BHARATHIDASAN UNIVERSITY TIRUCHIRAPPALLI - 620 024.

M.Sc. PHYSICS: CHOICE BASED CREDIT SYSTEM -
LEARNING OUTCOMES BASED CURRICULUM FRAMEWORK (CBCS - LOCF)

(Applicable to the candidates admitted from the academic year 2022-23 onwards)

Sem.	Courses	Title	Ins. Hrs.	Credit	Exam Hrs.	Marks		Total
						Int.	Ext.	
I	Core Course I (CC)	Classical Mechanics	6	5	3	25	75	100
	Core Course II (CC)	Mathematical Physics	6	5	3	25	75	100
	Core Choice Course I (CCC) (Any one choice)	1. Analog and Digital Electronics 2. Optoelectronics	6	5	3	25	75	100
	Core Practical I (CP)	General Physics and Electronics I	6	3	3	40	60	100
	Elective Course I (EC) (Any one choice)	1. Computational Physics with C++ 2. Physics Simulations with Python	6	4	3	25	75	100
	Value Added Course I (VAC)	Research Publication and Ethics	-	2*	3	25	75	100*
	TOTAL		**30**	**22**	**-**	**-**	**-**	**500**
II	Core Course III (CC)	Quantum Mechanics	6	5	3	25	75	100
	Core Course IV (CC)	Electromagnetic Theory	5	5	3	25	75	100
	Core Choice Course II (CCC) (Any one choice)	1. Advanced Mathematical Physics 2. Complex Systems and Networks	5	5	3	25	75	100
	Core Practical II (CP)	General Physics and Electronics II	6	3	3	40	60	100
	Elective Course II (EC) (Any one choice)	1. Microprocessor and Microcontroller 2. Electronic Devices and Circuits	5	4	3	25	75	100
	Non-Major Elective Course I	Physics for Everyone	3	2	3	25	75	100
	TOTAL		**30**	**24**	**-**	**-**	**-**	**600**
III	Core Course V (CC)	Thermodynamics and Statistical Mechanics	6	5	3	25	75	100
	Core Course VI (CC)	Solid State Physics	5	5	3	25	75	100
	Core Choice Course III (CCC)	(i) Advanced Quantum Mechanics (ii) Quantum Computation	5	5	3	25	75	100
	Core Practical III (CP)	Microprocessor and Programming in C++	6	3	3	40	60	100
	Elective Course III (EC)	(i) Physics of Nanomaterials (ii) Methods of Spectroscopy	5	4	3	25	75	100
	Non-Major Elective Course II	Renewable Energy Sources	3	2	3	25	75	100
	TOTAL		**30**	**24**	**-**	**-**	**-**	**600**
IV	Core Course VII (CC)	Crystal Growth and Thin Film Physics	6	5	3	25	75	100
	Core Course VIII (CC)	Nuclear and Particle Physics	6	5	3	25	75	100
	Entrepreneurship / Industry Based Course	Analytical Characterization Techniques	6	5	3	25	75	100
	Project		12	5	-	20	80	100
	Value Added Course II (VAC)	Medical Instrumentation	-	2*	3	25	75	100*
	TOTAL		**30**	**20**	**-**	**-**	**-**	**400**
GRAND TOTAL			**120**	**90**	**-**	**-**	**-**	**2100**

***The value added courses credit will not be included in the total CGPA.**
These courses are extra-credit courses.
Instruction hours for these courses is 30 hours.

SUMMARY OF CURRICULUM STRUCTURE OF PG PROGRAMMES

Sl. No.	Types of the Courses	No. of Courses	No. of Credits	Marks
1.	Core Courses	8	40	800
2.	Core Choice Courses	3	15	300
3.	Core Practicals	3	9	300
4.	Elective Courses	3	12	300
5.	Entrepreneurship/ Industry Based Course	1	5	100
6.	Project	1	5	100
7.	Non-Major Elective Courses	2	4	200
	Total	**21**	**90**	**2100**
	Value Added Courses *	2*	4*	200*

PROGRAMME OBJECTIVES:

- To impart comprehensive knowledge in theoretical, experimental and computational Physics and a better understanding of the subject.
- To train and empower to think creatively and critically about Physics in foundations and contemporary applications.
- To enrich knowledge through problem-solving skills, projects, seminars, participation in scientific events and study visits.
- To specialize in interdisciplinary content and to acquaint them with cutting-edge research.
- To prepare for careers in Teaching, Research laboratories and public/private sector units and to implant the entrepreneurship character.

PROGRAMME OUTCOME:

On the successful completion of the M.Sc. Physics Programme, the students will

- Have a deep knowledge of the fundamental concepts of Physics and understand how the various phenomena in nature follow the laws of Physics.
- Identify, formulate and analyze the scientific problems using the basic principles.
- Develop problem-solving skills and have the ability to apply mathematical tools to understand and describe physical problems.
- Be able to handle the laboratory equipments, gain knowledge about advanced experimental techniques and can successfully interpret results required for research and industrial applications.
- Acquire effective computational skills to apply them to scientific and technological problems.
- Get familiarized with contemporary research within various fields of Physics.
- Equip to take a career in teaching, research laboratories and public/private sector units and imbibe the entrepreneurship character.

PROGRAMME EMPLOYMENT OPPORTUNITY:

The M.Sc. Physics curriculum is designed so that the students can develop their mathematical, problem solving, and critical thinking skills. All these skills widen the scope of employability in industries and IT companies besides teaching. Students who undergo this course will have a wide range of options based on their interests and abilities. More specifically, students with M.Sc. Physics have the following career options: (i) Post-Graduate Teachers (PGT), (ii) Scientific Assistants/Officers in National Physical Laboratories or in various Government Agencies (BARC, ISRO etc.,), (iii) Content Writers in Physics and Scientific Magazines, (iv) Pursue in cutting-edges scientific research in International and National Laboratories, (v) Scientists in R&D sectors, Oil and Natural Gas Companies, Space organizations, etc. (vi) Assistant Professors in Colleges/Universities (after clearing NET/TNSET).

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First Year | **CORE COURSE I** | **Semester I**

CLASSICAL MECHANICS

Code: | **(Theory)** | **Credit: 5**

COURSE OBJECTIVES:

- To provide in-depth knowledge on the foundations of Classical Mechanics.
- To familiarize the laws of motion and learn about their applications in other branches of Physics.
- To build a strong base on dynamical systems.

UNIT - I: LAGRANGE'S FORMULATION:

Mechanics of a system of particles – Constraints – Generalized coordinates – D Alembert's principle and Lagrange's equations – Simple application of the Lagrangian formulation – Hamilton's (variational) principle and derivation of Lagrange's equations – Generalized momenta and energy – Cyclic coordinates – Conservation Laws.

UNIT – II CENTRAL FORCE MOTION AND RIGID BODY DYNAMICS:

Central Force Motion: General features – The Kepler Problem: inverse square law force – Scattering in a central force field. Rigid Body Dynamics: Moment of inertia tensor – Euler angles – Euler's equations of motion – Symmetrical top – Problems.

UNIT – III HAMILTON'S FORMULATION:

Legendre transformation – Hamiltonian and Hamilton's equation of motion – Properties – Derivation of Hamilton's equations from variational principle – Canonical transformation – Applications – Poisson brackets – Hamilton Jacobi equation for Hamilton's principle function – Hamilton's characteristic function – Application (Harmonic Oscillator) – Action-angle variables - Problems.

Unit – IV Small Oscillations and Vibrations:

Small Oscillations: Theory of small oscillations – Eigenvalue problem – Normal modes and Normal frequencies - Frequencies of free vibrations – Normal coordinates – Examples – Two coupled Pendula - Linear triatomic molecule – Forced vibrations.

Unit – 5 Theory of Relativity:

Inertial and non-inertial reference frames – Addition of velocities, mass, energy – Mass-Energy equivalence – Pseudo forces – Galilean and Lorentz transformations – Invariance of Maxwell's equations under Lorentz transformation – Lagrangian and Hamiltonian of relativistic particles.

UNIT – 6 CURRENT CONTOURS (For continuous internal assessment only):

Nonlinear Dynamical Systems - Linear Stability Analysis – Classification of Fixed points. Hamilton's principle and Lagrange's equations to electrical systems – Dynamics of gyroscopes – Multibody dynamics and robotics.

