Bachelor of Science
B.Sc. Physics (Semester -V)

Course Code	US05CPHY51	Title of the Course	Classical Mechanics
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	1. To provide training of the generalized coordinates to deal with mechanics of classical systems through Lagrangian formulation. 2. To create awareness about rotating co-ordinate systems and its application to study the motion of Earth, rigid body motions, motion of symmetric top etc. 3. To provide an exposure to the mathematical techniques of calculus of variation and its applications to physical systems through Lagrangian and Hamiltonian method.

Course Content

Unit	Description	Weightage* (%)
1.	**Lagrangian Formulation** Constraints, Generalized co-ordinates, D'Alembert's principle, Lagrange's equations, A General expression for kinetic energy, Symmetries and the laws of conservation, Cyclic or Ignorable coordinates, Illustrations, Velocity dependent potential of electromagnetic field, Rayleigh's dissipation function [Introduction to Classical Mechanics by R G Takwale & P S Puranik: 8.1, 8.2, 8.3, 8.4, 8.5, 8.6, 8.7, 8.8, 8.9]	25%
2.	**Moving coordinate systems and motion of a rigid body** Coordinate systems with relative translation motions, Rotating coordinate systems, The Coriolis force, Motion on the earth, Effect of Coriolis force on freely falling particle, Euler's Theorem, Angular momentum and kinetic energy, The inertia tensor, Euler's equations of motion, Torque free motion, Euler's angles, Motion of a symmetric top [Introduction to Classical Mechanics by R G Takwale & P S Puranik: 9.1, 9.2, 9.3, 9.4, 9.5, 10.1, 10.2, 10.4, 10.5, 10.6, 10.7]	25%
3.	**Variational Principle** Configuration space, Some techniques of calculus of variation, The δ Notations, Applications of the variational principle, Hamilton's principle, Equivalence of Lagrange's and Newton's equations, Advantages of the Lagrangian Formulation – Electro–Mechanical analogies, Lagrange's undetermined multipliers, Lagrange's equations for Non holonomic systems, Applications of the Lagrangian method of undetermined multipliers [Introduction to Classical Mechanics by R G Takwale & P S Puranik: 11.1, 11.2, 11.3, 11.4, 11.5, 11.6, 11.7, 11.8, 11.9]	25%

4.	**Hamiltonian Formulation** Hamilton's equations of motion, Some applications of the Hamiltonian formulation, Phase Space, Comments on the Hamiltonian formulation, Gauge Transformation, Canonical transformation, Conditions for transformation to be Canonical, Illustrations of Canonical transformations, Poisson brackets [Introduction to Classical Mechanics by R G Takwale & P S Puranik: 11.10, 11.11, 11.12, 11.13, 12.1, 12.2, 12.3, 12.4, 12.5]	25%

Teaching-Learning Methodology	Direct Teaching through Chalk-Walk and Talk ICT enabled teaching Question-Answer Class discussion led by teacher/students Case Studies Literature review Problem solving activities Debate Collaborative and Co-operative Learning Think Pair Share Jigsaw Inquiry Based Learning Panel Discussion Project Based Learning Flipped Classroom Blended Learning designs Concept Mapping

Evaluation Pattern

Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	At the end of the course students will be able to understand the generality of generalized coordinates and will be able to apply for the study of the mechanics of classical systems.
2.	Students will be able to understand the effect of rotational motion of the earth and its effect on weather conditions.
3.	They will get an idea of inertia and symmetry of rigid bodies, variational method for motion of the system as another formulation to solve mechanical problems.
4.	Students will be able to understand the production of Hamiltonian function and use of Lagrangian and Hamiltonian formulation for the study related to motion of classical systems.

Suggested References:	
Sr. No.	References
1.	Introduction to Classical Mechanics R G Takwale and P S Puranik Tata McGraw Hill Education Pvt Ltd.
2.	Classical Mechanics Herbert Goldstein, Charles P. Poole and John Safko Third Edition, Pearson
3.	Classical Mechanics Aruldhas PHI Learning Pvt Ltd, New Delhi

On-line resources to be used if available as reference material
On-line Resources
https://www.google.com/search?q=Lagrangian+formulation&source=lnms&sa=X&ved=0ahUKEwiEjaPe1rHuAhVrFLcAHc2ZA18Q_AUICigA&biw=1094&bih=472&dpr=1.25 https://en.wikipedia.org/wiki/Hamiltonian_mechanics

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Bachelor of Science
B.Sc. Physics (Semester - V)

Course Code	US05CPHY52	Title of the Course	Mathematical Methods
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	1. To provide the concept of generalized curvilinear coordinates and their vector differential operators and its deduction for the cases of rectangular, cylindrical and spherical coordinates. 2. To provide the basic definition and applications of Beta, Gamma and harmonic functions to solve physical problems. 3. To train the students in the applications of Fourier series for solving certain special classes of physical problems. 4. To provide various numerical techniques useful for the scientific data analysis as well as to train how to find the differentiation and integration of numerical data.

