INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Physics Department**

1. Subject Code: **PH-785** Course Title: **Classical Mechanics and Classical Electrodynamics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weightage**: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

5. Credits**: 4** 6. Semester**: - Spring/Autumn (both)** 7.Subject Area**:** Pre-PhD

8. Pre-requisite**: NIL**

9. Objective: **A Pre-PhD course on Classical Mechanics and Classical Electrodynamics**

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Review of Newton's program for tackling problems in statics and kinematics:** Variable mass problems, Central forces, Applications to planetary and stellar systems	8
2.	**Canonical Transformations:** Equations of canonical transformations and examples, sympletic approach, Poisson brackets and equation of motion, conservation laws, angular momentum Constraints, Generalized Coordinates, Problems involving Lagrangian and Hamiltonian formulation of Classical mechanics	7
3.	**Special relativity:** Relativistic Lagrangian and Hamiltonian function, Relativistic kinematics of collisions and collision threshold energies	6
4.	**Boundary -Value Problems in Electrostatics:** Laplace equation, Legendre equation and Legendre polynomials, Expansion of Greens function, solution of potential problems with the Greens function expansion **Maxwell's Equations:** Maxwell's equations, vector and scalar potentials, Green functions for wave equations **Plane EM Waves and Propagation:** Plane waves in non-conducting medium, Reflection and refraction of EM waves at plane interface between two dielectrics, polarization, dispersion characteristics of dielectric, conductors and plasma	8
4.	**Collisions between charged particles**: Quick review of (modified) Bessel functions (of the first and second kinds); Electromagnetic field in a medium due to incident charged particle moving with constant	4

	velocity; energy loss in a charged particle moving near a harmonically bound charged particle; Cherenkov radiation and singular vector potential	
5.	**Radiation from accelerated charges**: Retarded and advanced Green's functions; Lienard-Wiechert potentials; Larmor's formula and its relativistic generalization (Lienard's result); relativistic enhancement of power by a particle in circular motion relative to rectilinear motion; angular distribution of radiation and distribution in frequency and solid angle for a relativistic particle in instantaneous circular motion; Thomson scattering; Bremsstrahlung (double differential intensity distribution of radiation emitted during interaction of the lighter charged particle with a fixed field, polarization and spectrum integrated over solid angles)	7
6.	**Cavities and Wave Guides**: Transverse electric and magnetic fields, TEM modes, TM and TE modes and solutions of Helmholtz equation in wave guides and cut-off frequencies	2
Total		42

11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	Goldstein H, "Classical Mechanics", Narosa	2001
2.	Rana W.C. and Jog P.S, "Classical Mechanics", Tata McGraw Hill	1991
3.	Kleppner and Kolenkow, "An Introduction to Mechanics", Cambridge University Press, 2nd Ed.	2013
4.	J. D. Jackson, "Classical Electrodynamics", Wiley, 3rd Ed.	2007
5.	Griffiths D J, "Introduction to Electrodynamics", Prentice Hall	1999
6.	Capri A.Z. and Panat P.V., "Introduction to Electrodynamics" Narosa Publication House	2002
7.	Franklin J., "Classical Electromagnetism", Pearson Education	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Physics Department**

1. Subject Code: **PH-786** Course Title: **Advanced Quantum and Statistical Mechanics**

2. Contact Hours: **L: 3** **T: 1 P: 0**

3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weightage**: CWS 25 PRS 0 MTE 0 ETE 50 PRE 0**