REFERENCES:

1. H. Goldstein, C. P. Poole and J. Safko, *Classical Mechanics* (Pearson, New Delhi, 2011).
2. G. Aruldhas, *Classical Mechanics* (Prentice Hall of India, New Delhi, 2015).
3. J. C. Upadhyaya, *Classical Mechanics* (Himalaya, Bangalore, 2019).
4. B. D. Gupta and Satya Prakash, *Classical Mechanics* (Kedar Nath Ram Nath, Meerut, 2020).
5. S. Dutta, *Mechanics* (Pearson, New Delhi, 2012).
6. M. Lakshmanan and S. Rajasekar, *Nonlinear Dynamics: Integrability, Chaos, and Patterns* (Springer, Chennai, 2003).
7. T. L. Chow, *Classical Mechanics* (CRC, New York, 2013).
8. N. Rana and P. Joag, *Classical Mechanics* (McGraw Hill, New Delhi, 2017).
9. S. T. Thornton and J. B. Marion, *Classical Dynamics of Particles and Systems* (Cengage Learning, New Delhi, 2012).
10. H. V. Sharma, S. L. Gupta and V. Kumar, *Classical Mechanics* (Pragati Prakashan, New Delhi, 2019).
11. R. G. Takwale and P. S. Puranik, *Introduction to Classical Mechanics* (McGraw Hill, New Delhi, 2017).
12. K. Prathapan, *Analytical Problems in Classical Mechanics: Complete Solutions* (Dreamtech, New Delhi, 2019).
13. J. Awrejcewicz and Z. Koruba, *Classical Mechanics: Applied Mechanics and Mechatronics* (Springer, Heidelberg, 2012).
14. F. C. Moon, Applied Dynamics (Wiley-VCH, New Delhi, 2008).
15. 1.https://ocw.mit.edu/courses/8-09-classical-mechanics-iii-fall-2014/pages/lecture-notes/
16. https://nptel.ac.in/courses/115105098

COURSE OUTCOME:

On the successful completion of the course, students will be able to

- Solve problems involving Lagrangian and Hamiltonian mechanics.
- Attain sound knowledge of the basic formalism and geometric aspects of classical mechanics.
- Understand the usefulness of variational calculus in formulating the mechanical laws of motion.
- Find solutions to problems in the normal mode analysis and its applications.
- Get familiarized with the dynamical systems.

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First Year	**CORE COURSE II**	**Semester I**
	MATHEMATICAL PHYSICS	
Code:	**(Theory)**	**Credit: 5**

COURSE OBJECTIVES:

- To give a solid mathematical foundation in vector calculus, matrices and differential equations.
- To help learn and appreciate the importance of Special functions and their applications in Physics.
- To develop mathematical skills and solve problems in various branches of Physics.

UNIT – I VECTOR CALCULUS:

Vector integration – Line integral – Path independence – Surface integral – Flux – Volume integral – Green's theorem – Stokes' theorem – Divergence theorem – Orthogonal curvilinear coordinates – Unit vectors in curvilinear coordinate system – Gradient, divergence, curl and Laplacian in cylindrical and spherical polar coordinates.

UNIT – II MATRICES:

Matrix algebra – Solution of a system of linear equations – Properties of (i) symmetric, (ii) anti-symmetric, (iii) orthogonal, (iv) Hermitian, (v) skew-Hermitian and (vi) unitary matrix – Eigenvalues and eigenvectors of a square matrix – Diagonalization – Matrix Analysis of Single n^{th} order differential equation and system of second order linear differential equations and their solutions.

UNIT – III ORDINARY DIFFERENTIAL EQUATIONS:

Methods of finding solutions of first and second order ordinary differential equations (ODEs) with constant coefficients – Initial value and boundary value problem – Methods of finding solutions – Superposition principle – Wronskian – Definition of ordinary and singular points of second order ODEs – Power series solution – Examples – Solutions about ordinary point and singular point in power series.

UNIT – IV SPECIAL FUNCTIONS:

Strum-Liouville problem – Basic properties – Need for studying Strum-Liouville problems in physics – Specific examples for Strum-Liouville equation: (i) Legendre, (ii) Hermite and (iii) Laguerre differential equations – Power series solutions – Polynomials – Generating function – Rodrigue's formula – Recursion relations – Orthogonality relations.

UNIT – V PROBABILITY:

Definition – Addition rule of probability – Multiplication law of probability – Probability distribution – Binomial distribution – The first four moments of Binomial distribution – Poisson distribution – Normal distribution – The first four moments of Poisson and Normal distribution – Applications of Binomial, Poisson and Normal distributions – Central limit theorem.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Beta, Gamma and Delta functions – Concepts of regression, dimensionality reduction, density estimation and classification – Linear filters and wavelets.

REFERENCES:

1. H. K. Dass and R. Verma, *Mathematical Physics* (S. Chand, New Delhi, 2022).
2. B. S. Rajput, *Mathematical Physics* (Pragati Prakashan, Meerut, 2019).
3. N. Saran, S. D. Sharma and T. N. Trivedi, *Special Functions* (Pragati Prakashan, Meerut, 2021).
4. B. D. Gupta, *Mathematical Physics* (S. Chand, New Delhi, 2009).
5. Sathya Prakash, *Mathematical Physics with Classical Mechanics* (S. Chand, New Delhi, 2021).
6. D. G. Zill and M. R. Cullen, *Advanced Engineering Mathematics* (Narosa, New Delhi, 2020).
7. E. Kreysig, H. Kreysig and E. J. Norminton, *Advanced Engineering Mathematics* (John Wiley, New Delhi, 2011).
8. G. B. Arfken, H. J. Weber and R. E. Harris, *Mathematical Method for Physicists* (Academic, Cambridge, 2011).
9. T. L. Chow, *Mathematical Methods for Physicists: A Concise Introduction* (Cambridge University Press, Cambridge, 2014).
10. M. P. Boas, *Mathematical Methods in the Physical Sciences* (Wiley, New York, 2018).
11. Charlie Harper, *Introduction to Mathematical Physics* (Prentice Hall of India, New Delhi, 1998).
12. M. P. Deisenroth, A. A. Faisal and C. S. Ong, *Mathematics for Machine Learning* (Cambridge University Press, Cambridge, 2020).
13. C. Hurley and J. Mclean, *Wavelet Analysis and Methods* (Ed-Tech Press, London, 2018).
14. K. F. Reily, M. P. Hobson and S. J. Bence, Mathematical Methods for Physics and Engineering (Cambridge University Press, Cambridge, 2006).
15. https://nptel.ac.in/courses/115103036
16. http://www.issp.ac.ru/ebooks/books/open/Mathematical%20Methods.pdf

COURSE OUTCOME:

On the successful completion of the course, students will be able to

- Acquire the essential mathematical skills to solve problems in various branches of physics.
- Understand the usefulness of vector integration theorems and their utility in solving physics problems arising in electromagnetic theory and other branches of physics.
- Know the usefulness of matrices and matrix operations in solving physics and engineering problems.
- Attain sound knowledge of classical orthogonal polynomials and their applications in quantum physics.
- Solve various kinds of differential equations that model a variety of natural systems.

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First Year **CORE CHOICE COURSE I** **Semester I**

1) ANALOG AND DIGITAL ELECTRONICS

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To introduce students to the circuit designs and provide an in-depth knowledge on Digital Electronics.
- To understand the working of advanced semiconductor devices and digital circuits and the utility of OP-AMP.
- To learn the basics of integrated circuit fabrication, applications of timer IC-555 and the building block of digital systems.

UNIT – I SEMICONDUCTOR DEVICES:

SCR - DIAC - TRIAC – Construction, operation and V-I characteristics -Tunnel diode – Gunn diode **–** V-I characteristics. Basic monolithic ICs – Epitaxial growth – Masking – Etching - Impurity diffusion – Fabricating monolithic resistors, diodes, transistors, inductors and capacitors – Circuit layout – Contacts and inter connections.

UNIT – II OPERATIONAL AMPLIFIER:

Wien bridge and phase-shift oscillators – Triangular, saw-tooth and square-wave generators – Schmitt trigger – Voltage controlled oscillator – Phase-locked loops - Weighted resistor and binary R-2R ladder D/A converters - Counter type and successive approximation A/D converters – Solving simultaneous and differential equations.