Course Content

Unit	Description	Weightage* (%)
1.	**Curvilinear Co-ordinate System and Beta, Gamma Functions** **Curvilinear Coordinate System:** Curvilinear Coordinates, Orthogonal curvilinear coordinates, Condition for orthogonality, Reciprocal sets of two triads of mutually orthogonal vectors, Gradient in terms of orthogonal curvilinear coordinates, Divergence in terms of orthogonal curvilinear coordinates, Curl in terms of curvilinear coordinates, Laplacian in terms of orthogonal curvilinear coordinates, Equivalent expression for $\boldsymbol{\nabla}\emptyset, \boldsymbol{\nabla}\cdot\boldsymbol{F}$ and $\boldsymbol{\nabla}\times\boldsymbol{F}$ (gradient, div and curl) in rectangular coordinates, Cylindrical coordinates as a special curvilinear system, Spherical polar coordinates as a special curvilinear system, Related Numerical, **Beta, Gamma Functions** Definitions, Fundamental property of Gamma Functions, Transformation of Gamma Function, Relation:$\beta(m,n)=\beta(n,m)$, Different forms of Beta function, Relation between Beta and Gamma Functions [Mathematical Physics by B.D.Gupta (4^{th} Edition): 1.36, 1.37, 1.38, 1.39, 1.40, 1.41, 1.42, 1.43, 1.44, 1.45, 1.46, 6.1, 6.2, 6.4, 6.5, 6.6, 6.7]	25%
2.	**Harmonics with Special Functions** Legendre differential equation(Solution in descending power of *x*), Legendre polynomials(without corollary), Generating functions for $P_n(x)$, Recurrence formulas for $P_n(\mu)$, Rodrigue's formula, Orthogonal properties of Legendre polynomials of the first kind, Bessel's differential equation, Generating functions for$J_n(x)$, Recurrence formula for $J_n(x)$, Orthogonal properties of Bessel's polynomials, Hermite's differential equation, Hermite polynomials, Recurrence formula for $H_n(x)$, Orthogonal properties of Hermite polynomials [Mathematical Physics by B.D.Gupta (4^{th} Edition):8.3A, 8.3B, 8.3C, 8.3E, 8.3f$_2$, 8.3G, 8.4A, 8.4B, 8.4D, 8.4E, 8.7A, 8.4B, 8.4D, 8.4F]	25%

3.	**Fourier series, Diffusion Equation and Wave Equation** Definition and expansion of a function of x, Complex representation of Fourier's series, Physical application of Fourier's series: Fourier series involving phase angles, Effective values and the average of a product, Thermal state, Transverse vibration of a string, Diffusion equation or Fourier equation of heat flow, Independent derivation of one dimensional diffusion equation, Solution of one dimensional diffusion equation when both the ends of a bar at temperature zero, Two-dimensional diffusion equation, **The Wave Equations:** Derivation of one-dimensional wave equation, Derivation of Two-dimensional wave equation, Related Numerical [Mathematical Physics by B.D.Gupta (4^{th} Edition): 9.1, 9.4, 9.9, 9.9(1), 9.9(2), 9.9(3), 9.9(4), 12.2, 12.3A, 12.3B(b_1), 12.4, 12.10A, 12.10B]	25%
4.	**Numerical Techniques** **Curve Fitting:** Introduction, **The Least squares method**: Fitting a straight line, Fitting a parabola, Fitting a curve of the form $y = ax^b$, Fitting an exponential curve$y = ae^{bx}$ **Interpolation:** Introduction, Finite difference operator: Forward, Backward and Central Differences, Shift, Average and Differential operator, Newton's forward difference interpolation formula, Newton's backward difference interpolation formula, Lagrange's interpolation formula **Numerical differentiation and integration:** Differentiation using difference operators (Forward and Backward), Newton-Cotes Integration formula, The Trapezoidal Rule, Simpson's (1/3) Rule, Related Numerical [Numerical Methods for Scientists and Engineers by K Sankara Rao (3^{rd} Edition): 5.1, 5.3, 5.3.1, 5.3.2, 5.3.3, 5.3.4, 6.1, 6.2, 6.2.1, 6.2.2, 6.2.3, 6.3, 6.4, 6.5, 7.1, 7.2, 7.6, 7.6.1, 7.6.2]	25%

Teaching-Learning Methodology	Direct Teaching through Chalk-Walk and Talk ICT enabled teaching Question-Answer Class discussion led by teacher/students Case Studies Literature review Problem solving activities Debate Collaborative and Co-operative Learning Think Pair Share Jigsaw Inquiry Based Learning Panel Discussion Project Based Learning Flipped Classroom Blended Learning designs Concept Mapping

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: At the end of course, students will be expected to have learnt	
1.	The general features of curvilinear coordinate systems and its deductions to any particular coordinate system.
2.	The importance of some special harmonic functions and their properties.
3.	How Fourier series can be applied to solve certain types of differential equations.
4.	The students will be able to apply the numerical methods for solving various physical problems which are difficult to study analytically as well as how to analyze the experimental data.

Suggested References:	
Sr. No.	References
1.	Mathematical Physics B D Gupta (4th Edition) Vikas Publishing House Pvt. Ltd.
2.	Mathematical Methods in Physical Science Mary L Boas (2nd Edition) John Wiley & Sons
3.	Mathematical Methods for Physics George B. Arfken and Hans J. Weber (4th Edition) Academic Press, INC
4.	Numerical Methods for Scientists and Engineers K Sankara Rao (3rd Edition) PHI Learning Pvt. Ltd.

5.	Numerical Methods E Balagurusamy Tata McGraw Hill Publishers
6.	Numerical Mathematical Analysis J B Scarborough Oxford & IBH Publishing Pvt. Ltd.

