Center for Basic Sciences
Pt. Ravishankar Shukla Univesrity, Raipur(C.G.)

Program: Five Year M.Sc. Integrated (Physics Stream)

Following is the list and description of the modifications in the course structure/papers/units of the papers of Five Year M.Sc. Integrated (Physics Stream) Course

1. List of papers shifted to higher semester <u>without changing the content</u> of the paper

S. N.	Paper with code / Semester	Proposed Modified paper with code/ Semester	Justification	Remark
1.	P403 Statistical Mechanics-I (Semester IV)	P602: Statistical Mechanics-I (Semester VI)	The student will have better understanding of the paper in the higher semester where it has been shifted. The student will get benefit of acquiring necessary background knowledge required for these papers.	The content of paper has not been changed
2.	P602 Nuclear Physics-I (Semester VI)	P704: Nuclear Physics-I (Semester VII)		
3.	P701 Fluid Mechanics (Semester VII)	P802: Fluid Mechanics (Semester VIII)		
4.	P605 Nonlinear Dynamics and Chaos (Semester VI)	PE-7: Nonlinear Dynamics and Chaos (Semester X)	1. Syllabus of these papers do not have an overlap with the syllabus of CSIR-UGC (NET) EXAM (physical sciences). 2. These papers are shifted to tenth semester as elective papers. Where these paper can be offered according to the availability of instructors and minimum number of interested students to take the paper.	The content of paper has not been changed
5.	P704 Reactor Physics and Radiation Science (Semester VII)	PE-8: Reactor Physics and Radiation Science (Semester X)		
6.	P802 Accelerator Physics and Applications (Semester VIII)	PE-9: Accelerator Physics and Applications (Semester X)		
7	G202 Glimpses of Contemporary Science (Semester II) 2 credits	PE-11: Glimpses of Contemporary Science (Semester II)		
8	G502 Earth Science and Energy & Environmental Sciences (Semester V) 4 credit	PE-12: Earth Science and Energy & Environmental Sciences (Semester V)		

3. List of Papers for which credit has been modified

S. N.	Paper with code / Semester	Proposed Modified paper with code/ Semester	Justification	Remark
1.	P401 Mathematical Physics – II (Semester IV) 4 credit	P401 Mathematical Physics – II (Semester IV) 5 credit	Adding one more credit to these papers will give one hour additional contact hour per week in time-table, which is essential for achieving learning outcome goals for these papers.	
2.	P402 Quantum Mechanics – I (Semester IV) 4 credit	P402 Quantum Mechanics – I (Semester IV) 5 credit		
3.	P501 Quantum Mechanics – II (Semester IV) 4 credit	P501 Quantum Mechanics – II (Semester IV) 5 credit		
4.	P502 Classical Mechanics – II (Semester V) 4 credit	P502 Classical Mechanics – II (Semester V) 5 credit		
	P601 Electrodynamics (Semester VI) 4 credit	P601 Electrodynamics (Semester VI) 5 credit		
	P403 Statistical Mechanics-I (Semester IV)	P602 Statistical Mechanics – I (Semester VI) 5 credit		

4. List of papers with modification in its content

S. N.	Paper with code / Semester	Modified paper with code/ Semester	Justification	Remark
1.	P101(A) : Physics – I (PCM Stream) (Semester I) **UNIT- I** Mechanics: Energy, mass and momentum – evolution of the concepts and definitions. Newton's three laws of mechanics; conservative forces, potential energy functions; Conservation of mechanical energy, linear momentum and angular momentum; Applications to athletics; harmonic oscillator, inverse square law force; Kepler's laws. **UNIT- II** Elementary dynamics of rigid bodies: moment of inertia, angular momentum, rotational kinetic energy, displacement and rotation of rigid bodies. Friction, illustrations of non	P101: Introductory Physics – I (All stream) (Semester I) **UNIT - I** The Relation of Physics to Other Sciences: Chemistry, Biology, Astronomy, Geology, Psychology Conservation of Energy: What is energy?, Gravitational potential energy, Kinetic energy, Other forms of energy, Characteristics of Force: What is a force?, Friction, Molecular forces, Fundamental forces, Fields, Pseudo forces, Nuclear forces **UNIT - II** The Harmonic Oscillator: harmonic oscillator, Harmonic motion and circular motion, Initial conditions, Forced oscillations, Resonance: Complex numbers and harmonic motion, The forced oscillator with damping, Electrical resonance,	This paper has been re-structured to make a common (single) paper for 10+2 biology and mathematics background students instead of two separate	

