Semester: III

Paper Code	Paper No.	Paper Title	Credit L+T+P
	C5	Mathematical Physics-II	3+1+1
	C6	Thermal Physics	3+1+1
	C7	Analogue Systems & Applications	3+1+1
	GE3	Thermal Physics, Electricity & Magnetism and Electronics	3+0+1
	SEC1	Electronic Design and Fabrication	1+0+1

N.B. SEC-1 paper offered by the Dept of Physics can't be chosen by students of Physics Honours

Paper Code: **Paper No. C5**

Paper Name: Mathematical Physics-II

Credit: 3+1+1

Theory: 48

Fourier Series:

Periodic functions. Orthogonality of sine and cosine functions. Dirichlet conditions (statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Even and odd functions and their Fourier expansions. Applications. Summing of infinite Series. Term-by-term differentiation and integration of Fourier series. Parseval's identity.

(**12 Lectures)**

Frobenius Method and Special Functions:

Singular points of second order linear differential equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre differential equations. Properties of Legendre polynomials. Rodrigues' formula. Generating function. Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre polynomials. Bessel functions of the first kind. Generating function. Simple recurrence relations. Zeros of Bessel Functions and orthogonality

(**30 Lectures)**

Some Special Integrals:
Beta and gamma functions and relation between them. Expression of integrals in terms of gamma functions.

(6 Lectures)

Reference Books:

1. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
2. Fourier Analysis by M.R. Spiegel,g 2004, Tata McGraw-Hill.
3. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
4. Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
5. Mathematical methods for Scientists & Engineers, D.A.McQuarrie, 2003, Viva Books

List of Experiment: Credit=1 (16 Classes of 2 hours each)

(The aim of this Lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.)

1. Highlights the use of computational methods to solve physics problems
2. The course will consist of lectures (both theory and practical)in the Lab
3. Evaluation done not on the programming but on the basis of formulating the problem
4. Aim at teaching students to construct the computational problem to be solved
5. Students can use any one operating system Linux or Microsoft Windows
6. At least two programs must be attempted from each programming section.

Topics	Description with Applications
Introduction and Overview	Computer architecture and organization, memory and Input/output devices
Basics of scientific computing	Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow and overflow - emphasize the importance of making equations in terms of dimensionless

	variables, Iterative methods
Errors and error Analysis	Truncation and roundoff errors, Absolute and relative errors, Floating point computations
C++ Programming fundamentals	Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, cin and cout, Manupulators for data formatting, Control statements (decision making and looping statements), if-statement, if-else statement, nested if statement, else-if statement, ternary operator, goto statement, switch statement, unconditional and conditional looping, while and do while loop, for loop, nested loops, break and continue statements). Arrays (1D and 2D)and strings, user defined functions, Structures and Unions, Idea of classes and objects
Programs: using C++ language	Sum and average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Linear Search, Binary Search
Random number generation	Area of circle, area of square, volume of sphere, value of pi
Solution of Algebraic and Transcendental equations by Bisection, Fixed Point, Newton Raphson, Secant and Regula Falsi methods	Solution of linear and quadratic equation, solving $\alpha = \tan\alpha; I = I_0\left(\frac{\sin\alpha}{\alpha}\right)^2$

Interpolation by Lagrange interpolation, Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation	Evaluation of trigonometrical functions, eg., sinθ, cosθ and tanθ, etc.
Numerical differentiation (Forward and Backward difference formula)	Given Position with equidistant time data calculate velocity and acceleration and vice versa.
Numerical Integration (Trapezoidal and Simpson rules) method	Evaluation of some finite integrals
Numerical Gaussian Quadrature Methods	Evaluation of some finite integrals using Gauss-Legendre one, two and three point quadrature formula
Monte Carlo Integration	Evaluation of finite and infinite integrals, Multiple Integrals: Volume and Surface Integrals
Solution of Ordinary Differential Equations (ODE) First order Differential equation Euler, modified Euler and Runge-Kutta (RK) second and fourth order methods	First order differential equation • Radioactive decay • Current in RC, LC circuits with DC source • Newton's law of cooling • Classical equations of motion Attempt following problems using RK 4 order method: • Solve the coupled differential equations

	$\frac{dx}{dt} = y + x - \frac{x^3}{3}; \frac{dy}{dx} = -x$ four initial conditions x(0)=0; y(0)=-1,-2,-3,-4. Plot x vs y for each of the four initial conditions on the same screen for $0 \leq t \leq 15$. • The differential equation describing the motion of a pendulum is $\frac{d^2\theta}{dt^2} = -sin(\theta)$ .The pendulum is released from rest at an angular displacement α i.e., v(0)= α, v'(0)=0. Solve the equation for α=0.1, 0.5 and 1.0 and plot v as function of time in the range $0 \leq t \leq 8\pi$. Also plot the analytical solution valid for small v.

