optical Components: Mirrors, Lens, Prisms, Thin lens theory, Aberrations, Basic Optical Instruments, Lens Design and evaluation, Introduction to Optical Instrument design.

Reading Material:

- Optical Engineering Fundamentals, Second Edition, Bruce H Walker, SPIE Press
- Basic Optical Engineering for Engineers and Scientists, Haiyin Sun, SPIE Press

- Modern Optical Engineering, W.J. Smith, McGraw-Hill

PH5320/EP4120: Astronomy & Astrophysics Credits: 3

Introduction to astronomical and astrophysical nomenclature and concepts. Coordinate systems, celestial orbits, Telescopes. radiation, stars, stellar structure and evolution, galaxies and galaxy clusters. Active galaxies. Pulsars, Neutron Stars, Black Holes. Observational Cosmology

Reading Material:

- Astrophysics for physicists by Arnab Rai Chaudhari
- Introduction to Modern Astrophysics Carroll and Ostlie

EP4130/PH6130: Data Science Analysis Credits: 3

Measurement, analysis; Probability distributions; Parameter Estimation; Hypothesis testing; Model Comparison; Confidence Intervals; Bootstrap and Jacknife analysis. Bayesian Analysis; Markov Chain Monte Carlo techniques; Dimensionality Reduction; Time-series analysis. Periodogram analysis.

Reading Material:

- Statistics, Data Mining and Machine Learning in Astronomy by Z. Ivezic, A Connolly, J. VanderPlas and Alexander Gray
- Data Reduction and Error Analysis for the Physical Sciences. P.R. Bevington
- Data Analysis. A Bayesian tutorial by D.S. Sivia

PH6860/EP4860: Advanced Particle Physics Credits: 3

Standard Model as Gauge theory, Electroweak Lagrangina, Two-Three-body decays, muon decay, Scattering amplitude calculation, Symmetry breaking and Higgs mechanism, Yukawa interactions, CKM and CP-violation, Pion decay, flavour symmetries, Neutrino Oscillation, Neutrino matter effect, neutrino interactions, Neutrino mass, Dark Matter phenomenology, Young Tableau, Physics beyond the standard model.

Reading Material:

- F. Halzen and A. Martin, Quarks and Leptons, John Wiley
- Quantum Field theory by Peskin and Schroeder
- Gauge theory of elementary Particles Cheng and Li
- Particle Physics by Kerson and Huang
- Massive Neutrinos in Physics and Astrophysics by Mohapatra and Pal

PH7300/EP4500: Advanced Statistical Mechanics Credits: 3

Content: Spin and fields, Path Integral, The Renormalisation Group (Scaling Explained; Relevant, Irrelevant and Marginal; The Gaussian Fixed Point), Continuous Symmetry(O(N) Models, Goldstone Bosons and Goldstone's Theorem, The Mermin-Wagner Theorem; Sigma Models, Background Fields, Large N; the Kosterlitz-Thouless Transition, Vortices, the Coulomb Gas, the Sine-Gordon Model), Phase transitions

Reading Material:

- Statistical Field Theory by David Tong
- Subir Sachdev, "Quantum Phase Transitions"
- Mehran Kardar, "Statistical Mechanics of Fields"

PH7318/EP4518: Introduction to Nanomagnetism Credits: 2

Basics of magnetism, Magnetism at nanoscale (thin films and nanostructures), Magnetic interactions, Magnetic anisotropies, Magnetic domains, Spin textures at nanoscale (nanodisk, nanorings, nanowires), Interfacial physics in thin film multilayers, Techniques in nanomagnetism and applications (magnetic recording).

Reading Material:

- Principles of nanomagnetism by Alberto P Guimarães

PH7310/EP4510: Introduction to Nanomagnetism with lab Credits: 3

Basics of magnetism, Magnetism at nanoscale (thin films and nanostructures), Magnetic interactions, Magnetic anisotropies, Magnetic domains, Spin textures at nanoscale (nanodisk, nanorings, nanowires), Interfacial physics in thin film multilayers, Techniques in nanomagnetism and applications (magnetic recording). 1 credit Project

Reading Material:

- Principles of nanomagnetism by Alberto P Guimarães

PH7460/EP4460: Computational Particle Physics Credits: 3

CalcHEP: Cross-section Calculation, Decay calculation, Event Generations, PYTHIA: Event generation and LHC simulation, Madgraph, SARAH: Model writing via SARAH and beta function calculations, Alpgen: QCD processes, Delphes: Detector of LHC at CERN, Python, Pyplots, Root++: A plotter, MicrOmegas: Dark matter constraints calculators, Data analysis

Reading Material:

- All CERN HEPforge Documents, PYTHIA, SARAH, MADGRAPH, MicrOmegas manuals

EP3520: Fluid Mechanics Credits: 3

Conserved quantities and continuity, Euler's equation, hydrostatics, streamline flow, vortices, Bernoulli's equation, energy and momentum flux, incompressible fluids, flow past bodies, viscous fluids - Navier Stokes equation, energy dissipation, Stoke's formula. Shock Waves and Blast waves. Instabilities. Viscous flows. Turbulence.