	conservative forces. Impulse, elastic and inelastic collisions, Poisson's hypothesis, deformation energy, Karate punch. Dimensional analysis via examples illustrating Buckingham Pi theorem. **UNIT- III** Thermodynamics and kinetic theory: Thermodynamics: Basic notions of thermodynamics; Macroscopic equilibrium, quasistatic processes, reversible processes; Equation of state; Zeroth law; First law for closed systems; Notion of heat, work and internal energy; Notion of state variable and path. **UNIT- IV** Exact and inexact differentials; Ideal gas and Van der Waal's gas equation, some examples of non – pV systems (qualitative); Second law (Kelvin – Planck and Clausius statements); Carnot cycle; Entropy formulation of Second law; Third law (statement); Thermodynamic potentials. **UNIT- V** Kinetic theory: Kinetic theory of ideal gas; Kinetic interpretation of temperature; Adiabatic reversible compression; Boltzmann factor; Derivation of Maxwell's velocity distribution; Average, rms and most probable speed; Elementary theory of transport processes (viscosity, thermal conducting and diffusion coefficient); Failure of classical physics.	Resonance in nature **UNIT - III** heat: Equilibrium and the zeroth law: temperature, Calibrating temperature, Absolute zero and the Kelvin scale, Heat and specific heat, Phase change, Radiation, convection, and conduction, Heat as molecular kinetic energy, Boltzmann's constant and Avogadro's number, Microscopic definition of absolute temperature **UNIT - IV** Thermodynamics: Statistical properties of matter and radiation, Thermodynamic processes, Quasistatic processes , The first law of thermodynamics, Specific heats: c v and c p , Cycles and state variables, Adiabatic processes, The second law of thermodynamics, The Carnot engine, Defining T using Carnot engines **UNIT - V** Entropy and Irreversibility: Entropy, The second law: law of increasing entropy, Statistical mechanics and entropy, Entropy of an ideal gas: full microscopic analysis, illustration of maximum entropy principle , Gibbs formalism, third law of thermodynamics	papers. A portion of the content significantly overlaps with 10+2 (which is common for students of both the stream), to consolidate the knowledge acquired at +2 level by the students. The course is inclined towards developing the thought process to understand laws of nature.	
2.	P101(B): Physics-I (Biology Stream) (Semester I) **UNIT- I** Concepts of energy and mass, Linear kinematics and dynamics. Concept of force: Conservative and non-conservative forces, Friction. Conservation of momentum, energy, and angular momentum. Work-energy theorem, Centre of mass. **UNIT- II** Moment of inertia. Rotational kinematics and dynamics, Rigid body motion. Impulse and collisions, Central forces, Kinetic theory of gases, Equipartition of energy. **UNIT- III** Free oscillations in one, two, and many degrees of freedom. Linearity and			

	superposition principle. Normal modes; Transverse and longitudinal modes. General notion of a continuous string; Resonance; Coupled pendula and oscillators, Normal coordinates. **UNIT- IV** Probability (chance, fluctuations, random walk, probability distribution, Matter wave, Wave Packet, De-Brogle's theory, uncertainty principle); Curvilinear Coordinates. **UNIT- V** Vector calculus (differentiation and integration, gradient, divergence, curl, Green's theorem, Gauss' theorem, Stokes' theorem); Fourier series (an introduction).			
3.	P201: Physics – II (All Stream) (Semester II) **UNIT- I** Electricity and Magnetism: Electrostatics: Coulomb's law and Gauss' law; Electrostatic potential, uniqueness theorem, method of images; Electrostatic fields in matter; Conductors and insulators; Capacitors and capacitance; Electric current. **UNIT- II** Magnetostatics: Biot – Savart law, Ampere's law; Electromagnetic induction; Mutual inductance and self inductance; Magnetic fields in matter. Displacement current; Maxwell's equations; Alternating current circuits; Electric and magnetic properties of matter. **UNIT- III** Plane electromagnetic waves in vacuum; Polarisation; Energy and momentum in electromagnetic waves; electromagnetic radiation (qualitative); Dipole radiation formula; Larmor's formula for radiation due to accelerated charge (without proof); Synchrotron radiation (descriptive). **UNIT- IV** Optics: Interference of two beams and involving multiple reflections; Young's experiment, Fresnel's biprism, Lloyd's mirror. **UNIT- V** Optical instruments; Telescope and microscopes; Magnifying power and resolving power. Sources of light and spectra; Dispersion, polarisation, double refraction; Optical activity.	P201: Introductory Physics – I (All stream) (Semester II) **UNIT - I** The Electric Field: Review of key ideas, Digression on nuclear forces, The electric field E, Visualizing the field, Field of a dipole, Far field of dipole: general case, Response to a field, Dipole in a uniform field, Gauss's Law: Field of an infinite line charge, Field of an infinite sheet of charge, Spherical charge distribution: Gauss's law, Digression on the area vector dA, Composition of areas, An application of the area vector, Gauss's law through pictures, Continuous charge density **UNIT - II** Application of Gauss's Law: Applications of Gauss's law, Field inside a shell, Field of an infinite charged wire, Field of an infinite plane, Conductors, Field inside a perfect conductor, The net charge on a conductor, A conductor with a hole inside, Field on the surface of a conductor **UNIT - III** Magnetism: Experiments pointing to magnetism, Examples of the Lorentz force, the cyclotron, Lorentz force on current-carrying wires, The magnetic dipole, The DC motor, Biot-Savart Law, field of a loop, Microscopic description of a bar magnet, Magnetic field of an infinite wire, Ampere's law, Maxwell's equations (static case) **UNIT - IV** Wave Theory of Light: Interference of waves, Adding waves using real numbers, Adding waves with complex numbers, Analysis of interference, Diffraction grating, Single-slit diffraction, Understanding reflection and crystal	The course has been updated to give more emphasis on conceptual understanding of the electricity, magnetism , nature of light, optics and mechanism of human vision.	