UNIT – III 555 TIMER AND PHASE LOCKED LOOP:

Introduction – Description and functional diagram of 555 timer – Monostable operation – Frequency divider Astable operation – Frequency Shift Keying (FSK) generator. PLL Basic principle – Analog phase detector – Digital phase detector – PLL applications – Frequency multiplication/division.

Unit – IV Digital Circuits-I:

Digital comparator – Parity generator/checker – Data selector - BCD to decimal decoder – Seven segment decoder – Encoders – RS, JK, D, T and JK master-slave flip-flops.

UNIT – V DIGITAL CIRCUITS-II:

Serial-in serial-out, Serial-in parallel-out and Parallel-in serial-out shift registers – Synchronous, asynchronous, ring and up/down (using mod 10) counters - Multiplexers – De-multiplexers.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Nanoelectronic circuits – New Ohm's law – Energy harvesting – High speed electronic memories –Transmission lines.

REFERENCES:

1. D. P. Leach and A. P. Malvino, *Digital Principles and Applications* (McGraw Hill, New Delhi, 2006).
2. R. A. Gayakwad, *Op-Amps and Linear Integrated Circuits* (Pearson, New Delhi, 2021).
3. L. Floyd, *Electronic Devices* (Pearson, New Delhi, 2021).
4. J. Millman, C. Halkias and C. D. Parikh*, Integrated Electronics: Analog and Digital Circuits and Systems* (McGraw Hill, New Delhi, 2017).
5. V. Vjayendran, *Introduction to Integrated Electronics Digital and Analog* (S. Viswanathan Printers and Publishers, Chennai, 2014).
6. R. L. Geiger, P. E. Allen and N. R Strader, *VLSI Design Techniques for Analog and Digital Circuits* (McGraw Hill, Singapore, 2010).
7. D. R. Choudhury and S. B. Jain, *Linear Integrated Circuits* (New Age International Publications, New Delhi, 2018).
8. D. Chattopadhyay and P. C. Rakshit, *Electronics Fundamentals and Applications* (New Age International Publications, New Delhi, 2021).
9. T. F. Schubert and E. M. Kim, *Active and Nonlinear Electronics* (Wiley, New York, 1996).
10. J. Nagrath, *Electronics: Analong and Digital* (Prentice Hall of India, New Delhi, 2013).
11. W. D. Stanley, *Operational Amplifiers with Linear Integrated Circuits* (Pearson, New Delhi, 2002).
12. S. Salivahnan and S. Arivazhagan, *Digital Circuits and Design* (McGraw Hill, New Delhi, 2018).
13. C. Durkan, *Current at the Nanoscale* (World Scientific, London, 2013).
14. C. R. Paul, *Transmission Lines in Digital and Analog Electronic Systems* (Wiley, New York, 2010).
15. https://www2.mvcc.edu/users/faculty/jfiore/OpAmps/OperationalAmplifiersAndLinearICs_3E.pdf
16. https://nptel.ac.in/courses/108102112
17. https://nptel.ac.in/courses/108105132

COURSE OUTCOME:

On the successful completion of the course, students will be able to

- Understand the basic principle and the underlying concepts of electronic devices.
- Gain a clear understanding of the operations of electronic circuits.
- Design and analyze electronic circuits.
- Learn the applications of the operational amplifier and IC 555 and demonstrate them in timer.
- Realize the digital circuits and communication circuits.

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First Year **CORE CHOICE COURSE I** **Semester I**

2) OPTOELECTRONICS

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To expose the fundamental principles behind the operation of various light sources and detectors.
- To introduce fiber optic communications system and their widespread applications.
- To create awareness about the current scenario in fiber optic communications system and their mitigations.

UNIT – I OPTOELECTRONIC SOURCES:

Fundamental aspects of semiconductor physics – p-n junction of semiconductor – Current densities and injection efficiency – Injection luminescence and light emitting diode – Spectrum of injection luminescence – Internal and external quantum efficiency – LED Designs – Modulation response of LED – Injection Laser Diodes (ILD) – Modulation response of ILD – ILD structures.

UNIT – II OPTOELECTRONIC DETECTORS:

The basic principle of optoelectronic detection – Optical absorption coefficient and photocurrent – Quantum efficiency – Responsivity – long-wavelength cutoff - Types of photo diodes – p-n photodiode – p-i-n photodiode – Avalanche Photodiode – Photoconducting detectors – Noise considerations.

UNIT – III OPTOELECTRONIC MODULATORS:

Review of Basic Principles - Optical Polarization – Birefringence - Retardation Plates - Electro-Optic Modulators - Electro-Optic Effect - Longitudinal Electro-Optic Modulator - Transverse Electro-Optic Modulator - Acousto-Optic Modulators - Acousto-Optic Effect - Raman-Nath Modulator - Bragg Modulator.

UNIT – IV WAVELENGTH-DIVISION MULTIPLEXING:

The Concepts of Wavelength-Division Multiplexing (WDM) and dense Wavelength-Division Multiplexing DWDM - Passive Components – Couplers - Multiplexers and Demultiplexers - Active Components - Tunable Sources - Tunable Filters.

Unit – V Fiber-Optic Communication Systems:

System Design Considerations for Point-to-Point Links - Digital Systems - Analog Systems - System Architectures - Point-to-Point Links - Distribution Networks - Local Area Networks - Non-Linear Effects and System Performance - Stimulated Raman Scattering - Stimulated Brillouin Scattering - Four-Wave Mixing – Self- and Cross-Phase Modulation.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Fiber-Optic Sensors and its classification - Fiber-Optic Mach-Zehnder Interferometric Sensor - Fiber-Optic Gyroscope - Spectrally Modulated Sensors. Guided wave optoelectronics – Nano-optoelectronics - Laser metrology and spectroscopy.

REFERENCES:

1. R. P. Khare, Fiber Optics and Optoelectronics (Oxford University Press, Oxford, 2004).
2. J. Singh, Optoelectronics: An Introduction to Materials and Devices (McGraw Hill, New Delhi, 2013).
3. N. K. Dutta, X. Zhang, Optoelectronic Devices (World Scientific, Singapore, 2018).
4. A. K. Maini, Lasers and Optoelectronics: Fundamentals, Devices and Applications (Wiley, New York, 2013).
5. M. A. Parker, Physics of Optoelectronics (CRC, Boca Raton, 2018).
6. S. C. Gupta, Optoelectronic Devices and Systems (Prentice Hall of India, New Delhi, 2015).
7. G. P. Agarwal, Nonlinear Fiber Optics (Academic Press, Cambridge, 2019).
8. J. Wilson and J. F. B. Hawkes, Optoelectronics: An Introduction (Prentice Hall of India, New Delhi, 1989).
9. D. K. Mynbaev and L. L. Scheiner, Fiber-Optic Communications Technology (Pearson, New Delhi, 2011).
10. P. Bhattacharya, Semiconductor Optoelectronic Devices (Pearson, New Delhi, 2017)
11. L. F Mollenauer, J. P. Gordon and P. V. Mamyshev, Solitons in Optical Fibers: Fundamentals and Applications (Academic Press, Cambridge, 2006).
12. J. P. Dakin and R. Brown, Handbook of Optoelectronics (CRC Press, Boca Raton, 2020).
13. W. S. C. Chang, Fundamentals of Guided Wave Optoelectronics Devices (Cambridge University Press, Cambridge, 2010).
14. A. Donges and R. Noll, Laser Measurement Technology: Fundamentals and Applications (Springer, Heilderberg, 2016).
15. https://nptel.ac.in/courses/115102026

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

- Explain the working mechanisms of various types of LEDs.
- Comprehend the fundamentals of the coherent light source (LD).
- Explain the working principles of various types of photodetectors and apply them to design various modulators.
- Analyze the various types of fiber sensors.
- Understand the digital circuits and communication circuits.

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First Year **CORE PRACTICAL I** **Semester I**

GENERAL PHYSICS AND ELECTRONICS I

Code: **(Practical)** **Credit: 3**

COURSE OBJECTIVES:

Experimental determination of certain physical constants and properties and verification of characteristics and applications of electronic components and devices.