Reference Books:

1. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
2. Numerical Recipes in C++: The Art of Scientific Computing, W.H. Press et.al., 2nd Edn., 2013, Cambridge University Press.
3. C++ Programming: From problem analysis to program design, D S Malik, 5th Edition, 2011, Course Technology, Cengage Learning
4. An introduction to Numerical methods in C++, Brian H. Flowers, 2009, Oxford University Press.
5. A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning
6. Elementary Numerical Analysis, K.E. Atkinson,3rd Edn. , 2007 , Wiley India Edition
7. Computational Physics, Darren Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.

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Paper Code: **Paper No. C6**

Paper Name: Thermal Physics
Credit: 3+1+1
Theory: 48

Introduction to Thermodynamics:

Zeroth and first Law of thermodynamics, Extensive and intensive thermodynamic variables. Thermodynamic equilibrium. Zeroth law of thermodynamics and the concept of temperature. Work and heat. State variables. First law of thermodynamics and its differential form. Internal energy. First law & various processes. Applications of the first law: general relation between C_P and C_V, work done during isothermal and adiabatic processes.

(**6 lectures**)

Second Law of Thermodynamics:

Reversible and irreversible processes with examples. Heat engines. Carnot's cycle. Carnot engine and efficiency. 2nd law of thermodynamics: Kelvin-Planck and Clausius statements and their equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: thermodynamic scale of temperature and its equivalence to the perfect gas scale.

(**8 lectures**)

Entropy:

The concept of Entropy. Clausius theorem. Clausius inequality. Entropy of a perfect gas. Entropy changes in reversible and irreversible processes with examples. Entropy of the universe. Entropy changes in reversible and irreversible processes. Principle of increase of entropy. 2^{nd} law of thermodynamics in terms of entropy. Temperature–Entropy diagrams for Carnot's cycle.

(**6 lectures**)

Thermodynamic Potentials:

Thermodynamic potentials: internal energy, enthalpy, Helmholtz free energy, Gibb's free energy. Their definitions, properties and applications. Magnetic work and cooling due to adiabatic demagnetization. First-order phase transitions, Clausius-Clapeyron equation.

(**6 lectures**)

Maxwell's Thermodynamic Relations:

Derivation of Maxwell's thermodynamic relations and their applications. Maxwell's relations. Energy equations. TdS equations. C_P-C_V equation.

(**4 lectures**)

Kinetic Theory of Gases:

Distribution of velocities: Maxwell-Boltzmann law of distribution of velocities in an ideal gas. Mean, RMS and most probable speeds. Degrees of freedom. Law of equipartition of Energy. Specific heats of gases.

(**4 lectures**)

Molecular Collisions:

Mean free path. Collision probability. Estimation of mean free path. Transport phenomenon in ideal gases: Viscosity and thermal conductivity. Brownian Motion and its significance.

(**4 lectures**)

Real Gases:

Behavior of real gases: deviations from the ideal gas equation. Andrew's experiments on CO_2 gas. Critical Constants. Continuity of liquid and gaseous state. The van der Waals equation of state for real gases. Values of critical constants. Law of corresponding states. Comparison with experimental curves. P-V diagrams. Joule-Thomson porous plug experiment. Joule-Thomson effect for ideal and van der Waals gases. Temperature of inversion. Joule-Thomson cooling.

(**10 lectures**)

Reference Books:

1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
2. A Treatise on Heat : Including Kinetic Theory of Gases, Thermodynamics and Recent Advances in Statistical Thermodynamics by Meghnad Saha and B. N. Srivastava (Indian Press 1958).
3. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.

List of Experiments: Credit=1 (16 Classes of 2 hours each)

1. Determine the co-efficient of linear expansion by optical lever method.
2. Determine the value of Stefan's constant.
3. Determine the boiling point of a liquid with the help of a platinum resistance thermometer.
4. Determine the thermal conductivity of glass in the form of a tube.
5. Determine the melting point of a given substance (say, paraffin) with the help of a thermocouple.

(At least 5 Experiments to be performed. Few more may be added later.)