		diffraction, Light incident on an oil slick, Normal incidence, Oblique incidence **UNIT - V** Optics: The Principle of Least Time Light, Reflection and refraction, Fermat's principle of least time, Applications of Fermat's principle, Geometrical Optics: The focal length of a spherical surface, The focal length of a lens, Magnification, Compound lenses, Aberrations, Resolving power, Color Vision: The human eye, dependence of Color intensity, Measuring the color sensation, The chromaticity diagram, The mechanism of color vision, Physiochemistry of color vision, Mechanisms of Seeing: The sensation of color, The physiology of the eye, The rod cells, The compound (insect) eye, Other eyes, Neurology of vision.		
3.	G201: Electronics & Instrumentation (Semester II) **UNIT - I** Analog electronics: Introduction to passive electronic components -resistance, capacitance, inductance; Circuit theorems: Thevenin's theorem, Norton's theorem and Maximum power transfer theorem; basic concepts of semiconductor diode and transistor; applica- tion of Bipolar Junction Transistor (BJT) biasing circuits: The CE configuration, fixed base bias, emitter bias, and potential-divider or voltage divider bias; CE amplifier, amplifier as a switch, concept of negative feedback. **UNIT - II** Principle of DC power supply; half and full wave bridge rectifier, capacitor filter – ripple factor, concept of load and line regulation, concept of constant voltage source and constant current source; concept of short circuit protection and current limit protection; Zenerregulator; concept of Switch Mode Power Supply (SMPS), power supply ICs, charge pump ICs for stepping up volt- age and for bipolar supply. **UNIT - III** Differential amplifier; Operational Amplifier (OPAMP): princi- ple, basic characteristics and parameters relevant for general use; non-inverting and in- verting amplifier, voltage follower, difference amplifier, summing amplifier, voltage controlled current source; OPAMP	G201: Electronics & Instrumentation (Semester II) **UNIT - I** The Circuit Abstraction: The Power of Abstraction, The Lumped Circuit Abstraction, The Lumped Matter Discipline, Limitations of the Lumped Circuit Abstraction, Practical Two-Terminal Elements, Batteries, Linear Resistors, Associated Variables Convention, Ideal Two-Terminal Elements, Ideal Voltage Sources, Wires, and Resistors, Element Laws, The Current Source, Another Ideal Two-Terminal Element, Modeling Physical Elements, Signal Representation, Analog Signals, Digital Signals, Value Discretization **UNIT - II** Resistive Networks: Terminology, Kirchhoff's Laws, KCL, KVL, Circuit Analysis: Basic Method, Single-Resistor Circuits, Quick Intuitive Analysis of Single-Resistor Circuits, Energy Conservation, Voltage and Current Dividers, Intuitive Method of Circuit Analysis: Series and Parallel Simplification, Circuit Examples, Dependent Sources and the Control Concept Circuits with Dependent Sources, A Formulation Suitable for a Computer Solution Network Theorems: The Node Voltage, The Node Method, Floating Independent Voltage Sources, Dependent Sources and the Node Method, The Conductance and Source Matrices, Loop Method, Superposition,	This course has been updated to provide theoretical understanding of functionality of electronic components in circuitry and develop their thought process for the instrumentation.	