A. GENERAL PHYSICS EXPERIMENTS:

1. Determination of q, n, σ by elliptical fringes method.
2. Determination of Stefan's constant.
3. Determination of bulk modulus of a liquid by ultrasonic wave propagation.
4. Determination of Rydberg's constant.
5. Study of Hall effect in a semiconductor.
6. Determination of dielectric constant at high frequency by Lecher wire.
7. Michelson interferometer - Determination of wavelength of monochromatic source.
8. Determination of wavelength of monochromatic source using biprism.
9. Charge of an electron by spectrometer.
10. Polarization of light - Verification of Malus law and Brewster angle of glass.
11. BH loop – Energy loss of a magnetic material – Anchor ring using B.G./CRO.
12. Determination of e/m of an electron by magnetron method.

B. ELECTRONICS EXPERIMENTS:

1. Construction of dual regulated power supply.
2. Astable and monostable multivibrators using IC555.
3. Characteristics of UJT.
4. Characteristics of SCR.
5. Design and study of Wein bridge oscillator using op-amp.
6. Design and study of square and triangular waves generators using op-amp.
7. V-I characteristics of a solar cell.
8. Operation of shift register using serial-in serial-out, serial-in parallel-out and parallel-in serial-out.
9. Digital to analog converter - R-2R and weighted method.
10. BCD to 7 segment display.
11. Study of A/D converter - Counter ramp type method.

REFERENCES:

1. J. Millman and C. C. Halkias, *Electronic Devices and Circuits* (McGraw Hill, New Delhi, 1985).
2. G. Kennedy, *Electronic Communication Systems* (McGraw Hill, New Delhi, 1994).

3. D. R. Choudhury and S. Jain, *Linear Integrated circuits* (New Age International, New Delhi, 2001)
4. L. O. Chua, C. A. Desoer and E. S. Kuh, *Linear and Nonlinear circuits* (McGraw Hill, Singapore, 1987).
5. K. A. Navas, *Electronics Lab Manual*, Volume I&II (Rajat Publications, New Delhi, 2015).
6. M. N. Avadhanulu, A. A. Dani and P. M. Pokley, *Experiments in Engineering Physics* (S. Chand, New Delhi, 1999).

COURSE OUTCOME:

On the successful completion of the course, students will be able to

- Understand the different moduli using elliptical fringes.
- Gain knowledge of the Hydrogen spectrum.
- Comprehend the principle of Hall effect.
- Appreciate the operation of multivibrators using 555 Timer.
- Work on analog and digital circuits.

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First Year **ELECTIVE COURSE I** **Semester I**

1) COMPUTATIONAL PHYSICS WITH C++

Code: **(Theory)** **Credit: 4**

Objectives:

- To impart knowledge of curve fitting, interpolation, and linear and nonlinear equations.
- To familiarize numerical integration and differentiation.
- To provide the knowledge of C ++ language constructs.

UNIT – I THEORY OF EQUATIONS, THEIR ROOTS AND CURVE FITTING:

Descartes' rules and signs - Cardon method of solving cubic and biquadratic equation - Roots of algebraic and transcendental equations: Graphical method – Bisection method – Method of false position – Newton-Raphson method. Curve Fitting: Method of least squares – Normal equations, straight line fit, exponential and parabola fits.

UNIT – II SOLUTION TO SIMULTANEOUS LINEAR ALGEBRAIC EQUATIONS:

Solution using inverse of a matrix – Crammer rule – Gauss elimination method – Jordan method – Crout reduction method – Factorization method – Jacobi iterative method – Gauss-Seidel iterative method – Solution of tridiagonal system.

UNIT – III INTERPOLATION AND NUMERICAL INTEGRATION:

Interpolation: Divided differences - Lagrange interpolation formula. Integration of a function: Trapezoidal rule for single integral and Simpson's rule for single Integral - 1/3 and 3/8 rules. Integration of ODE: Euler formula – modified Euler formula – Fourth order Runge-Kutta method.

UNIT – IV FUNDAMENTALS OF C++ LANGUAGE:

Object Oriented Programming paradigm – Benefits of OOP - Applications of C++ - Structure of C++ program – Tokens: Keywords, Identifiers and Constants – Basic data types – User-defined data types – Scope resolution operator. Control structures: Decision making with simple if - if-else - nesting of if-else - switch - goto statement - Looping with while - do-while - for statements - break and continue statements-arrays -Library functions - User-defined functions.

UNIT – V SPECIAL FEATURES OF C++:

Encapsulation – Polymorphism - Classes and objects – Specifying a class – Creating objects – Accessing class members – Defining member functions – Inline functions - Arrays of objects – Objects as function arguments– Returning objects - Friendly functions - Constructors – Destructors – Function overloading -Operator overloading – Overloading unary operators - Overloading binary operators – Rules for overloading operators - Derived classes – Inheritance - Files.

Unit – VI Current Contours (For continuous internal assessment only):

Advanced interpolation methods and certain advanced features of C++: Newton divided difference interpolation formula for unequal intervals - Derivation of Newton forward interpolation formula from Newton divided difference formula.

REFERENCES:

1. H. S. Nita, Numerical Methods with C++ programming (Prentice Hall of India, New Delhi, 2009).
2. D. Ravichandran, Programming with C++ (McGraw Hill, New Delhi, 2014).
3. E. Balagurusamy, Numerical Methods (McGraw Hill, Chennai, 2017).
4. E. Balagurusamy, Object Oriented Programming with C++ (McGraw Hill, New Delhi, 2020).
5. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods: Problems and Solutions (New Age International, New Delhi, 2020).
6. K. B. Rajeev, Fundamentals of Numerical Methods (Narosa, New Delhi, 2018).
7. D. Walker, Computational Physics (Scientific International, New Delhi, 2015).
8. S. Bjarne, The C++ Programming Language (Pearson, New Delhi, 2022).
9. Y. Kanetkar, Let Us C++ (BPB Publications, New Delhi, 2020).
10. R. Rajaram, Object Oriented Programming and C++ (New Age International, New Delhi, 1999).
11. http://compphysics.github.io/ComputationalPhysics/doc/pub/learningcpp/html/learningcpp-bs.html
12. https://nptel.ac.in/courses/122106033

COURSE OUTCOME:

On the successful completion of the course, students will be able to

- Know about curve fitting, interpolation, and linear and nonlinear equations.
- Numerically integrate and differentiate.
- Use C ++ language constructs for numerical computation.
- Apply numerical methods to solve and visualize physical problems.
- Develop an idea to write a programme using python.

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First Year **ELECTIVE COURSE I** **Semester I**

2) PHYSICS SIMULATIONS WITH PYTHON

Code: **(Theory)** **Credit: 4**

COURSE OBJECTIVES:

- To introduce Python language and different Python modules.
- To give an exposure to solve and visualize the physical problems using Python.
- To develop the idea of writing programs using different numerical methods.

UNIT – I INTRODUCTION TO PYTHON LANGUAGE:

Input and Output methods – Variables – Operators – Expressions and statements – Strings – Lists – List Functions and methods – Sets – Set Function and methods – Tuples and Dictionaries – Conditionals, Iterations and Looping – Functions and Modules – File Input and File Output.

UNIT – II NUMPY MODULES – ARRAYS AND MATRICES:

Creation of Arrays and Matrices (arrange, line space, zeros, ones, random, reshape, copying arrays) - Arithmetic Operations - Cross Product – Dot Product – Saving and Restoring – Matrix Inversion – Solution of Simultaneous equations.

UNIT – III MATPLOTLIB MODULE – DATA VISUALIZATION:

Methods defined in Matplotlib – Plotting graphs – Multiple Plots – Polar plots – Pie charts – Plotting Sine, Log, Exponential, Legendre, Bessel, Gaussian and Gamma functions – Parametric Plots.

UNIT – IV NUMERIC METHODS:

Inverse of a Function – Interpolation with a Cubic Spline – Zeros of Polynomials – Monte Carlo methods – Simple Integration – Integration by Importance sampling, Eigenvalues and Eigenfunctions – Shooting and Relaxation methods – Sampled Data: Sampling Theorem – Fast Fourier Transform.

UNIT – V INTRODUCTION TO COMPUTATIONAL APPROACH IN PHYSICS:

Formulation: From Analytical methods to Numerical Methods – Oscillatory motions – Ideal Simple Harmonic Oscillator (Euler Method) – Driven LCR Circuit (R-K Method) – Circuit Analysis using Kirchoff's Law – Central Field Motion – Monte Carlo Simulations value of π – Simulation of Radioactivity – Logistic Maps.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

One Dimension Motion: Falling Objects: Freely falling body – Fall of body in viscous medium – Two dimensional motion: Projectile motion (Euler method) – Motion of damped oscillator (Feymann Newton method) – Logistic maps – Quantum Mechanics: 1D Schrodinger equation – Wavefunction and eigenvalues.