5. Credits**: 4** 6. Semester**: Both** Subject Area**:** Pre-Ph.D

8. Pre-requisite**: NIL**

9. Objective: A course on Advanced Quantum and Statistical Mechanics

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Classical and Quantum Statistical Mechanics:** Macro and microstates, phase space; Liouville's Theorem. Microcanonical, canonical and grand canonical ensembles Quantum mechanical ensemble theory, the density matrix and partition function with examples. Symmetric and Antisymmetric Wavefunctions. Microcanonical ensemble of ideal Bose, Fermi and Boltzmann gases, derivation of Bose, Fermi and Boltzmann statistics; Grand Partition function of ideal Bose and Fermi gases	11
2.	**Ideal Bose and Fermi Systems:** Thermodynamic behaviour of an ideal Bose gas; Bose condensation; Liquid Helium; Blackbody radiation and Planck's law of radiation; Thermodynamic behaviour of an ideal Fermi gas; Electrons in metals, specific heat and Pauli susceptibility of electron gas.	10
3.	**Rotations and Addition of Angular Momenta:** Rotation Matrices and the Spherical Harmonics, Coupling and addition of Angular Momenta, Rotation Matrices for Coupling Two Angular Momenta, Wigner Eckart Theorem Angular Momentum :	5
4.	Three-Dimensional Problems: 3D Problems in Cartesian Coordinates and spherical coordinates, Central Potential: General Treatment , The Free Particle in Spherical Coordinates, The Spherical Square Well Potential , The Isotropic Harmonic Oscillator , The Hydrogen Atom, Effect of Magnetic Fields on Central Potentials	6
5	Perturbation Theory: Time-Independent Perturbation Theory,	6

	The Variational Method, The Wentzel–Kramers–Brillouin Method, Time-Dependent Perturbation Theory, Adiabatic and Sudden Approximation, Interaction of Atoms with Radiation	
6	Scattering Theory: Scattering and Cross Section, Scattering Amplitude of Spinless Particles, The Born Approximation, Partial Wave Analysis, Scattering of Identical Particles	4
Total		42

11. Suggested Books:

S. No.	**Name of Authors/ Books/Publishers**	**Year of Publication/Reprint**
1.	Patharia R K "Statistical Mechanics" (2nd Ed.), Pergaman press	2001
2.	Huang K "Statistical Mechanics" (2nd Ed., 2nd reprint), John Wiley & Sons	2003
3.	Landau L.D. and Lifshitz E M "Statistical Mechanics", Butteworth-Heinemaun	1998
4.	Griffiths D J, "Introduction to Quantum Mechanics", 2nd Ed, Pearson Eduction	**2005**
5.	Bransden B H and Joachain C J, "Quantum Mechanics", 2nd Ed, Pearson Eduction	**2000**
6.	Zettili N, "Quantum Mechanics: Concepts and Applications", 2nd Ed, John Wiley	**2009**

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NAME OF DEPTT./CENTRE: DEPARTMENT OF PHYSICS

1. Subject Code: PH-788 Course Title: **Advanced Characterization Techniques**

2. Contact Hours: L: 3 T: 1 P: 0

3. Examination Duration (Hrs.): Theory 3 Practical **0**

4. Relative Weightage**:** CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits**: 4** 6. Semester**: 0** 7. Subject Area**:** Pre PhD

8. Pre-requisite**: Nil**

9. Objective: To introduce different experimental techniques.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Vacuum science and technology: Introduction and basics of vacuum science, Rotary, Diffusion, Turbo molecular, Getter and Cryo pumps. McLeod, Bourdon, Diaphragm, Capacitance, Thermal conductivity gauge (pirani), Cold cathode ionization gauge (Penning), Hot cathode ionisation and Bayard Alpert gauges. Partial pressure measurement, leak detection, gas flow through pipes and apertures, effective pumping speed, vacuum components. Applications: Thermal evaporation, e-beam evaporation, Sputtering, Pulsed laser deposition	**7**
2.	Cryogenics: Properties of materials at low temperature, Cryogenic fluids, Gas liquifiers, cryogenic fluid baths, cryostat design, closed cycle He refrigerator (CCR), Single and double cycle He^3 refrigerator, He^3-He^4 refrigerator, Magnetic refrigerator, Low temperature thermometry	**5**
3.	Measurement Techniques-I: Working principles of different sensors, signal processing and lock-in detection. Photomultiplier tubes, Charge coupled devices. Principles and applications of X-ray diffraction, Superconducting Quantum interference Devices (SQUID), Vibrating sample magnetometer, Measurement of electrical conductivity in different materials- insulators, metals and semiconductors using four probe method, Electron microscopes (SEM, TEM), Energy dispersive spectroscopy, Differential thermal analysis (DTA), Thermogravimetric analysis (TGA).	**11**