	comparator, Schmidt trigger; Digital to Analog Converter (DAC) with weighted resistance and R-2R ladder network; Anlog to Digital Converter (ADC); filters: low pass, high pass; band pass; Butterworth filter. **UNIT-IV** Digital electronics: Review of basic logic gates; DeMorgan's theo-rem, Use of NAND / NOR as universal building blocks; arithmetic circuits; binary addition, half adder, full adder, binary subtraction - 1s and 2s complement, controlled inverter, adder / subtracter, parity checker; Flip-Flops (FF): RS-FF, D-FF, JK-FF; counters and shift registers: binary counter, ripple counter. UNIT-V Basic concepts of instrumentation, generalized instrumentation systems block diagram representation; Sensing elements: electrodes and transducers. Electrode-electrolyte interface, stability of electrode potentials, circuit models, external and internal electrodes, pH, pO_2 and pCO_2 electrodes. Transducer, definition, types, displacement, velocity, acceleration, pressure, temperature vibration, ultrasound etc., calibration, sensitivity and resolution.	Superposition Rules for Dependent Sources, Thevenin's Theorem and Norton's Theorem, The Thevenin Equivalent Network, The Norton Equivalent Network, UNIT - III Number Systems and Codes: Decimal Odometer, Binary Odometer, Number codes, Binary-to-Decimal conversion, Decimal-to-Binary conversion, Hexadecimal Numbers, Hexadecimal-to-Binary conversion, Binary-to-Hexadecimal conversion, Decimal-to-Hexadecimal conversion, BCD Numbers, ASCII code Digital electronics: Review of basic logic gates; DeMorgan's theorem, Use of NAND / NOR as universal building blocks; arithmetic circuits; binary addition, half adder, full adder, binary subtraction - 1s and 2s complement, controlled inverter, adder / subtracter, parity checker UNIT - IV Introduction to measurements: Measurement units, Measurement system applications, Elements of a measurement system, Choosing appropriate measuring instruments Instrument types and Performance Characteristics: Review of instrument types, Active and passive instruments, Null-type and deflection-type instruments, Analogue and digital instruments, Indicating instruments and instruments with a signal output, Smart and non-smart instruments Static characteristics of instruments: Accuracy and inaccuracy (measurement uncertainty), Precision/ repeatability/ reproducibility, Tolerance, Range or span, Linearity, Sensitivity of measurement, Threshold, Resolution, Sensitivity to disturbance, Hysteresis effects, Dead space Dynamic characteristics of instruments: Zero order instrument, First order instrument, Second order instrument, Necessity for calibration UNIT - V Errors during the Measurement Process: Sources of systematic error, System disturbance due to measurement, Errors due to environmental inputs, Wear in instrument components, Connecting leads, Reduction of systematic errors, Careful instrument design, Method of opposing inputs, High-gain8 feedback, Calibration, Manual correction of output reading, Intelligent instruments, Quantification of systematic errors, Random errors, Statistical analysis of measurements subject		

		to random errors, Graphical data analysis techniques – frequency distributions, Aggregation of measurement system errors, Combined effect of systematic and random errors, Aggregation of errors from separate measurement system components, Total error when combining multiple measurements Calibration of Measuring Sensors and Instruments: Principles of calibration, Control of calibration environment, Calibration chain and traceability, Calibration records		
4.	P402: Quantum Mechanics – I (Semester IV) **UNIT- I** Origins of quantum theory (short version); Wave – particle duality, wave packets, uncertainty relation; Time dependent and time independent Schrödinger equation; Interpretative postulates; Hermitian operators, eigenfunctions and eigenvalues; nodal lines and domains; Orthonormality and completion. **UNIT- II** Energy and momentum eigenfunctions; Illustrative one dimensional phenomena (short revision if done in an earlier semester) rigid box; square well and barrier; Linear harmonic oscillator (detailed treatment). **UNIT- III** Abstract vector space formulation of quantum mechanics; Hilbert space, Dirac notation; Hermitian and unitary operators, momentum space representation; Schrödinger and Heisenberg pictures; Linear Harmonic oscillator (matrix theory). **UNIT- IV** Schrödinger equation for a central potential; Orbital angular momentum eigenfunctions (spherical harmonics) and eigenvalues; Bound state solution of Schrödinger equation for Coulomb potential, Hydrogen atom orbits and energies, degeneracy; Electron spin; Addition of two angular momenta, Clebsch – Gordon coefficients. **UNIT- V** **Approximation methods:** stationary perturbation theory (non – degenerate and degenerate); Stark effect; Zeeman effect; Time dependent perturbation theory;	P402: Quantum Mechanics – I (Semester IV) **UNIT - I** Quantum Mechanics: The Main Experiment, Double-slit experiment with light, Trouble with Maxwell, Digression on photons, Photoelectric effect, Compton effect, Matter waves, Photons versus electrons, The Heisenberg uncertainty principle, states of position and momentum in QM, Heisenberg micro- scope, The wave function Ψ, Collapse of the wave function **UNIT - II** The Wave Function and Its Interpretation, Probability in classical and quantum mechanics, Statis- tical concepts: mean and uncertainty, Quantization and Measurement, More on momentum states, Single-valuedness and quantization of momentum, Quantization, The integral of Ψ p (x), Measurement postulate: momentum An example solvable by inspection, Using a normalized Ψ, Finding A(p) by computation, Fourier's theorems **UNIT - III** Measurement postulate: general, More than one variable, States of Definite Energy, Free particle on a ring, Analysis of energy levels: degeneracy, Particle in a well, The box: an exact solution, Energy measurement in the box **UNIT - IV** Scattering and Dynamics, Quantum scattering (1-D), Scattering for $E > V_0$ Scattering for $E < V_0$, Tunneling, Quantum dynamics, A solution of the time dependent Schrödinger equation, Derivation of	Syllabus has been updated to give more emphasis on developing the foundations of quantum mechanics	