REFERENCES:

1. S. S. Shastry, Introductory Methods of Numerical Analysis (Prentice Hall of India, New Delhi, 2012).
2. B. S. Grewal, Numerical Methods in Engineering and Science (Khanna Publishers, New Delhi, 2013)
3. J. B. Scarborough, Numerical Mathematical Analysis (Oxford & IBH Publishing, New Delhi, 2005).
4. B.P. A. Kumar, Python for Education (Inter University Accelerator Centre, New Delhi, 2010).
5. T. E. Oliphant, Guide to Numpy (Createspace Independent, California, 2015).
6. S. Tosi, Matplotlib for Python Developers (Packt Publishing, Brimingham, 2010).
7. D. M. Beazley, Python Essential Reference (Addison Wesley, New York, 2009).
8. W. J. Chun, Core Python Applications Programming (Pearson, New Delhi, 2016).
9. E. Balagurusamy, Numerical Methods (McGraw Hill, New Delhi, 2017).
10. T. Veerarajan and T. Ramachandran, Numerical Methods (McGraw Hill, New Delhi, 2018).
11. V. K. Mittal, R. C. Verma and S. C. Gupta, Computational Physics (Ane Books, New Delhi, 2021).
12. J. Kiusalaas, Numerical Methods in Engineering with Python (Cambridge University Press, Cambridge, 2013).
13. https://greenteapress.com/modsimpy/ModSimPy3.pdf
14. https://archive.nptel.ac.in/courses/115/104/115104095/

COURSE OUTCOME:

On the successful completion of the course, students will be able to

- Familiarize with Python language.
- Understand the basics of Python.
- Acquaint with different Python modules.
- Use numerical methods to solve and visualize the physical problems.
- Develop ideas to write a programme using python.

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First Year | **VALUE ADDED COURSE I** | **Semester I**

RESEARCH PUBLICATION AND ETHICS

Code: | **(Theory)** | **Credit: *2**

COURSE OBJECTIVES:

- To provide the fundamental knowledge on basics of research ethics, research integrity and publication ethics.
- To expose research misconduct and predatory publications.
- To explore citation databases, open access publications, research metrics (citations, h-index, Impact Factor, etc.)

UNIT – I PHILOSOPHY AND ETHICS:

Introduction to philosophy: definition - Nature and scope - Concept - Branches – Ethics: Definition - Moral philosophy - Nature of moral judgements and reactions.

UNIT – II SCIENTIFIC CONDUCT:

Ethics with respect to science and research – Intellectual honesty and research integrity – Scientific misconducts: Falsification, Fabrication and Plagiarism (FFP) – Redundant Publications: duplicate and overlapping publications, salami slicing – Selective reporting and misrepresentation of data.

UNIT – III PUBLICATION ETHICS:

Publication ethics: definition, introduction and importance – Conflicts of interest – Publication misconduct: definition, concept, problems that lead to unethical behavior and vice – versa, types – Violation of publication ethics, authorship and contributorship – Identification of publication misconduct, complaints and appeals – Predatory publisher and journals.

UNIT – IV OPEN ACCESS PUBLISHING AND PLAGIARISM TOOLS:

Open access publications and initiatives – SHERPA/RoMEO online resource to check publisher copyright & self – archiving policies – Software tool to identify predatory publications developed by SPPU – Journal finger / journal suggestion tolls viz. JANE, Elsevier Journal Finder, Springer, Journal Suggester, etc.
Use of plagiarism software like Turnitin, Urkund and other open source software tools.

UNIT – V DATABASES AND RESEARCH METRICS:

Databases: Indexing databases, Citation databases: Web of Science, Scopus, etc.
Research Metrics: Impact Factor of journal as per journal Citations Report, SNIP, SJR, IPP, Citation score – Metrics: h-index, g index, i10 Index, altmetrics.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Group Discussions: Subject specific ethical issues and authorship - Conflicts of interest - Complaints and appeals: examples.

REFERENCES:

1. K. Ravichandran, A. T. Ravichandran, M. Ayyanar and P. Kavitha, *Research Methodology and Publication Ethics* (Jazym Publications, Tiruchirappalli, 2022).
2. N. H. Steneck, *Introduction to the Responsible Conduct of Research* (Office of Research Integrity, Maryland, 2007).
3. P. Oliver, *Student's Guide to Research Ethics* (Open University Press, United Kingdom, 2003).
4. A. E. Shamoo and D. B. Resnik, *Responsible Conduct of Research* (Oxford University Press, Oxford, 2003).
5. A. B.H. Dursaton and M. Poole, *Thesis and Assignment Writing* (Wiley Eastern, New York, 1997).
6. B. Gustavii, *How to Write and Illustrate Scientific Papers?* (Cambridge University Press, Cambridge, 2008).
7. K. S. Bordens and B. B. Abbott, *Research Design and Methods* (McGraw Hill, New York, 2008).
8. A. M. Graziano and M. L. Raulin, *Research Methods – A Process of Inquiry* (Pearson, New York, 2020).
9. https://ori.hhs.gov/sites/default/files/rcrintro.pdf
10. https://www.enago.co.kr/academy/wp-content/uploads/2018/05/Research_Ethics.pub_V2.pdf

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

- Know about the publication ethics and publication misconducts.
- Understand the research ethics and research integrity.
- Understand research misconduct and predatory publications.
- Differentiate citation databases, open access publication and research metrics.
- Use plagiarism and open source software tools.

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First Year | **CORE COURSE III** | **Semester II**

QUANTUM MECHANICS

Code: | **(Theory)** | **Credit: 5**

COURSE OBJECTIVES:

- To enhance the knowledge of the foundations of Quantum Mechanics.
- To get acquainted with solving problems using the Schrödinger equation.
- To provide a basic understanding of state vectors in abstract representation.

UNIT – I FOUNDATIONS OF QUANTUM MECHANICS:

Equations of motion of matter waves: Postulates of Quantum mechanics - Time independent Schrödinger equation, Time dependent Schrödinger equations-Physical interpretation of wave function-Normalized and orthogonal wave functions – Solution of Schrödinger equation - Stationary state solutions – Expectation value of dynamical quantities – Probability current density – Ehrenfest's theorem – Wave packets.

UNIT – II EXACTLY SOLVABLE SYSTEMS:

The free particle – One and three dimensional Harmonic oscillator - Particle in a box– Rigid rotator with free axis, with fixed plane – Hydrogen atom — Rectangular potential barrier – Square well potential.

UNIT – III LINEAR VECTOR SPACE AND FORMULATION OF QUANTUM MECHANICS:

Linear vector space – The Hilbert space, Dimensions and basis – Operator and properties – Representation of vectors and operators, Commutator, Function of operator, Eigenvalue and Eigenvector – Matrix representation of bras, kets, and operator – Coordinate and momentum representation and their connection – Projection operator.

UNIT – IV ANGULAR MOMENTUM:

Angular momentum operators – The rotation operator and angular momentum – Spin angular momentum – Total angular momentum operator – Commutation relation – Eigenvalue of angular momentum operator – Matrix Representation – Addition of angular momentum – Clebsch-Gordan coefficients.

UNIT – V PARTICLES AND SPIN:

Physical meaning of identity – Symmetric and anti-symmetric wave functions – Exchange degeneracy – Particle exchange operator – Distinguishability of identical particle – The Pauli exclusion principle – Spin angular momentum – Electron spin hypothesis - (Pauli) spin matrix for electron – Commutation relations – Two component wave function – Pauli operator – Pauli Eigenvalues and Eigenfunction – Electron-spin formulation – Spin matrix and Eigenmatrix – Spin matrices and Eigenfunctions.

UNIT – IV CURRENT CONTOURS (For continuous internal assessment only):

Time dependence of density matrix – Symmetry and anti-symmetric wave functions of hydrogen molecule. Concepts of Quantum circuits, computation and information.