On-line resources to be used if available as reference material
On-line Resources
https://en.wikipedia.org/wiki/Curvilinear_coordinates https://en.wikipedia.org/wiki/Beta_function https://en.wikipedia.org/wiki/Legendre_polynomials https://en.wikipedia.org/wiki/Bessel_function https://en.wikipedia.org/wiki/Fourier_series

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Bachelor of science
B.Sc. Physics Semester-5

Course Code	US05CPHY53	Title of the Course	Thermodynamics and Statistical Mechanics
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	1. To provide the fundamentals of thermodynamics and their applications to study of thermal characteristics of different states of matter. 2. To provide the fundamental concept of Classical Statistical Mechanics. 3. To create awareness about the importance of partition functions and statistical distribution of particles for the better understanding of many body systems.

Course Content		
Unit	Description	Weightage* (%)
1.	**Thermodynamical Laws and Entropy** Thermodynamical laws: Refrigerator, Clausius statement of the second law, Carnot's theorem and corollary, Kelvin temperature scale, Absolute zero, Equality of ideal gas temperature and Kelvin temperature. Entropy: Clausius' theorem, Entropy and the mathematical formulation of the second law, Entropy of an ideal gas, T – S diagram, Entropy and reversibility, Entropy and irreversibility, Entropy and non equilibrium states, Principle of increase of entropy, Application of the entropy principle, Entropy and unavailable Energy, Entropy and disorder, Entropy and direction, Absolute entropy, First-order Transition, Clapeyron's equation, Second-order Transition, Ehrenfest's equations Heat and Thermodynamics By: M W Zemansky 1.5,4.4,7.5,7.6,9.4,9.5,9.6,9.7,10.1,10.2,10.4,10.5,10.6,10.7,10.8,10.9, 10.10,10.11,10.12,10.13,15.1,15.6,16.20	25
2.	**Heat and Thermodynamics** Properties of pure substances: T-S diagram for a pure substance, Gibb's U-V-S surface, Enthalpy, Helmholtz function, Gibb's function, Names and symbols for the thermodynamic functions. Applications of Thermodynamics to pure substances: Two mathematical theorems, Maxwell's equations, First and second T-dS equations, Energy equations, Difference and ratio of heat capacities, Expansivity, Compressibility, Joule-Kelvin effect (porous plug experiment) Heat and Thermodynamics By: M W Zemansky 11.8,11.9,11.10,11.12,11.13,11.14,13.1,13.2,13.3,13.4,13.5,13.6,13.7 13.8,13.9,14.1	25

3.	**Fundamentals of Classical Statistical Mechanics** Macroscopic and Microscopic states, Phase space, Liouville's theorem, Fluctuations in a physical quantity, Microcanonical Ensemble: Microcanonical distribution, Equal a priori probability, Entropy, Entropy of a perfect gas in a Microcanonical ensemble, Gibbs paradox, Removal of Gibbs paradox, Thermodynamic quantities in a Microcanonical ensemble, Average energy per particle, Specific heat at constant volume, Sackur-Tetrode formula, Nernst's heat theorem, Canonical Ensemble: Canonical distribution, Canonical average, Canonical partition function, Related Numerical A Text Book of Statistical mechanics By: Suresh Chandra and Mohit Kumar Sharma 2.1,2.2,2.4,2.6,3.1,3.2,3.3,3.4,3.5,3.5.1, 3.6,3.7, 3.8,4.1, 4.1.1,4.2	25
4.	**Partition Functions and Statistical Distribution** Grand Canonical Ensemble: Grand Canonical distribution, Grand Canonical average, Grand Canonical partition function. Three Distributions: Maxwell-Boltzmann Distribution, Fermi-Dirac distribution, Bose-Einstein Distribution, Applications of Maxwell-Boltzmann Distribution: Energy distribution function, Energy distribution law, Partition function, Most probable energy, Total number of particles, Average energy, Velocity distribution function, Total number of particles, Most probable velocity, Average velocity and Root mean square velocity, Related Numerical A Text Book of Statistical mechanics By: Suresh Chandra and Mohit Kumar Sharma 5.1,5.1.1,5.2,6.1,6.2,6.3,6.4,7.1,7.1.1,7.1.2,7.1.3, 7.1.4, 7.1.5,7.1.6,7.2,7.2.1,7.2.2,7.2.3,7.2.4	25

Teaching-Learning Methodology	Direct Teaching through Chalk-Walk and Talk ICT enabled teaching Question-Answer Class discussion led by teacher/students Case Studies Literature review Problem solving activities Debate Collaborative and Co-operative Learning Think Pair Share Jigsaw Inquiry Based Learning Panel Discussion Project Based Learning Flipped Classroom Blended Learning designs Concept Mapping

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learnerwill be able to	
1.	The laws and mathematical formulations of thermodynamics, the concept of entropy etc
2.	The behaviour of different states of matter under thermal environment.
3.	The fundamental concept of statistical mechanics like phase space, micro canonical ensemble as isolated system and canonical ensembles which allows exchange of energy.
4.	The partition functions and MB, BE, FD statistical distribution of particles with distinct intrinsic properties such as classical gas, Fermionic gas and Bosonic gas etc.