4	Measurement Techniques-II: Principles and applications of LASERS, Spectrophotometer, Fourier transform-Infrared (FT-IR) spectrometer, Optical microscope,Interferometry, Photometry, Imaging techniques, Raman spectroscopy, Photoluminescence	**6**
5	Measurement Techniques-III: Properties of radiation detectors: operation mode, pulse height spectra, energy resolution, detection efficiency and dead time. Ionization chambers, Scintillation detectors: Inorganic and Organic scintillators, photomultiplier tube, Response of scintillation detectors to gamma-rays and neutrons. Application of scintillation detectors, Linear and circular accelerators, Nuclear reactor: neutron source and power generator, Applications in tracing, material modification, sterilization, material modification; neutron activation analysis, medicine: CT, PET, SPECT, MRI	**13**
	Total	**42**

11. Suggested Books.

S. No.	**Name of Authors/Book/Publisher**	**Year of Publication/Reprint**
1.	A. Roth, "Vacuum Technology", Elsevier .	1990
2	Ohring Milton, " The Materials Science of thin films", Academic Press, INC.	1991
3	G. K. White , "Experimental Techniques in Low Temperature Physics", Clarendon,	1993
4	Guglielmo Ventura & Lara Risegari " The Art of Cryogenics-Low-Temperature Experimental Techniques" Elsevier.	2008
5	A. Kent " Experimental low-temperature physics" MacMillan	1993
6	A. D. Helfrick and W.D.Cooper, "Modern Electronic Instrumentation and Measurement Techniques", PHI	1976
7	Willard, H. H., Merritt, L. L. and Dean, J. A., "Instrumental Methods of Analysis", CBS publications.	1991
8	A. Ghatak and K.Thyagarajan, Optical Electronics, C.U.P.	1989
9	Egerton, R. F., "Physical Principles of Electron Microscopy", Springer.	2008
10	Fultz, B. and Howe, J. M., "Transmission Electron Microscopy and Diffractometry of Materials", Springer.	2007
11	Culity, B. D., "Elements of X-ray Diffraction", Addison-Wesley.	2001
12	Glenn F. Knoll, "Radiation Detection and Measurement" 4th Ed.	2010
13	W.R. Leo, "Techniques for Nuclear and Particle Physics experiments", Springer-Verlag	1994

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **PHYSICS**

1. Subject Code: **PH-789** Course Title: **Mathematical and Computational Techniques**

2. Contact Hours (per week): **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 2**

4. Relative Weightage**:** **CWS: 15** **PRS: 25** **MTE: 20** **ETE: 20** **PRE: 20**

5. Credits**: 4** 6. Semester**: Autumn/Spring** 7.Subject Area**: Pre-PhD**

8.Pre-requisite**:**NIL

9. Objective: **To familiarize the students with computational techniques and train them in computing physics problems**

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Review of Legendre and associated Legendre equations, Hermite equation, Laguerre and associated Laguerre equations, Bessel's equation, Hypergeometric equations and their solutions and related properties, Green's function and Fourier transform techniques and their applications, Complex variables and evaluation of integrals	10
2.	Programming in FORTRAN or C++ language. To solve various problems of Physics utilizing the following numerical methods along with computer programming of the problem as well as running them on computers	15
3.	Numerical interpolation through Newton's formula, Lagrange's and Gauss's central difference formula. Numerical Integration by Trapezoidal, Simpson's, Gauss quadrature formulae, Numerical differentiation by Newton-Gregory forward polynomial and Spline interpolating polynomials. Matrix algebra and solution of linear equations	10
4.	Numerical solutions of differential equations using initial value problems, Runge Kutta and other methods, Least square polynomial approximation and evaluation of two to three dimensional integrals using Simpson's and Monte Carlo methods.	7
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	Arfken G. B. and Weber H. J., "Mathematical Methods for Physicists" , 5th Ed. Academic Press.	2005
2.	Whittaker E.T. and Watson E.W., "A Course of Modern Analysis", Cambridge University Press	2008
3.	Wolfram S, "The Mathematica Book," 5th Ed., Wolfram Media	2003
4.	Gerald C F and Wheatley P O, "Applied Numerical Analysis", 7th Ed, Addison Wesley	2003
5.	J M McCormick and M G Salvadori " Numerical Methods in FORTRAN" Prentice-Hall,	1964.
6.	Press, W H, Teukolsk, S A, Vetterling, W T and Flannery, B P, "Numerical Recipes in Fortran 77: The Art of Scientific Computing", Cambridge University Press; 3rd Ed.	2007