REFERENCES:

1. P. M. Mathews and K. Venkatesan, *Quantum Mechanics* (McGraw Hill, New Delhi, 2010).
2. Satya Prakash, *Advanced Quantum Mechanics* (Kedar Nath Ram Nath, New Delhi, 2014).
3. S. Rajasekar and R. Velusamy, *Quantum Mechanics I: The Fundamentals* (CRC Press, Boca Raton, 2022).
4. D. J. Griffiths, *Introduction to Quantum Mechanics* (Cambridge University Press, Cambridge, 2018).
5. V. Murugan, *Quantum Mechanics* (Pearson, New Delhi, 2014).
6. A. Kumar, *Fundamental of Quantum Mechanics* (Cambridge University Press, Cambridge, 2018).
7. G. Aruldhas, Quantum Mechanics (Prentice Hall of India, New Delhi, 2008).
8. A. K. Ghatak and S. Lokanathan, *Quantum Mechanics-Theory and Applications* (Trinity, New Delhi, 2019).
9. N. Zettili, *Quantum Mechanics: Concepts and Application* (Wiley, New Jersey, 2022).
10. D. Mclntyre, C. A. Manogue and J. Tate, *Quantum Mechanics* (Pearson, New York, 2015).
11. L. I. Schiff, J. Bandhyopadhyay, *Quantum Mechanics* (McGraw Hill, New Delhi, 2017).
12. A. D. Vos, S. De Baerdemacker and Y. V. Rentergem, *Synthesis of Quantum Circuits vs. Synthesis of Classical Reversible Circuits* (Morgan and Claypool, California, 2018).
13. M. A. Nielsen and I. L. Chuang, *Quantum Computation and Quantum Information* (Cambridge University Press, Cambridge, 2011).
14. https://nptel.ac.in/courses/122106034

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

- Understand the foundations of Quantum Mechanics.
- Develop skills to solve Schrödinger's equation with various potentials.
- Familiarize with the Dirac notations and operator algebra.
- Acquire knowledge about the theory of identical particle and spins.
- Learn quantum mechanical angular momentum theory.

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First Year **CORE COURSE IV** **Semester II**

ELECTROMAGNETIC THEORY

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To impart an understanding of the fundamental aspects of electromagnetic theory.
- To build a strong base in Maxwell's equations.
- To bestow knowledge about dispersion and scattering of electromagnetic waves.

UNIT – I ELECTROSTATICS, MAGNETOSTATICS AND ELECTROMOTIVE FORCE:

Coulomb's law - Gauss's law in differential form - Poisson's equation - Laplace's equation – Work and energy in electrostatics – Energy of a point charge distribution – Dielectrics – Induced dipoles – Gauss's Law in the presence of dielectrics. Lorentz force– Biot-Savart Law – Divergence and curl of B – Ampere's Law – Comparison of magnetostatics and electrostatics – Magnetic vector potential. Ohm's Law – Electromotive force - Faraday's Law – induced electric field – Energy in magnetic field.

UNIT – II MAXWELL'S EQUATION AND ELECTROMAGNETIC WAVES:

Maxwell's equations – Poynting theorem - Wave equation in terms of scalar and vector potential – Transverse nature of electromagnetic wave- Conservation of energy and momentum - Continuity equation - Propagation of plane electromagnetic waves in (a) free space, (b) Isotropic and Anisotropic non-conducting medium and (c) conducting medium - Skin depth - Polarization of electromagnetic waves.

UNIT – III APPLICATIONS OF ELECTROMAGNETIC WAVES:

Boundary conditions at the surface of discontinuity - Reflection and refraction of electromagnetic waves at the interface of non-conducting media –Fresnel's equations – Reflection and transmission coefficients at the interface between two dielectric media - Brewster's law and degree of polarization -Total internal reflection.

UNIT – IV MICROWAVE GENERATION AND WAVEGUIDES:

Klystron, Magnetron -Travelling wave tube - Rectangular and cylindrical waveguides - TM mode – TE mode – TEM mode - Resonant cavities.

UNIT – V DISPERSION AND SCATTERING OF ELECTROMAGNETIC WAVES:

Normal and Anomalous dispersion – Dispersion in Gases – Experimental demonstration of Anomalous dispersion in gases- Solids and Liquids – Clasusius Mossotti relation – Lorentz formula – Scattering and scattering parameters -

Theory of scattering of electromagnetic waves – Polarization of scattered light – Coherence and incoherence of scattered light.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Introduction - Conditions for plasma existence – Occurrence of plasma – Magneto hydrodynamics – Magnetic confinement -Pinch Effect-Instabilities- Plasma waves. Waves in guiding structures – Emission of electromagnetic waves – Cellular phone applications – Electromagnetic tunnelling - Photonic crystals.

REFERENCES:

1. Satya Prakash, *Electromagnetic Theory and Electrodynamics* (Kedar Nath Ram Nath, New Delhi, 2016).
2. D. J. Griffith, *Introduction to Electrodynamics* (Pearson, New York, 2013)
3. K. K. Chopra and G. C. Agarwal, *Introduction to Electromagnetic Theory* (Kedar Nath Ram Nath, Meerut, 2010).
4. Narayana Rao, *Basic Electromagnetics with Application* (Prentice Hall of India, New Delhi, 1997).
5. B. B. Laud, *Electromagnetics* (New Age International Publishers, New Delhi, 2011).
6. A. K. Saxena, *Electromagnetic Theory and Applications* (Narosa, New Delhi, 2013).
7. J. R. Reitz, F. J. Milford and R. W. Christy, *Foundations of Electromagnetic Theory* (Pearson, New Delhi, 2010).
8. J. D. Jackson, *Classical Electrodynamics* (Wiley, New York, 2021).
9. W. Miah, *Fundamentals of Electromagnetics* (McGraw Hill, New York, 1980).
10. D. K. Cheng, *Field and Wave Electromagnetics* (Pearson, New Delhi, 2015).
11. J. D. Joannopoulo, S. G. Johnson, J. N. Winn and R. D. Meade, *Photonic Crystals: Molding the Flow of Light* (Princeton University Press, Princeton, 2008).
12. https://nptel.ac.in/courses/108104087

COURSE OUTCOME:

On the successful completion of the course, students will be able to

- Describe the fundamentals of electro and magneto statics.
- Understand Maxwell's equations, and scalar and vector potentials.
- Acknowledge the applications of electromagnetic waves to reflection and refraction.
- Describe the application of dispersion and scattering of electromagnetic waves.
- Realize the existence of plasma, and understand the fundamentals of magneto hydrodynamics.

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First Year **CORE CHOICE COURSE II** **Semester II**

1) ADVANCED MATHEMATICAL PHYSICS

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To give a strong mathematical foundation in linear vector space, tensors and complex analysis.
- To provide a basic understanding of hypergeometric functions.
- To impart knowledge on applying group theory to physical problems.

UNIT – I LINEAR VECTOR SPACE:

Definition of linear vector space – Examples – Linear independence – Basis and dimensions of a vector space – Scalar product – Schwartz Inequality – Orthogonality of vectors – Linear transformations – Linear operator – Matrix representation of a linear operator.

UNIT – II TENSORS:

Tensors – Rank of the Tensors – Covariant and Contravariant Tensors – Mixed Tensors – Symmetric and Anti-symmetric Tensors – Invariant Tensors – Kronecker Delta – Levi Civita Symbol – Contraction – Tensor product – Exterior Product – Metric Tensor – Application – Stress and Strain Tensors – Polarizability Tensor - Dynamics of rigid bodies.

UNIT – III COMPLEX ANALYSIS:

Complex variables and functions – Analytic functions – Cauchy-Riemann conditions with proof– Complex integration – Cauchy's integral theorem and integral formula – Taylor's and Laurent's series – Residues and Singularities – Poles – Cauchy's residue theorem – Computations of Residue – Evaluation of the definite integrals – Principal value integrals.

UNIT – IV HYPERGEOMETRIC FUNCTION:

Hypergeometric series – Elementary Properties of Hypergeometric function – Integral representation of Hypergeometric function – Solution of Hypergeometric differential equation – Confluent Hypergeometric function - Properties of confluent Hypergeometric function – Representation of various functions in terms of Hypergeometric and confluent Hypergeometric functions.