Suggested References:	
Sr. No.	References
1.	Heat & Thermodynamics Mark W. Zemansky (4th Edition) McGraw-Hill Book Company, Inc.
2.	A textbook of Statistical Mechanics Suresh Chandra CBS Publishers & Distributers
3.	Heat and Thermodynamics Brij Lal and Subrahmanyam. S Chand Publication.
4.	Statistical Mechanics B K Agarwal and Melvin Eisner New Age International Limited Publishers
5.	Fundamentals of Statistical Mechanics B. B. Laud New Age International publishers

On-line resources to be used if available as reference material

On-line Resources

1. Introduction to Thermodynamics and Statistical Mechanics by David Albert
https://www.youtube.com/awatch?v=8Ku6_7J2c6I&feature=youtu.be
2. Thermodynamics 5e - Statistical Mechanics V
https://www.youtube.com/watch?v=S9OulbNy2_4&feature=youtu.be
3. Thermodynamics 5d - Statistical Mechanics IV
https://www.youtube.com/watch?v=TI5mG2bkvd4&feature=youtu.be
4. Thermodynamics 5a - Statistical Mechanics I
https://www.youtube.com/watch?v=cOalyjCkHIc&feature=youtu.be
5. Thermodynamics 5c - Statistical Mechanics III
https://www.youtube.com/watch?v=jUYK-wD4VUg&feature=youtu.be
6. Relation between Statistical Mechanics and Thermodynamics Derivation | Entropy and Probability.
https://www.youtube.com/watch?v=rV9vjjT9lFU&feature=youtu.be
7. Statistical Thermodynamics l Mechanics | Asst. Prof. Aditi Joshi
https://www.youtube.com/watch?v=hAGewYa5Hn8&feature=youtu.be
8. B Sc Phy.Sem 5 US05CPHY23 Thermodynamics &Statistical Mechanics Unit1Thermodynamical Laws&Entropy-13
https://www.youtube.com/watch?v=sYs_y27w11I&feature=youtu.be
9. Statistical Thermodynamics - Midnight Crash Course
https://www.youtube.com/watch?v=BwIUE1C6Iwk&feature=youtu.be
10. Statistical Thermodynamics || Lecture 1 || IIT JAM | DU | BHU | NET || By Manjeet Sir
https://www.youtube.com/watch?v=MkqQ6DrmaFc&feature=youtu.be
11. Zeroth laws and first law of Thermodynamics/ Lec-6 / Thermodynamics and Statistical mechanics
https://www.youtube.com/watch?v=DrkXs5kQXOY&feature=youtu.be
12. ICTP MediaCore Statistical mechanics Lecture 1 of 29
https://www.youtube.com/watch?v=iha9t8-BztE&feature=youtu.be
13. What is Statistical Mechanics | Beautiful discussion of beautiful Subject | Statistical Mechanics
https://www.youtube.com/watch?v=5L5L-Nlvnho&feature=youtu.be

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Bachelor of Science
B.Sc. Physics (Semester -V)

Course Code	US05CPHY54	Title of the Course	Analog and Digital Circuits
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To train the students on the analog and digital electronic circuits and their applications in Voltage and power amplifications. 2. To provide exposure to the working and wide applications of operational amplifiers. 3. To train the students in the basics of digital logic circuits and the working and applications of digital circuits as registers, counters etc.

Course Content

Unit	Description	Weightage* (%)
1.	**<u>Frequency Response of Amplifiers:</u>** **Low Frequency Response of The Transistor Amplifier:** Effect of Emitter Bypass Capacitor on Low Frequency response, Effect of Coupling Capacitor on Low Frequency response. **High Frequency Response of The Transistor Amplifier:** High Frequency Model For The Common Emitter Amplifier, Approximate CE High Frequency Model with a Resistive Load, CE Short Circuit Gain, High Frequency Current Gain with a Resistive Load. **Transistor Power Amplifiers:** Class A Direct Coupled Resistive Load, Transformer Coupled Resistive Load Amplifier. **Push-Pull Amplifiers:** Description of Operation of a Class A Push-Pull Amplifier, Theory of Operation of a Class A Push-Pull Amplifier. The Class B Push-Pull Amplifier, Crossover Distortion, Class AB Push-Pull Amplifier, Transistor Phase Inverter, Conversion Efficiency of a Class B Amplifier, Relation between maximum output power and load resistance, Other Class B Push-Pull Amplifiers, Complementary Symmetry. [Electronic Devices and Circuits by Allen Mottershead: 15-1, 15-2, 16-1, 16-2, 16-3, 16-4, 19-1, 19-2, 19-11, 19-12, 19-13, 20-1, 20-2, 20-3, 20-4, 20-5, 20-6, 20-9, 20-10] Related Numerical	25%

2.	**Operational Amplifiers:** **Operational Amplifier Characteristics:** Basic Differential amplifier analysis, DC Analysis of the Bipolar Diff. Amplifier, AC Analysis of the Bipolar Diff. Amplifier, The Common mode rejection ratio – CMRR, The Ideal Operational Amplifier -Op-Amp., Inverting and Noninverting Amplifiers –Ideal case, Op-Amp Parameters –Definitions, Universal Balancing Techniques, Measurements of Op- Amp Parameters, General Description of various Stages in Op-Amp. **Applications of operational amplifier:** Summing amplifier (Inverting Mode) and Difference amplifier, The Integrator and Differentiator, Current to Voltage Converter, Voltage to Current Converter- Floating Load, Logarithmic Amplifier using diode (Basic only). **Active filters:** Introduction, General characteristics of filters, Various filter responses, First-order active filters (Basic Low-Pass and High-Pass filters). [Integrated Circuits by K R Botkar: 7.1, 7.1.1, 7.1.2, 7.4.1, 7.4.2, 7.4.3, 7.4.4, 7.5.1, 8.3.1, 8.3.2, 8.4.2, 8.5.3, 9.1, 9.1.1, 9.1.2, 9.2, 9.2.1] Related Numerical	25%
3.	**Number Systems, Gates and Logic Family:** **Number systems and codes:** Decimal and binary odometer, Binary numbers, Use of binary numbers, Binary to decimal conversion, Decimal to Binary conversion, Hexadecimal numbers, Hexadecimal Binary conversion, Hexadecimal to decimal conversion, Decimal to hexadecimal conversion, BCD numbers, The ASCII code. **Gates:** Inverters, OR gates, AND gates, Boolean algebra, NOR gates, De Morgan's first theorem, NAND gates, De Morgan's Second theorem, EXCLUSIVE-OR gates, EXCLUSIVE-NOR gates. **TTL circuits:** Digital integrated circuits, 7400 devices, TTL characteristics. [Digital Computer Electronics by P Malvino and J A Brown: 1-1, 1-2, 1-4, 1-5, 1-7, 1-8, 1-9, 1-10, 1-11, 1-12, 1-13, 2-1, 2-2, 2-3, 2-4, 3-1, 3-2, 3-3, 3-4, 3-5, 3-7, 4-1, 4-2, 4-3] Related Numerical	25%