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Paper Code: **Paper No. C7**

Paper Name: Analogue Systems & Applications

Credit:3+1+1

Theory: 48

Network theorem: Voltage and Current Sources, Mesh and Node Circuit Analysis with the help of Kirchhoff's Current and voltage Laws, T-π Transformations, Delta to Star and Vice- Versa Transformations, Superposition Theorem, Reciprocal Theorem, Thevenin's Theorem, Norton's Theorem, Maximum power transfer Theorem. Wheatstone Bridge

and its application to Wein Bridge and Andersion Bridge

(8 Lectures)

Two-terminal Device and their Application: Rectifier Diode, Half-wave Rectifiers, Centre-tapped and Bridge Full-wave rectifiers, Calculation of Ripple Factor and Rectification Efficiency. Qualitative idea of Filters, Zener Diode and Voltage Regulation, Photo Diode, Tunnel Diode, LED, Varactor Diode.

(6 Lectures)

Bipolar Junction transistor:- n-p-n and p-n-p Transistors, Characteristics of CB, CE, CC Configurations, Current gains α, β and α and γ Relations between them, Load Line Analysis of Transistors, DC Load line and Q-point.

(4 Lecture)

Amplifiers: Transistor Biasing and Stabilization Circuits, Fixed Bias and Voltage Divider Bias, Class A, Class B, Class C Class AB and Push Pull Amplifiers. Transistor as 2-port Network: Z, Y and H-parameter Equivalent Circuit.

(4Lectures)

Coupled Amplifiers: RC- Coupled Amplifier and its Frequency Response of Voltage Gain

(2 Lectures)

Feedback in Amplifiers: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance and Gain, Stability, Distortion and Noise, Basic idea of Oscillators; Phase shift, Wein Bridge, Hartley, Colpitts and Tuned Collector and Crystal Oscillator

(6 Lectures)

Three- terminal Devices (UJT and FETs): (1) UJT: Its Characteristics and Equivalent Circuit.

(4 Lectures)

OPERATIONAL AMPLIFIERS:

Operational Amplifiers (Use Black Box Approach): Basic Characteristics of Op-Amps Characteristics of an Ideal Op-Amp, Feedback in Amplifiers, Open –loop and Closed-loop Gain, Frequency Response, CMRR, Virtual ground. Application of Op-Amps; (1) Inverting and Non-inverting Amplifiers, (2) Adder, (3) Subtractor, (4) Unity Follower, (5) Differentiator, (6) Integrator, (7) Zero Crossing Detector

(6 lectures)

Converter: D/A Resistive networks (Weighted and R-2R Ladder). Accuracy and Resolution

(2 Lectures)

Modulation and Demodulation: Types of Modulation. Amplitude Modulation, Modulation Index. Analysis of amplitude, frequency and phase modulation and modulators and demodulators

(6 Lectures)

List of Experiments: Credit=1 (16 Classes of 2 hours each)

1. To draw the characteristics curve of a semiconductor diode and hence determine the DC and AC resistance for a given current when the diode is forward biased (Using Breadboard).
2. To draw the characteristics curve of a Zener diode and determine its DC and AC resistance for a given current. Also determine the breakdown voltage of the Zener diode (Using Breadboard).
3. To draw the output characteristics curves of a transistor in CB or CE mode and find its sort circuit current gain. (Using Breadboard).
4. Draw the frequency response of RC- Coupled Amplifier and find its bandwidth
5. To design a Wien bridge oscillator for given frequency using an op-amp.
6. To design a phase shift oscillator of given specifications using BJT.
7. To design a digital to analog converter (DAC) of given specifications.
8. To design an inverting amplifier using Op-amp (741,351)for dc voltage of given gain
9. To design inverting amplifier using Op-amp (741,351) & study its frequency response
10. To design non-inverting amplifier using Op-amp (741,351) & study frequency response
11. OPAMP-Addition, Subtraction
12. OPAMP-Differentiation, Integration

(At least 05 experiments from the above list)

Recommended Books:

1. Electricity and magnetism – Berkeley series
2. Electricity and magnetism- D Chattopadhyay and P C Rakshit
3. A textbook of Electronics by Santanu chattopadhy, NCBA.
4. Electronics Theory and Applications by Dr. S.L. Kakani and K.C. Bhandari, NewAge.
5. Electronic Principles by A.P. Malvino, Tata McGrawHill.
6. Robert Boylestad, Louis Nashelsky, Electronic Devices and Circuit Theory, 8th Edition, Pearson Education, India, 2004.
7. A. P. Malvino, Electronic Principals, Glencoe,1993.
8. John Morris, Analog Electronics.
9. Allen Mottershead, Electronic Circuits and Devices, PHI, 1997.
10. Solid State Electronic Devices by Ben G. Streetman & Sanjay Banerjee, Pearson Prentice Hall, 2006.
11. Basic Electronics & Linear Circuits by N.N. Bhargava, D. C. Kulshreshtha & SC Gupta, Tata McGrawHill, 2006.