Reading Material:

- Introduction to Fluid Mechanics by Landau and Lifshitz
- Astrophysical Fluid dynamics by Carswell and Clarke

PH6168/EP4068: Spintronics Credits: 2

Energetics of magnetic system, Domain and Domain wall, Magnetoresistance and spin dependent transport, Magnetic Recording, Materials for spintronics, Opportunity and challenges in spintronics, Length and time correlation in magnetic system, Spin transfer torque, Spin orbit interaction, Skyrmions, Spin injection, Ultrafast Spin dynamics, Spin relaxation, Spin waves, Micromagnetic methods,

Reading Material:

- Magnetic waves and oscillations by Gurevich and Melkov
- Micromagnetic methods using OOMMF by Donahue and Porter
- Magnetic domains by Hubert and Schäfer
- Introduction to Magnetism by Cullity

PH 6338/EP4368: Advanced functional materials Credits: 2

Introduction to Functional Materials, Concept in dielectric and magnetic properties, magnetoresistive and magnetocaloric materials, Spintronics, thermoelectric materials, Nano-X (X = materials, wires, tubes, dots , magnetism, etc), introduction to Impedance spectroscopy, processing methods (Bulk and Thin films) and Characterization techniques (XRD, SEM, etc.) in brief.

Reading Material:

- Introduction to magnetism by B.D. Cullity
- Dielectric Phenomenon in Solids by K C Kao

PH7478/EP4118: Laser Spectroscopy Credits: 2

Lasers Overview; Spectroscopic instrumentation; Doppler-limited Absorption and Fluorescence spectroscopy; nonlinear optics and Spectroscopy; Laser spectroscopy of Molecular Beams; Time resolved laser spectroscopy; coherent spectroscopy; THz spectroscopy

Reading Material:

- Laser Spectroscopy by W. Demtroder

PH7470/EP4110: Laser Spectroscopy (Theory and Lab) Credits: 3

Lasers Overview; Spectroscopic instrumentation; Doppler-limited Absorption and Fluorescence spectroscopy; nonlinear optics and Spectroscopy; Laser spectroscopy of Molecular Beams; Time resolved laser spectroscopy; coherent spectroscopy; THz spectroscopy, 1 credit lab project

Reading Material:

- Laser Spectroscopy by W. Demtroder

PH7488/EP4488: Atmospheric Optics and Instrumentation Credits: 2

Introduction to principles of optics; atmospheric optics; optical instrumentation; optical remote sensing of the atmosphere; radiometry for ocean climate studies

Reading Material:

- Field Guide to Atmospheric Optics, Larry C Andrews, SPIE Press.
- Lidar: Range-Resolved Optical Remote Sensing of the Atmosphere, Ed. Claus Weitkamp, Springer Series in Optical Sciences, 2005
- Optical Radiometry for Ocean Climate Measurements, Ed. Giuseppe Zibordi Craig Donlon Albert Parr, Elsevier, 2014.

EP1031: EP Lab 1 Credits: 2

Young’s Modulus of wood using a Strain Gauge. Rigidity Modulus of a wire using Torsional Pendulum. Stefan’s law and Planck’s constant. Principle of superposition using a Cathode Ray Oscilloscope. Refractive index of the material of the prism using a Spectrometer. Measurement of radius of curvature of the plano convex lens by forming Newton`s rings. Wavelength of a laser by studying the diffraction from a scale. Field along the axis of a coil and the earth’s magnetic field. Energy gap of a semiconductor. Characteristics of Bipolar Junction Transistor (BJT).

Reading Material:

- Concept of Modern Physics by Arthur Beiser
- Modern Physics by Kenneth S Krane
- Feynmann Lecture series

PH6730/EP4590 Plasma Physics and MHD Credits: 3

Plasma and its occurrence in nature • Concept of Temperature • Debye Shielding • Plasma Parameter • Criteria for Plasmas • Applications of Plasma Physics • Motion of charged particles in fields • Waves in plasmas Methods of plasma production • Ionization and equilibrium models in a plasma • Radiation from plasmas and diagnostics • Absorption processes and instabilities in plasmas • Laser Plasma Interaction Modes of description of a plasma • Collisional plasma • The one-fluid description• The two-fluid description. Collisionless plasma • The guiding center limit of the Vlasov equation • The double adiabatic theory • Consequences of the MHD description. Conservation relations • Flux frozen in plasma

- Chen, F. F.*Introduction to Plasma Physics*. 2nd ed. Plenum Press, 1995. ISBN: 9780306307553.
- Tanenbaum, B. S.*Plasma Physics.* New York, NY: McGraw-Hill, 1967. ISBN: 9780070628120.
- Dendy, R., ed.*Plasma Physics.* Cambridge, UK: Cambridge University Press, 1994. ISBN: 9780521433099. (Recommended for specific chapters on space and plasmas and on industrial plasmas)
- Hutchinson, I. H. *Principles of Plasma Diagnostics.* 2nd ed. Cambridge, UK: Cambridge University Press, 1987. ISBN: 9780521326223.
- W. L. Kruer, “The Physics of Laser Plasma Interaction” Addison-Wesley Publishing Co. 1987
- Shalom Eliezer, “ The Interaction of High-Power Lasers with Plasmas” Institute of Physics Publishing Ltd. 2002
- Paul Gibbon, “Short Pulse Laser Interactions with Matter-An Introduction” Imperial College Press 2007

EP4940/PH6940 Fundamentals of Accelerator Physics Credits:3

Accelerator magnets, Particle Dynamics, Steady state Electric and Magnetic fields, Modifications of E& B fields by Materials, Electric and Magnetic field Lenses, Focusing Fields, LINAC, Betatrons, Phase Dynamics; effects of linear magnet errors; chromatic effects and their correction; effects of nonlinearities; basic beam manipulations; RF systems, diagnostic systems; and introduction to accelerator lattice design. Other topics such as synchrotron radiation excitation and damping; beam-beam interaction; collective effects and instabilities; linear accelerators

Reading Material:

- D. A. Edwards and M. J. Syphers, "An Introduction to the Physics of High Energy Accelerators", John Wiley & Sons, Inc., (1993)