4.	**Flip-Flops, Registers and Counters:** **Flip –Flops:** Introduction, RS latches, Level clocking, D latches, Edge triggered D flip-flops, Edge triggered JK flip-flops, JK master slave flip flop. **Registers:** Buffer registers, Shift registers, Controlled shift registers. **Counters:** Ripple counters, Synchronous counters, Ring counters, MOD-10 counter, down counter, up - down counter. [Digital Computer Electronics by P Malvino and J A Brown: 7-1, 7-2, 7-3, 7-4, 7-5, 7-6, 8-1, 8-2, 8-3, 8-4, 8-5, 8-6, 8-7] Related Numerical	25%

Teaching-Learning Methodology	Direct Teaching through Chalk-Walk and Talk ICT enabled teaching Question-Answer Class discussion led by teacher/students Case Studies Literature review Problem solving activities Debate Collaborative and Co-operative Learning Think Pair Share Jigsaw Inquiry Based Learning Panel Discussion Project Based Learning Flipped Classroom Blended Learning designs Concept Mapping

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: On the successful completion of the course, the students will be able to	
1	Explain Transistor amplifiers and their analysis for different range of frequencies.
2	Describe the power capabilities of transistor power amplifiers and various techniques to achieve higher efficiency.
3	Understand the basic structure of Operational Amplifier and its analysis with its wide applications.
4	Analyse different number systems and different types of gates, flip-flops, registers and counters which are essential components of digital electronic technology.

Suggested References:	
Sr. No.	References
1.	Allen Mottershead, Electronic Devices and Circuits, (2011), PHI Pvt. Ltd., New Delhi.
2.	K R Botkar, Integrated Circuits, Ninth Edition, (Fifth Reprint 2001), Khanna Publishers, New Delhi.
3.	P. Malvino and J. A. Brown, (Third Edition 2004), Digital Computer Electronics, Tata McGraw Hill Publishing Co. Ltd., New Delhi.
4.	G K Mittal, Electronic Devices and Circuits, (Twenty Third Edition), Khanna Publishers, New Delhi
5.	Jacob Millman and Christos C. Halkias, Integrated electronics: Analog and Digital Circuits and Systems, (2009) Tata McGraw Hill Pub. Co. Ltd, New Delhi
6.	P Malvino, Electronic Principles (Seventh Edition), Tata McGraw Hill Pub. Co. Ltd, New Delhi
7.	B L Theraja, Basic Electronics (Solid State), (Reprint 2007), S. Chand & Company Ltd.

On-line resources to be used if available as reference material
On-line Resources:
https://nptel.ac.in/courses/115/102/115102014/ https://nptel.ac.in/courses/115/102/115102014/ Online lectures of Power Amplifiers and Operational Amplifiers are available on YouTube also. https://nptel.ac.in/courses/108/105/108105132/ 12 weeks course with downloadable video lectures of Digital Electronic Circuits.
Glossary of Analog and Digital Circuits: Resource Type: Reference https://wiki.analog.com/university/courses/electronics/text/glossary This website contains a glossary of electronic terms used in analog electronics. It provides quick reference to the frequently used definitions. http://www.pmcgibbon.net/teachcte/electron/degloss1.htm This website provides quick reference to the terms used in digital electronics. The glossary can be browsed and searched, and contributions of new entries are welcome. **Analog and Digital Electronics: History** Resource Type: Other educational resources https://en.wikipedia.org/wiki/Analogue_electronics https://en.wikipedia.org/wiki/Digital_electronics https://www.elprocus.com/know-about-brief-history-of-electronics-and-their-generations/ A brief history and the development of electronics is provided. **Introduction to Electronic circuits**: Resource Type: Lecture notes https://www.ee.iitb.ac.in/~sequel/course_material.html Lecture notes slides, notes on selected topics, related lab sheets and Java application simulations are available for the ready reference. **Your source for the latest research news:** https://www.sciencedaily.com/news/matter_energy/electronics/

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Bachelor of Science (Programme Name)
B.Sc. Physics Practical (Semester – V)

Course Code	US05CPHY55	Title of the Course	Physics Practical
Total Credits of the Course	08	Hours per Week	16

Course Objectives:	1. To learn by performing the experiments based on principles and applications of the theoretical courses. 2. To have working knowledge of equipment like CRO, Interferometer and electronic circuits. 3. To have the working knowledge of experiments related to optics, solid state physics, electrodynamics, analog and digital electronics etc. 4. To have ability to solve problems through numerical methods.