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Paper Code: **Paper No. GE3**

Paper Name: Thermal Physics, Electricity & Magnetism and Electronics

Credit: 3+0+1

Theory : 48 Lectures

Kinetic Theory of Gases and Maxwell-Boltzmann Statistics, Equipartition of energy, free path. The Zeroth, First and Second Law of thermodynamics, Thermodynamic temperature scale, Reversible and irreversible processes, Heat Engines, Entropy. **(12 classes)**

Coulomb's law, electric field, Gauss's Law, Electrostatic potential, Uniqueness theorem, Conductors, capacitance, Method of images, Bound charges and dipole moment density, Energy stored in electric fields. **(10 classes)**

Biot-savart law, Ampere's law, magnetic fields of straight wires, circular loops and infinite solenoids, Vector potential; Lorentz force. **(8 classes)**

Electric current density, continuity equation, Ohm's law as $J = \sigma E$, Applications of Kirchoff's law to solve electrical network problem. Self and mutual induction, self-induction of a long solenoid, mutual induction of two solenoids. Alternating current and potential across resistive, inductive and capacitive elements and their phase relationships, power factor. **(10 classes)**

Semiconductors, P-N junction diode, unbiased and biased P-N junction, depletion layer, barrier potential, junction capacitance, photo diode, Zener diode, LED and their uses. Diodes as rectifier: Rectifier Diode, Half-wave Rectifiers, Centre-tapped and Bridge Full-wave rectifiers.Calculation of Ripple Factor and Rectification Efficiency. N-P-N and P-N-P transistor, CB, CE, CC Configurations, and characteristics of transistor, α, β and α and γ of a transistor, transistor as amplifier. **(8 classes)**

Reference Books:

1. A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.
2. Heat and Thermodynamics, M.W.Zemasky and R. Dittman, 1981, McGraw Hill
3. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education.
4. Introduction to Electrodynamics, David J Griffiths, 4th Edition., 2015, Pearson.
5. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw
6. Basic Electronics, B.L. Thereja
7. Electronics fundamentals and applications, D. Chattopadhyay and P.C. Rakshit

List of Experiments:- GENERIC III LAB (1 Credit, 16 Periods of 2 hours)
(Thermal Physics, Electricity & Magnetism and Electronics**)**

(At least 05 experiments from the following list)

1. To determine the coefficient of linear expansion of a rod.
2. To determine the conductivity of a bad conductor by Lee's Disc Method.
3. To determine the thermal conductivity of the material of an Indian Rubber Pipe.
4. Study of magnetic field due to one coil and calculation of its diameter & Study of principal of super-imposition of magnetic field due to 2 coils by keeping the distance between the coils at a, greater than a and less than a, where a is the radius of the coil.
5. To determine the specific resistance of the material of the given wire by Meter Bridge and then find the length of wire necessary to construct a one ohm coil.
6. To determine the emf of a cell using a cell of known emf with the help of Potentiometer.
7. To determine the resistance per unit of the length of meter bridge wire by Carey-Foster method.
8. To draw the characteristics of a forward biased PN diode and hence determine the ac resistance of the PN diode.
9. To draw the characteristics of a given transistor with CB and CE configurations and determine the alpha and beta of the transistor.
10. To draw the characteristics of a reverse biased Zener diode and hence determine the breakdown voltage of the Zener diode.

Reference Books

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. A Laboratory Manual of Physics for Undergraduate Classes, D.P.Khandelwal, 1985, Vani Publication.
4. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.

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Paper Code: **Paper No. SEC1**

Paper Name: Electronic Design and fabrication

Credit:1+0+1

Lecture: 16

Theory:

1 Familiarization of different Electronic components, instruments and their identification.

1. Colour code determination of the value of resistor and verification with the help of multimeter.
2. PCB layout from schematic diagram.
3. Circuit of half wave and full wave rectifier.
4. Fabrication of (Constant/variable) Power Supply.
5. Design and fabrication of an Extension Board.
6. Making of an inductor.

List of Experiments:

1. To find the value of a given resistor by using with colour code method and compare the value with multimeter.
2. Design a variable power supply circuit and compare the output with input value.
3. Design a full wave rectifier circuit and find the value of ripple factor.
4. Prepare a PCB from a given circuit.
5. Design an extension board.
6. Design an inductor and find the inductance value.

N.B. To be offered to students other than Physics Honours.