	Harmonic perturbations, transition probability (Fermi's golden rule).	the particular solution Ψ E (x, t), Special properties of the product solution, General solution for time evolution, Time evolution: a more complicated example UNIT - V Discussion on postulates of quantum mechanics, Eigenvalue problem, The Dirac delta function and the operator X, Postulates: final. Many particles, bosons, and fermions, Identical versus indistinguishable, Implications for atomic structure, Energy-time, uncertainty principle Time-Independent Schrödinger Equation: Stationary States, The Infinite Square Well, The Harmonic Oscillator, Algebraic Method, Analytic Method, The Free Particle, The Delta-Function Potential, Bound States and Scattering States, The Delta-Function Well, The Finite Square Well		
5.	PCB 401(A): Physical and Chemical Kinetics (semester IV) UNIT- I **Basic Concepts:** Rate, order and molecularity of a reaction, First, second and third order reactions – effect of concentration on reaction rate, rate expressions and integrated form, pseudounimolecular and second order autocatalytic reactions, nth order reaction of a single component, effect of temperature on reaction rate – Arrhenius equation and activation energy. UNIT- II **Complex Reactions:** parallel first order reactions, series first order reactions – determination of rate constants by graphical method and the time ratio method. The stationary state, radioactive decay, general first order series and parallel reactions. Competitive, consecutive second order reactions, reversible reactions, equilibrium from the kinetic view point, complex mechanisms involving equilibria. UNIT- III **Kinetic Measurements:** Experimental determination of reaction rates and order of reactions – correlation of physical properties with concentrations, reactions in the phase, reactions at constant pressure, fractional-life period method, initial rate as a function of initial concentrations.	PCB 401: Physical and Chemical Kinetics (semester IV) UNIT - I Basic Concepts: Rate, order and molecularity of a reaction, Specific rate and specific rate constant, First, second and third order reactions – effect of concentration on reaction rate, rate expressions and integrated form, pseudo-unimolecular, nth order reaction of a single component. UNIT - II Kinetic Measurements:Experimental determination of reaction rates and order of reactions, Integrated rate method, Vant Haff differential rate method, Graphical method, Half life method, Ostwald dilution law method, initial rate as a function of initial concentrations. Order of complex reaction, Steady State approximation method, Equilibrium method, relaxation methods for fast reaction UNIT - III Factors Affecting Reaction Rate: Effect of temperature on reaction rate – Arrhenius equation and activation energy, temperature coefficient theory, overall rate constant, overall activation energy, overall pre-exponential factor, effect of ionic strength on reactions between ions, kinetic salt effect, effect of solvent on ionic reaction, dielectric constant, linear free	Syllabus has been updated to make this paper suitable for all the streams.	