Course Content	
Description	Weightage* (%)
SECTION A: 1. Capacitance by de Sauty's method 2. Phage angle by C.R.O. 3. Constants of ballistic galvanometer 4. Low resistance by ballistic galvanometer 5. Four probe method 6. Study of Hysteresis curve 7. Resonance pendulum	25%
SECTION B: 1. Astable Multivibrator 2. Monostable Multivibrator 3. Operational amplifier (Inverting and non-inverting modes) 4. Frequency response of OpAmp 5. Logic gates (discrete and IC based AND, OR, NOT NAND and NOR gates) 6. Flip-flops (RS, JK, D) 7. MOSFET characteristics	25%
SECTION C: 1. Michelson interferometer (λ measurement) 2. Solar cell characteristics 3. Diagonalization of a matrix (Jacobi method) 4. Thickness of a thin wire using optical bench 5. Determination of lattice parameter by X-ray from a photograph (powder method) 6. Dissociation of I_2 molecule 7. Numerical differentiation (computer related)	25%

SECTION D: 1. Searle's Goniometer (Fixed distance) 2. Hall effect (constant magnetic field) 3. Amplitude modulation and demodulation 4. Class A amplifier 5. FET amplifier- Common Source- study of frequency response. 6. Laser beam divergence and spot size (Computer simulation) 7. Phonon dispersion relation of monoatomic chain	25%

NOTE	Minimum 80% practical should be performed. To provide flexibility up to the maximum of 20% of total experiments can be replaced/ added to the list by respective colleges

Evaluation Pattern

Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce	15%
3.	University Examination	70%

Course Outcomes:
Having completed this course, the learner will be able to

1.	The various properties of materials like resistivity, Hall coefficient, energy band gap, thickness of film etc.
2.	The numerical methods to analyze the observational data as well as the applications of numerical methods to solve dynamics of Physics problems.

Suggested References:

Sr. No.	References
1.	Advanced Practical Physics for students B L Worsnop and H T Flint, Methuen and Co. Ltd., London D Chattopadhyay and P C Rakshit, New Central book agency Pvt. Ltd.
2.	2. B.Sc. Practical Physics C L Arora, S. Chand & Co. Ltd., New Delhi

3.	Advanced Practical Physics M S Chauhan and S P Singh, Pragati Prakashan, Meerut
4.	Advanced Practical Physics S L Gupta and V Kumar, Pragati Prakashan, Meerut
5.	An advanced course in practical Physics D Chattopadhyay and P C Rakshit, New Central book agency Pvt. Ltd

On-line resources to be used if available as reference material
On-line Resources
CAPACITANCE BY DE SAUTY'S METHOD https://www.youtube.com/watch?v=RxqiRHPw0wI https://www.studentsroom.in/measurement-of-capacitance-by-de-sautys-bridge/#:~:text=Theory%3A,ratio%20arms%20of%20this%20bridge. PHASE ANGLE BY C.R.O. https://www.tutorialspoint.com/electronic_measuring_instruments/electronic_measuring_instruments_lissajous_figures.htm https://www.uoanbar.edu.iq/eStoreImages/Bank/5301.pdf CONSTANTS OF BALLISTIC GALVANOMETER https://www.youtube.com/watch?v=Z5ZlYltXs9c http://www.stpius.ac.in/crm/assets/download/Practical_paper-2_-_Continued.pdf LOW RESITANCE BY BALLISTIC GALVANOMETER http://www.stpius.ac.in/crm/assets/download/Practical_paper-2_-_Continued.pdf FOUR PROBE METHOD https://vlab.amrita.edu/?sub=1&brch=282&sim=1512&cnt=3 HYSTERESIS CURVE https://www.youtube.com/watch?v=mT_zDJY4LyI https://www.iitr.ac.in/departments/PH/uploads/Teaching%20Laboratory/5%20B-H%20Curve.pdf RESONANCE PANDULUM https://iopscience.iop.org/0031-9120/53/1/015016/media/PE015016_Annex%20A.pdf MICHELSON INTERFEROMETER https://vlab.amrita.edu/?sub=1&brch=189&sim=1106&cnt=1#:~:text=The%20Michelson%20interferometer%20is%20the,called%20an% https://www.youtube.com/watch?v=lzBKlY4f1XA THICKNESS OF A THIN WIRE USING OPTICAL BENCH http://www.bsauniv.ac.in/UploadImages/Downloads/PHYSICS-LAB-MANUAL2017-(new-regulation).pdf

DETERMINATION OF LATTICE PARAMETER BY X-RAY FROM A PHOTOGRAPH (POWDER METHOD)
https://www.youtube.com/watch?v=oR822tzRkZ0

DISSOCIATION OF I_2 MOLECULE
https://www.niser.ac.in/sps/sites/default/files/basic_page/2_absorption%20spectrum%20of%20iodine%20vapour.pdf

SOLAR CELL CHARACTERISTICS
https://www.iitr.ac.in/departments/PH/uploads/Teaching%20Laboratory/Thermal/2.%20solar%20cell.pdf
https://www.youtube.com/watch?v=1BlUC8nYuTs

SEARLE'S GONIOMETER
https://www.youtube.com/watch?v=m2EiFqSzBnY
https://www.youtube.com/watch?v=DVU0VTMoJoY

DIAGONALIZATION OF MATRIX BY JACOBI METHOD
https://www.youtube.com/watch?v=YfTrNElThDs
https://www.patnauniversity.ac.in/e-content/science/physics/MScPhy58.pdf

NUMERICAL DIFFERENTIATION BY COMPUTER
https://www.slideshare.net/Developedia/numerical-differentiations-solved-examples

HALL EFFECT
https://vlab.amrita.edu/?sub=1&brch=282&sim=879&cnt=6

LASER BEAM DIVERGENCE AND SPOT SIZE
Laser beam divergence and spot size (Theory) : Laser Optics Virtual Lab : Physical Sciences : Amrita Vishwa Vidyapeetham Virtual Lab

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Bachelor of Science
B.Sc. Physics (Semester -VI)

Course Code	US05DPHY56	Title of the Course	Renewable Energy Sources
Total Credits of the Course	02	Hours per Week	02

Course Objectives:	1. To make the students aware about the different renewable energy sources such as solar, geothermal, wind and fuel cells and technological advancements in this field. 2. To make the students aware of the importance of using nonconventional energy resources and their utilization for the present day and future energy needs.