UNIT – V GROUP THEORY:

Definition of Group theory – Group table – Sub Group – Classes – Isomorphism and Homomorphism – Schur's Lemma – Orthogonality theorem – The character of representation – Reducible and Irreducible – Formation of character table – Point Groups – Elementary ideas of rotation Groups.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Solving three dimensional inhomogeneous differential equations using Green's functions technique - Fourier spectrum analysis for real time data of nonlinear phenomena like Tsunami waves and unusual seasonal data - Evaluation of integrals using residues for natural phenomena.

REFERENCES:

1. H. K. Dass and R. Verma, *Mathematical Physics* (S. Chand, New Delhi, 2022).
2. G. B. Arfken, H. J. Weber and R. E. Harris, *Mathematical Method for Physicists* (Academic Press, Cambridge, 2011).
3. T. L. Chow, *Mathematical Methods for Physicists: A Concise Introduction* (Cambridge University Press, Cambridge, 2000).
4. M. P. Boas, *Mathematical Methods in the Physical Sciences* (Wiley, New York, 2005).
5. D. G. Zill and M. R. Cullen, *Advanced Engineering Mathematics* (Narosa, New Delhi, 2020).
6. V. K. Sharma, *Matrix methods and Vector Spaces in Physics* (Prentice Hall of India, New Delhi, 2009).
7. S. Rajput, *Mathematical Physics* (Pragati Prakashan, Meerut, 2020).
8. N. Saran, S. D. Sharma and T. N. Trivedi, *Special Functions* (Pragati Prakashan, Meerut, 2002).
9. G. Zill and P. D. Shanahan, *Complex Analysis* (Pearson, New Delhi, 2017).
10. Harper, *Introduction to Mathematical Physics* (Prentice Hall of India, New Delhi, 1993).
11. https://nptel.ac.in/courses/115105097
12. https://nptel.ac.in/courses/115103036

COURSE OUTCOME:

On the successful completion of the course, students will be able to

- Develop the essential mathematical skills to solve problems in various branches of physics.
- Explain the usefulness of linear vector space and tensors in physics.
- Understand the usefulness of complex analysis that arise in various physical systems.
- Illustrate the properties of hyper geometric functions and their applications.
- Apply group theory to various physical problems.

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First Year **CORE CHOICE COURSE II** **Semester II**

2) COMPLEX SYSTEMS AND NETWORKS

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To enhance understanding of Network Science.
- To build a strong base on the foundation of Complex Systems in Network structure.
- To provide an insight into the structure, dynamics and evolution of various networks.

UNIT – I GRAPH THEORY:

Vertices and edges - Graph theoretic measures of network structures: Degree, average degree, degree distribution, paths and distances, connectedness, clustering coefficients – Undirected, directed, bipartite, weighted and hypergraphs – Adjacent matrix – Sparseness.

UNIT – II RANDOM NETWORK:

Random graphs – Mean number of edges and mean degree – Degree distribution – Clustering coefficient – Giant component – Small component: Sizes, Average size, Complete distribution – Paths and lengths – Problems with the random graph.

UNIT – III THE SMALL-WORLD AND SCALE-FREE NETWORKS:

The Small-world model: Degree distribution - Clustering coefficients - Average path lengths – The scale-free networks : Power laws – Hubs – The meaning of scale-free – Universality – Ultra-small property – The role of degree exponent – Generating networks with arbitrary degree distribution.

UNIT - -IV MODELS OF NETWORK FORMATION:

Preferential attachment – The model of Barab**ási** and Albert – Degree dynamics – Degree distribution – The absence of preferential attachment – Measuring preferential attachment – Non-linear preferential attachment – The origins of preferential attachments – Diameter and clustering coefficient.

UNIT – V PROCESSES ON NETWORKS:

Percolation – Uniform removal of vertices - Non-uniform removal of vertices – percolation in real worlds – Traffic – Congestion – Robustness - Web search – Searching distributed databases - Message passing.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

The telephone network – Interviews and questionnaires - The World Wide Web – Neural networks – Ecological networks. Agent based modelling and network dynamics – Econophysics – Neuronal dynamics.

REFERENCES:

1. M. E. J. Newmann, Networks: An Introduction (Oxford University Press, Oxford, 2010).
2. L. Barabási, Network Science (Cambridge University Press, Cambridge, 2016).
3. S. Dorogovstev, Lectures on Complex Networks (Claredon Press, Oxford, 2010).
4. S. Bornholdt and H. G. Schuster, Handbook of Graphs and Networks: From the Genome to the Internet (Wiley, New York, 2005).
5. S. A. Kauffman, Origins of Order (Oxford University Press, Oxford, 1993).
6. Y. B. Yam, Dynamics of Complex Systems (CRC, New York, 2020).
7. Namatame and S. H. Chen, Agent Based Modelling and Network Dynamics (Oxford University Press, Oxford, 2016).
8. R. N. Mantegna and H. E. Stanley, Introduction to Econophysics (Cambridge University Press, Cambridge, 2007).
9. https://nptel.ac.in/courses/106105154
10. https://cse.iitkgp.ac.in/~animeshm/scribe.pdf

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

- Apply the knowledge of graph theory in solving complex physics problems.
- Characterize the structure of various complex networks.
- Model and analyze various phenomena that occur in nature.
- Understand the evolution of various complex networks.
- Connect the structure and the functions of the networks.

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First Year **CORE PRACTICAL II** **Semester II**

GENERAL PHYSICS AND ELECTRONICS II

Code: **(Practical)** **Credit: 3**

COURSE OBJECTIVES:

Experimental determination of certain physical constants and properties and verification of characteristics and applications of electronic components and devices.

A. GENERAL PHYSICS EXPERIMENTS

1. Determination of q, n, σ by hyperbolic fringes method.
2. Determination of thermal conductivity of a good conductor – Forbe's method.
3. Determination of bulk modulus of a liquid using ultrasonic interferometer.
4. Planck's constant - Photoelectric cell.
5. Band gap energy of a semiconductor - Four-probe method.
6. Determination of L of a coil by Anderson's method.
7. Determination of e/m of an electron by Thomson's method.
8. Determinations of wavelength of a laser source using plane diffraction grating and thickness of a wire.
9. Polarizability of liquids by finding the refractive indices at different wavelengths.
10. Magnetic susceptibility of a paramagnetic solution using Quincke's tube method.
11. Determination of specific rotatory power of a liquid using polarimeter.
12. Determination of magnetic susceptibility of liquid by Guoy method.

B. ELECTRONICS EXPERIMENTS:

1. Characteristics of LED and photo diodes.
2. Characteristics of laser diode and tunnel diode.
3. Study of phase-shift oscillator using op-amp.
4. Design and study of Schmitt trigger using op-amp.
5. Flip-flops - RS, JK and D.
6. Decoder and encoder.
7. Pulse-width and pulse-position modulations.
8. Digital comparator using XOR and NAND gates.
9. Characteristics of LDR.
10. Pulse code modulation and demodulation.
11. Voltage controlled oscillator using IC 555.
12. Design of AC/DC voltage regulator using SCR.

REFERENCES:

1. J. Millman and C. C. Halkias, Electronic Devices and Circuits (McGraw Hill, New Delhi, 1985).
2. G. Kennedy, Electronic Communication Systems (McGraw Hill, New Delhi, 1994).
3. D. R. Choudhury and S. Jain, Linear Integrated Circuits (New Age International, New Delhi, 2001).
4. K. A. Navas, Electronics Lab Manual, Volume I&II (Rajat Publications, New Delhi, 2015).
5. M. N. Avadhanulu, A. A. Dani and P. M. Pokley, Experiments in Engineering Physics (S. Chand, New Delhi, 1999).

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

- Understand the different moduli using hyperbolic fringes.
- Gain knowledge of thermal conductivity.
- Appreciate the properties of liquid using ultrasonic waves.
- Understand the characteristics of LED and Photodiodes.
- Work on combinational and sequential circuits.

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First Year **ELECTIVE COURSE II** **Semester II**

1) MICROPROCESSOR AND MICROCONTROLLER

Code: **(Theory)** **Credit: 4**

COURSE OBJECTIVES:

- To learn the architecture and programming and applications of Intel 8085.
- To know the various peripheral devices and interfacing applications.
- To understand the architecture and programming, and applications of Intel 8051.