	UNIT- IV **Reactions in Solutions:** General Properties, Phenomenological theory of reaction rates, Diffusion limited rate constant, Slow reactions, Effect of ionic strength on reactions between ions, Linear free energy relationships, Relaxation methods for fast reactions. UNIT- V **Catalysis:** Homogeneous catalysis in gas phase, in solution, basis of catalytic action, catalysis and the equilibrium constant, acid base catalysis, The Bronsted catalysis law, linear free energy changes, general and specific catalysis. Heterogeneous catalysis. Negative catalysis and inhibition, Surface reactions – effect of temperature and nature of surface. Industrial catalysis.	energy relationship UNIT - IV Complex Reactions: Kinetics of parallel first order reaction, Wegscheider Test, kinetics of reversible reaction/opposing reaction, kinetics of consecutive reaction, kinetics of photochemical reaction, radioactive decay, complex mechanisms involving equilibria. UNIT - V Catalysis:Homogeneous catalysis, basis of catalytic action, catalysis and the equilibrium constant, Michaelis-Menten kinetics, acid base catalysis, the Bronsted catalysis law,negative catalysis and inhibition,heterogeneous catalysis, surface reactions – effect of temperature and nature of surface		
6.	P501: Quantum Mechanics – II (semester V) UNIT- I Collision theory: Scattering cross section; Scattering by spherically symmetric potential; Differential cross section, phase shift; Scattering by rigid sphere; Born approximation. **UNIT- II** Path integral formulation of quantum mechanics; The WKB approximation, solution near a turning point, the connection formulas; Tunnelling through a barrier; The adiabatic approximation. **UNIT- III** Variational method, expectation value of energy, application to excited states, ground state of He-atom, Zero point energy of one dimensional harmonic oscillator, Vander-waals interaction. **UNIT- IV** Foundations (Introductory ideas): The EPR paradox, quantum entanglement; Bell's theorem, the No-clone theorem, Schrodinger's cat; Decoherence, quantum Zeno paradox. UNIT- V Symmetry in quantum mechanics; Translation, rotation and space inversion operators; Identical particles; Symmetrical and anti-symmetrical wave functions; Spin – statistics connection (empirical); Density matrix; Equation of motion of density matrix	P501: Quantum Mechanics – II (semester V) UNIT - I Formalism of quantum mechanics: Hilbert Space, Observables, Hermitian Operators, Determinate States, Eigenfunctions of a Hermitian Operator, Discrete Spectra, Continuous Spectra, Generalized Statistical Interpretation, The Uncertainty Principle, Proof of the Generalized Uncertainty Principle, The Minimum-Uncertainty Wave Packet, The Energy-Time Uncertainty Principle, Vectors and Operators, Bases in Hilbert Space, Dirac Notation, Changing Bases in Dirac Notation Quantum Mechanics in Three Dimensions: The Schröger Equation, Spherical Coordinates, The Angular Equation, The Radial Equation, The Hydrogen Atom, The Radial Wave Function, The Spectrum of Hydrogen, Angular Momentum, Eigenvalues, Eigenfunctions, Spin, Spin 1/2, Electron in a Magnetic Field, Addition of Angular Momenta, Electromagnetic Interactions, Minimal Coupling, The Aharonov-Bohm Effect UNIT - II Identical Particles: Two-Particle Systems, Bosons and Fermions, Exchange Forces, Spin, Generalized Symmetrization Principle, Atoms, Helium, The Periodic Table, Solids, The Free Electron Gas, Band Structure UNIT - III Time-Independent Perturbation Theory: Nondegenerate Perturbation Theory,	Syllabus has been updated to give more emphasis on the application of quantum mechanics	

		General Formulation, First-Order Theory, Second-Order Energies, Degenerate Perturbation Theory, Two-Fold Degeneracy, "Good" States, Higher-Order Degeneracy, The Fine Structure of Hydrogen, The Relativistic Correction, Spin-Orbit Coupling, The Zeeman Effect, Weak-Field Zeeman Effect, Strong-Field Zeeman Effect, Intermediate-Field Zeeman Effect, Hyperfine Splitting in Hydrogen. **UNIT - IV** The Variational Principle: Theory, The Ground State of Helium, The Hydrogen Molecule Ion, The Hydrogen Molecule The WKB Approximation, The "Classical" Region, Tunneling, The Connection Formulas **UNIT - V** Scattering: Classical Scattering Theory, Quantum Scattering Theory, Partial Wave Analysis, Formalism, Strategy, Phase Shifts, The Born Approximation, Integral Form of the Schrödinger Equation, The First Born Approximation, The Born Series		
7.	H 601(A) Ethics of Science and IPR (Semester VI) Introduction to a Collective, Participatory Teaching-learning Program: A Science of Our own. Science Stands the Test of Ethics ... Some indicators. Levels of Moral Development - Does it mean anything? Medical Ethics: Different themes pertaining to medical ethics including ethical issues in public health. History, Philosophy and Psychology of Ethics: History of Political Economy and Modern Ethics. Environmental Ethics. Intellectual Property Rights and Associated Issues: History of Patenting. Digitalizing Culture-I: Free Software and Free Culture. Digitalizing Culture-II: Concentration and appropriation of Power by the few as well as Possibility of Distributive Justice. Journals and Publishers: Monopolistic practices by Academic Publishers. Quest for Determining what is Virtuous: Ethics in Practice. Collaborative Projects by the Class. Teaching the Teachers	H 601 Ethics of Science and IPR (Semester VI) **UNIT - I** Introduction to Ethics– causes of unethical acts, Definition – moral, values, ethics; Role and importance of ethics in science; Professional ethics – professional conduct, Teaching ethical values to scientists, good laboratory practices, good manufacturing practices, Basic Approaches to Ethics; Posthumanism and Anti-Posthumanism. **UNIT - II** Medical Ethics: Different themes pertaining to medical ethics including ethical issues in public health. Environmental Ethics, Bioethics, Journals and Publishers: Monopolistic practices by Academic Publishers. Plagiarism, softwares for plagiarism detection. **UNIT- III** Introduction to IPR; Types of Intellectual property – Patents, Trademarks, Copyrights and related rights; Traditional vs. Novelty; Importance of intellectual property rights in the modern global economic environment, Importance of intellectual property rights in India. **UNIT - IV** Patents: Definition, patentable and non patentable inventions; types of patent application – Ordinary, Conventional, PCT,	Syllabus has been updated to make it suitable for all the streams	