Course Content		
Unit	Description	Weightage* (%)
1.	**Solar Thermal Energy Conversion Systems**: Introduction-Subsystems, Solar Thermal Collectors, Characteristics features of a collectors, Important aspects of solar thermal Collectors, Collector Efficiency, Simple Flat plate Collectors, Installation of Flat Plate Collectors, Guidelines for Installation, Shadow Effect, Cosine loss factor and reflective Loss Factor, Heliostats with Central Receiver, Heat Transfer-fluid. **Solar Photovoltaic Systems**: Introduction to Photovoltaic systems, Merits and Limitations of Solar PV Systems, V-I characteristics of Solar Cell and Efficiency of a solar cell, Configuration of a solar PV Panel, Small and Large PV systems. [Energy Technology Nonconventional, Renewable and Conventional by S Rao and Dr. B B Parulekar: 4.1, 4.2 ,4.3, 4.3.1, 4.3.2, 4.8, 4.9, 5.1, 5.2, 5.6, 5.8, 5.10, 5.11, 5.15]	25%
2.	**Geothermal Energy and Wind Energy-Fundamentals and Applications:** Geothermal Energy: Introduction, Application, Geothermal Energy Resources, Origin of Geothermal Resources, Hydro Geothermal Resources. Wind Energy- Fundamentals and applications: Introduction of Wind Energy, Wind power density, Power in a wind stream, Wind turbine Efficiency, Power of a wind Turbine for given incoming Wind Velocity, Types of wind turbine –Generator Units, Mono- Blade Horizontal axis Wind turbine (HAWT), Twin- Blade Horizontal axis Wind turbine (HAWT) and Three-Blade Horizontal axis Wind turbine (HAWT). [Energy Technology Nonconventional, Renewable and Conventional by S Rao and Dr. B B Parulekar: 6.1, 6.2, 6.4, 6.5, 6.8, 8.1, 8.7, 8.8, 8.9, 8.10, 9.3, 9.5.1, 9.5.2, 9.6]	25%

3.	**Tidal Energy Conversion and Ocean Energy Technology:** Tidal Energy Conversion: Introduction-Tidal range, high and low Tides, Tidal Energy Conversion, Tidal Power Ocean Energy Technology: Introduction to Energy from Ocean, Ocean Energy Resources, Ocean Thermal Energy, Ocean Waves, Ocean Tides, Advantages and Limitations of Ocean Energy Conversation Technologies, Ocean Energy Routes. [Energy Technology Nonconventional, Renewable and Conventional by S Rao and Dr. B B Parulekar: 18.1, 18.2.1, 18.2.2, 18.3, 18.4, 15.1, 15.2, 15.2.1, 15.2.2, 15.2.3, 15.4, 15.5]	25%
4.	**Fuel Cells and Fuel Cell Power Plants:** Introduction, Advantages of Fuel Cell Power Sources, Theory of Electro-Chemistry applied to fuel Cells, Principle and Operation of fuel Cells, H_2-O_2 Acidic fuel Cell, Alkaline H2-O2 fuel Cell, Classification and Types of Fuel Cells, Fuels for Fuel Cells, Performance Characteristics of Fuel Cells-Voltage Vc-Current Density Id Characteristic (Polarization Curve), Power per cell Pc, Cell Efficiency. [Energy Technology Nonconventional, Renewable and Conventional by S Rao and Dr. B B Parulekar: 23.1, 23.2, 23.3, 23.4, 23.5, 23.6, 23.8,]	25%

Teaching-Learning Methodology	Direct Teaching through Chalk-Walk and Talk ICT enabled teaching Question-Answer Class discussion led by teacher/students Case Studies Literature review Problem solving activities Debate Collaborative and Co-operative Learning Think Pair Share Jigsaw Inquiry Based Learning Panel Discussion Project Based Learning Flipped Classroom Blended Learning designs Concept Mapping

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	University Examination	100%

Course Outcomes: On the successful completion of the course, the students will be able to understand,	
	The various sources of renewable energy routes comprising the exploration and extraction of primary raw energy, conversions to intermediate/secondary forms of energy and by-products, transportation alternatives, storage, distribution and supply of secondary forms of energy.
	Fuel cells and Fuel cell power plants.

Suggested References:

Sr. No.	References
1.	Energy Technology Nonconventional, Renewable and Conventional S Rao and Dr. B B Parulekar (2015) Khanna Publishers
2.	Biomedical Instrumentation R S Khandpur (2nd Edition) Tata McGraw Hill Publishing Co. Ltd., New Delhi (2003)

On-line resources to be used if available as reference material

On-line Resources:

https://www.britannica.com/technology/solar-cell
https://www.electrical4u.com/solar-cell/
https://en.wikipedia.org/wiki/Geothermal_energy
https://www.britannica.com/science/geothermal-energy
https://www.britannica.com/science/tide
http://www.docbrown.info/page01/ExIndChem/electrochemistry11.htm

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Bachelor of Science
B.Sc. Physics (Semester -V)

Course Code	US05DPHY57	Title of the Course	Astronomy and Astrophysics
Total Credits of the Course	02	Hours per Week	02

Course Objectives:	1. To create awareness about astronomy and astrophysics in relation to our universe. 2. To provide the fundamental knowledge of stars in general and our sun in particular. 3. To provide observational methods to get information about planets, binary, multiple stars and our galaxy.