	and other Virtuous Inquiries.	Divisional, and Patent of addition; Concept of Prior Art; Precautions while patenting disclosure / nondisclosure; **UNIT - V** Case studies and agreements - Evolution of GATT and WTO and IPR provisions under TRIPS; Madrid agreement; Hague agreement; WIPO treaties; Budapest treaty; Indian Patent Act (1970)		
8.	P702: Quantum Mechanics – III (semester VII) **UNIT- I** Relativistic Equations: Lorentz transformations, covariant notation, Klein – Gordon equation, difficulties with probability interpretation of one – particle K-G equation; Dirac equation; Properties of γ matrices. **UNIT - II** Dirac equation in external electromagnetic field; Non – relativistic reduction; Gyrofactor for spin; Lorentz covariance of Dirac equation; Bilinear covariants. **UNIT - III** Solutions of Dirac equation: Plane wave solutions; Negative energy solutions; Hole theoretic interpretation; Spin; Dirac momentum space spinors; Orthonormality and completeness relations; Projection operators for energy, helicity and spin; Trace theorems; Exact solution of Dirac equation for Coulomb potential; Energy levels of Hydrogen atom in Dirac theory; Fine structure splitting; Relativistic corrections and Lamb shift. **UNIT - IV** Introduction to quantum field theory: Lagrangian field theory, symmetry and conservation laws, Klein – Gordon field (real and complex); Covariant commutators, the K-G propagator; Dirac field; Anti-commutation relations, the Fermion propagator; Electromagnetic field; Covariant quantisation, the photon propagator. **UNIT - V** Feynman rules for QED: Dyson expansion of S – matrix; Feynman diagrams in momentum space, Feynman rules, QED processes in lowest order.	P702: Quantum Mechanics – III (semester VII) **UNIT - I** Foundations (Introductory ideas): The EPR paradox, quantum entanglement; Bell's theorem, the No-clone theorem, Schrodinger's cat; Decoherence, quantum Zeno paradox. **UNIT - II** Symmetry and Conservation Laws: Transformation of the Wave Function under Coordinate Transformations, Group of Symmetry of the Schrödinger Equation and the Conservation Laws, Homogeneity of Time and Space: Conservation of Energy and Momentum, Isotropy of Space: Conservation of Angular Momentum, Symmetry of the Hamiltonian and Degeneracy, Space Inversion Symmetry, Time Reversal Symmetry and Time Reversal Operator Kramers' Degeneracy and Kramers' Theorem **UNIT - III** Relativistic Wave Equations: Generalization of the Schrödinger Equation, the Klein-Gordon equation, Plane Wave Solutions, Charge and Current Densities, Interaction with Electromagnetic Fields, Hydrogen-Like Atom, Nonrelativistic Limit **UNIT - IV** The Dirac equation, Dirac's Relativistic Hamiltonian, Position Probability Density, Expectation Values, Dirac Matrices Plane Wave Solutions of the Dirac Equation; Energy Spectrum The Spin of the Dirac Particle, Significance of Negative Energy States; Dirac Particle in Electromagnetic Fields, **UNIT - V** Relativistic Electron in a Central Potential: Total Angular Momentum, Radial Wave Equations in Coulomb Potential, Series Solutions of the Radial Equations: Asymptotic Behaviour, Determination of the Energy Levels, Exact Radial Wave Functions, Comparison to Non-Relativistic Case, Electron in a Magnetic Field - Spin	The syllabus has been updated to develop an course for relativistic quantum mechanics and develop foundations to study Quantum Field Theory	

		Magnetic Moment, The Spin Orbit Energy		
9.	P801: Astronomy and Astrophysics (semester VIII) **UNIT-I** Stellar Physics: Equations governing the structure of stars: Mechanical & Thermal equilibrium. Virial theorem. Modes of energy transfer in stars: radiative & convective transport of energy. Auxiliary input: equation of state, opacity and energy generation by thermonulcear processes. Boundary conditions at the stellar surface & at the centre. **UNIT-II** Models with linear & quadratic density profiles. Polytropic models. Mass-luminosity-radius relations for low, intermediate & high mass stars. Sources of opacity and nucleosynthesis in stars. Manufacturing of iron-peak and heavier elements by rapid neutron capture processes. Mixing length theory of convective transport of hear. Completely convective stars. Hertzsprung-Russel diagram. Pre-main sequence contraction and the Hayashi phase. Zero-age main sequence. UNIT-III Stellar evolution: main sequence, red giant and asymptotic giant branch. Advanced stages of stellar evolution: white dwarfs, neutron stars & black holes. Physics and astrophysics of collapsed objects: pulsars, X-ray &gamma ray sources. Spherical accretion and Bondi solution. Physics of accretion discs. Stellar rotation and magnetism. **UNIT-IV** Galactic Physics: Units in astronomy, co-ordinate system, multi-wavelength sky (radio, IR, Optical, UV, X-ray, Gamma ray), distance ladder, Milkyway Galaxy, interstellar medium, basics of star formation, spiral and elliptical galaxies (morphology, content and kinematics), evidences for dark matter, . astronomy and society (including citizen science), constraints and prospects of astronomy and astrophysics research in India. UNIT-V AGNs, evidences for supermassive black holes, M-sigma and similar correlations, radio galaxies, synchrotron radiation, accretion onto black hole, physical processes behind black holegalaxy co-evolution (merger, infall and feedback), clusters of galaxies (contents and	P801: Astronomy and Astrophysics - II (semester VIII) **UNIT - I** Stellar Physics: Equations governing the structure of stars: Mechanical & Thermal equilibrium.Virial theorem. Modes of energy transfer in stars: radiative & convective transport of energy. Auxiliary input: equation of state, opacity and energy generation by thermonulcear processes. Boundary conditions at the stellar surface & at the centre.The main sequence, Stellar energy sources, Gravitational potential energy of a sphere, Gravitational lifetime for a star, Other energy sources, Nuclear energy for stars, Overcoming the fusion barrier, Stellar structure, Hydrostatic equilibrium, Energy transport, Stellar models, Solar neutrinos **UNIT - II** Stellar old age, Evolution off the main sequence, Low mass stars, High mass stars, Cepheid variables Variable stars, Cepheid mechanism, Period–luminosity relation, Planetary nebulae, White dwarfs, Electron degeneracy, Properties of white dwarfs, Relativistic effects **UNIT - III** The death of high mass stars, Supernovae , Core evolution of high mass stars, Supernova remnants Neutron stars, Neutron degeneracy pressure , Rotation of neutron stars, Magnetic fields of neutron stars, Pulsars, Discovery of Pulsars, What are pulsars? , Period changes, Pulsars as probes of inter-stellar space, Stellar black holes **UNIT - IV** THE MILKY WAY - OUR GALAXY: An overview of the Milky Way, The mass of the Milky Way, The disc of the Milky Way, The stellar halo and bulge of the Milky Way, The formation and evolution of the Milky Way, NORMAL GALAXIES: The classification of galaxies, The determination of the properties of galaxies, The determination of the distances of galaxies, The formation and evolution of galaxies. ACTIVE GALAXIES: The spectra of galaxies, Types of active galaxies, The central engine, Models of active galaxies, Outstanding issues UNIT - V Cosmology, The scale of the universe,	The course structure has been modified to have two papers of Astronomy and Astrophysics (P701 and P801) Syllabus of this paper has been modified accordingly.	

	kinematics), high redshift galaxies, cosmic evolution of galaxies and black holes, hierarchical structure formation, cosmic-web, GMRT	Expansion of the universe, Olbers's paradox Keeping track of expansion, Cosmology and Newtonian gravitation, Cosmology and general relativity, Geometry of the universe, Cosmological redshift, Models of the universe, Is the universe open or closed?		

5. List of paper with only change in the name of paper code

S. N.	Paper with code / Semester	Modified paper with code/ Semester	Justification	Remark
1.	H302 (A): History and Philosophy of Science (semester III)	H302: History and Philosophy of Science (semester III)	The syllabus of H302 (A) is suitable for all the stream. The paper code has been changed accordingly.	Syllabus not changed

6. List of modifications in Additional/ Core papers of communication skills (English / Hindi/ Communication Skill Lab)

The following papers has been listed for completeness the syllabus will be modified by relevant board of studies

S. N.	Paper with code / Semester	Proposed Modified paper with code/ Semester	Justification	Remark
1.	CH101: Creative Hindi (Semester I) Additional Paper 2 credit	H101: Communication Skills 2 credit	CH101 Additional paper has been merged in H101	The syllabus is to be approved by relevant board of studies
2.	H201 Communication Skills Lab (Semester II) 2 credit Additional Paper	H201 Communication Skills Lab (Semester II) 2 credit	To give more importance to the development of communication skills of the students H201 has been made a core paper	
3.	H301: World Literature (semester III) 2 credit	H301: Creative Hindi (semester III) 2 credit	To develop communication skills of the students in Hindi	
4.	H401 Communication Skills Lab -II (semester -IV) 2 credit Additional paper	H401 Communication Skills Lab -II (semester -IV) 2 credit	To give more importance to the development of communication skills of the students H401 has been made a core paper	
5.	H501: Scientific Writing (semester - V) 2 credit Additional Paper	H501: Scientific Writing in Hindi (semester - V) 2 credit	To develop science communication skills of students in Hindi the paper	

			has been made a core paper	
6.	H602: Scientific Writing Lab (semester - VI) 2 credit Additional Paper	H602: Scientific Writing in English (semester - VI) 2 credit	To develop science communication skills of students in English the paper has been made a core paper	