Course Content		
Unit	Description	Weightage* (%)
1.	**Basic concepts of Astronomy and Astrophysics:** Mass, length and time scale in Astrophysics, Celestial coordinates, Sources of astronomical information. Astronomy in different bands of electromagnetic radiation. The Earth's atmosphere and the electromagnetic radiation, Optical telescopes, Radio telescope, The Hubble Space Telescope (HST), Detectors and image processing. [Astrophysics for Physicists by Arnab Rai Choudhuri, (Reprint 2012) Rai Chaudhari :1.1, 1.3, 1.6, 1.7] [An Introduction to Astrophysics by Baidyanath Basu, Tanuka Chattopadhyay and Sudhindra Nath Biswas (2nd Edition 2017) :1.2, 1.3, 1.4, 1.5, 1.10]	25%
2.	**Fundamentals of Stars and Sun**: Stellar magnitude sequence, Absolute magnitude and the distance modules, The bolometric magnitude, The colour index of a star, Luminosities of stars, Harvard system of spectral classification: Henry Draper (H-D) catalogue, The Hertzsprung – Russell (H - R) diagram. **The Sun:** Sun - a typical star, The photosphere: limb-darkening, Solar granulation, Faculae, Chromospheres, Solar Corona, Prominences, Solar flares, Solar wind. [An Introduction to Astrophysics by Baidyanath Basu, Tanuka Chattopadhyay and Sudhindra Nath Biswas (2nd Edition 2017) : 3.1, 3.2, 3.3, 3.6, 3.7. 4.4., 4.8, 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.11, 5.13]	25%

3.	**Binary and Multiple Stars:** Introduction to binary and multiple stars, Visual binary, Spectroscopic binary, Eclipsing binary, Multiple Stars, Origin of binary stars, Stellar masses and mass-luminosity relation, Mass transfer in close binary systems. [An Introduction to Astrophysics by Baidyanath Basu, Tanuka Chattopadhyay and Sudhindra Nath Biswas (2nd Edition 2017) :7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7, 7.8]	25%
4.	**Our Galaxy:** Introduction to our galaxy, The general structure of the Galaxy, Central region and nucleus, The Galactic Disc, The Galactic Halo, The mass of the Galaxy, Cosmic Rays, Continuous radio emission in the Galaxy. [An Introduction to Astrophysics by Baidyanath Basu, Tanuka Chattopadhyay and Sudhindra Nath Biswas (2nd Edition 2017) :16.1, 16.7, 16.8, 16.10, 16.11]	25%

Teaching-Learning Methodology	Direct Teaching through Chalk-Walk and Talk ICT enabled teaching Question-Answer Class discussion led by teacher/students Case Studies Literature review Problem solving activities Debate Collaborative and Co-operative Learning Think Pair Share Jigsaw Inquiry Based Learning Panel Discussion Project Based Learning Flipped Classroom Blended Learning designs Concept Mapping

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: On the successful completion of the course, the students will be able to	
1	Understand Basic concept of astronomy and astrophysics and working of various tools used in astronomical observations, their sensitivity and applications.
2	Achieve an understanding of the Physical properties of our sun, the characterization of stars, evolution of stars etc.
3	Demonstrate an understanding of the binary and multiple stars and finding relation between the mass and luminosity of stars.
4	Understand Galaxies including Milky way galaxy and other cosmic events.

Suggested References:	
Sr. No.	References
1.	An Introduction to Astrophysics Baidyanath Basu, Tanuka Chattopadhyay and Sudhindra Nath Biswas (2nd Edition 2017) PHI learning Private Limited, Delhi
2.	Astrophysics for Physicists Arnab Rai Choudhuri, (Reprint 2012) Cambridge University Press, New Delhi

On-line resources to be used if available as reference material
On-line Resources:
NDLI: Astrophysics & Cosmology (iitkgp.ac.in) http://ndl.iitkgp.ac.in/document/Z2JzN0ZmU2VhdW5kODBJdWRCTmg3SU5GTE92L3pvNk5BNkN1OU9hYnlLQlB6cHhadnZPbWVvemFhZnlJU25YMTRxVUdHQnIvdm1XNFhFSjZMVElVSUE9PQ Online course with a series of forty lectures by Prof. Somnath Bharadwaj of Department of Physics and Meteorology, IIT Kharagpur is available on National Digital Library of India.
Glossary of Astronomy and Astrophysics: Resource Type: Reference http://www.seasky.org/astronomy/astronomy-glossary.html This glossary of astronomy terms contains definitions for some of the most common words used in astronomy, cosmology, astrophysics and space exploration. You can click on any letter of the alphabet below to jump directly to that section in the glossary listing. **Astronomy and Astrophysics: History** Resource Type: Other educational resources Astrophysics - Wikipedia A brief history and the development of Astronomy and Astrophysics is provided. **Introduction to Astrophysics** Resource Type: Lecture notes http://www.aoc.nrao.edu/~smyers/courses/astro12/lecnotes.html Lecture notes on selected topics by Steven T. Myers available for the ready reference. **Your source for the latest research news** Astronomy & Astrophysics (A&A) (https://www.aanda.org/) Worldwide astronomical and astrophysical research published by EDP Sciences.

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