UNIT - I MICROPROCESSOR ARCHITECTURE AND INTERFACING:

Intel 8085 microprocessor architecture – Pin configuration – Instruction cycle – Timing diagram – Instruction and data formats – Addressing modes - Memory mapping and I/O mapping I/O scheme - Memory mapping I/O interfacing - Data transfer schemes - Synchronous and asynchronous data transfer – Interrupt driven data transfer - Interrupts of Intel 8085.

UNIT - II ASSEMBLY LANGUAGE PROGRAMS (8085 ONLY):

BCD arithmetic - Addition and subtraction two 8-bit and 16-bit numbers - Largest and smallest numbers in a data set – Ascending order and descending order – Sum of a series of a 8-bit numbers – Sum of a series of multibyte decimal numbers – Square root of a number – Block movement of data - Time delay – Square-wave generator.

UNIT - III PERIPHERAL DEVICES AND MICROPROCESSOR APPLICATIONS:

Generation of control signals for memory and I/O devices - I/O ports - Programmable peripheral interface - Architecture of 8255A - Control word - Programmable interrupt controller (8259) - Programmable counter - Intel 8253 - Architecture, control word and operation – Block diagram and interfacing of analog to digital converter (ADC 0800) – Digital to analog converter (DAC 0800) – Stepper motor – Traffic control.

UNIT - IV MICROCONTROLLER 8051:

Features of 8051 – Architecture – Pin configuration – Memory organization -- External data and program memory - Counters and timers – Serial data input/output - Interrupt structure – External interrupts – Addressing modes - Comparison between microprocessor and microcontroller.

UNIT - V 8051 INSTRUCTION SET AND PROGRAMMING:

Instruction set – Data transfer, arithmetic and logical instructions – Boolean variable manipulation instructions – Program and machine control instructions – Simple programs – Addition and subtraction of two 8-bit and 16-bit numbers – Division – Multiplication - Largest number in a set – Sum of a set of numbers.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Discussion and demonstration of water level indicator – Security alarm – EVM - Microprocessor system design – FPGAs – Embedded systems - Raspberry Pi.

REFERENCES:

1. B. Ram, Fundamentals of Microprocessor and Microcomputers (Dhanpat Rai Publication, New Delhi, 2006).
2. M. A. Mazidi, J. G. Mazidi and R. Mckinlay, The 8051 Microcontroller and Embbeded Systems using Assembly and C (Pearson, New Delhi, 2007).
3. A. P. Godse and D. A. Godse, Microprocessors and Microcontrollers (Technical Publications, Pune, 2021).
4. R. Gaonkar, Microprocessor Architecture, Programming and Applications with 8085 (Penram International Publishing, Mumbai, 2013).
5. K. Kant, Microprocessors and Microcontroller (Prentice Hall of India, New Delhi, 2013).
6. P. S. Manoharan, Microprocessors and Microcontroller (Charulatha Publications, Chennai, 2019).
7. K. Ayala, The Microcontroller (Cengage Learning, New Delhi, 2013).
8. V. Vijayendran, Fundamentals of Microprocessor 808 Architecture, Programming and Interfacing (Viswanathan Publication, Chennai, 2002).
9. R. S. Gaonkar, Microprocessor Architecture, Programming and Application with the 8085 (Penram International Publishing, Mumbai, 2013).
10. M. Spinks, Microprocessor System Design (Newnes, Oxford, 1992).
11. U. M. Baese, Embedded Microprocessor System Design using FPGAs (Springer, Switzerland, 2021).
12. https://kanchiuniv.ac.in/coursematerials/VIJAYARAGHAVAN_mp%20_mc%20notes.pdf
13. https://nptel.ac.in/courses/108105102

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

- Appreciate the use of microprocessors and microcontrollers in the basics of Modern computation.
- Familiar with the basic concepts of assembly language programming of 8085 microprocessor and microcontroller.
- Design circuits for various mathematical operations using Op-Amps.
- Apply the mnemonics of 8085 to write microprocessor programs.
- Explain the working and design of various A/D and D/A convertors.

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First Year **ELECTIVE COURSE II** **Semester II**

2) ELECTRONIC DEVICES AND CIRCUITS

Code: **(Theory)** **Credit: 4**

COURSE OBJECTIVES:

- To understand the characteristics of semiconductor diodes, transistors and their operations.
- To learn the performance of special devices like SCR, TRIAC and DIAC.
- To gain knowledge on small-signal amplifiers at low frequency.

UNIT – I SEMICONDUCTOR DIODES:

p-n Junction Diode: Theory of p-n junction diode - Energy band diagram of p-n diode - VI characteristics - Static and dynamic resistances - Diode equivalent circuits - Diode current equation - Diode logic circuits and diode clipper circuits. Zener Diode: VI characteristics - Breakdown mechanism - Zener diode as a voltage regulator. Backward diode: VI characteristics

UNIT – II SPECIAL PURPOSE DEVICES:

Tunnel Diode - Photo Diode - Varactor Diode - Schottky Diode – Operation - VI characteristics applications - Principle of operation and characteristics of SCR. SCR specification - SCR control circuits -The TRIAC and DIAC.

UNIT – III TRANSISTOR:

Characteristics - Current components Current gain: α and β - Variation of transistor parameter with temperature and current level - Operating point - Hybrid model - h-parameter equivalent circuits. DC and AC analysis of single stage CE - Emitter follower and CB amplifiers - AC and DC load line - Biasing and stabilization techniques - Thermal runaway - Thermal stability.

UNIT – IV FIELD EFFECT TRANSISTOR & UJT:

JFET& MOSFET- Construction and operation - Noise performance of FET - Biasing of JFET's and MOSFET's - Low Frequency single stage JFET amplifiers - FET as voltage variable resistor and active load -UJT- characteristics - parameters and specification - UJT as relaxation Oscillator.

UNIT – V SMALL SIGNAL AMPLIFIERS AT LOW FREQUENCY:

Analysis of BJT and FET multistage amplifier - DC and RC coupled amplifiers - Frequency response of single stage - multistage amplifiers - Analysis of differential amplifiers - Miller's theorem - Use of Miller and bootstrap configuration - Cascade configuration of multistage amplifiers - Darlington pair.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only)

Characteristics-comparison of knee voltage and forward bias resistance for different PN diodes - Comparison of transistor parameters for different NPN transistors - Construction of RC coupled amplifier with different coupling capacitors and bypass capacitors. Nonlinear electronics – importance of nonlinearity in electronics – Periodic and chaotic oscillations – Nonlinearity in power electronic circuits.

REFERENCES:

1. D. A. Bell, *Electronic Devices and Circuits* (Oxford University Press, Oxford, 2008).
2. S. Salivahanan, N. S. Kumar and A. Vallavaraj, *Electronic Devices and Circuits* (McGraw Hill, New Delhi, 2016).
3. J. Millman, C. Halkias and C. D. Parikh, *Integrated Electronics: Analog and Digital Circuits and Systems* (McGraw Hill, New Delhi, 2017).
4. S. L. Gupta and V. Kumar, *Hand Book of Electronics* (Pragati Prakashan, Meerut, 2013).
5. S. M. Sze, Y. Li and K. K. Ng, *Physics of Semiconductor Devices* (Wiley, New Jersey, 2021).
6. G. S. N. Raju, *Electronic Devices and Circuits* (I.K. International Publications, New Delhi, 2008).
7. B. V. Rao and K. R. Rajeswari, *Electronic Devices and Circuits* (Pearson, New Delhi, 2007).
8. B. P. Singh and R. Singh, *Electronic Devices and Circuits* (Pearson, New York, 2012).
9. K. L. Kishore, *Electronic Devices and Circuits* (BS Publisher, Hyderabad, 2016).
10. A. K. Maini and V. Agarwal, *Electronic Devices and Circuits* (Wiley, New Delhi, 2009).
11. T. L. Floyd, *Electronic Devices* (Pearson, New Delhi, 2021).
12. M. Lakshmanan and K. Murali, *Chaos in Nonlinear Oscillators* (World Scientific, Singapore, 1996).
13. J. C. Sprott and W. J. C. Thio, *Elegant Circuits: Simple Chaotic Oscillators* (World Scientific, Singapore, 2022).
14. https://nptel.ac.in/courses/108108112
15. https://archive.org/download/ElectronicDevicesAndCircuitTheory/Electronic%20Devices%20and%20Circuit%20Theory.pdf

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

- Know the VI characteristics of semiconductor diodes in detail.
- Acknowledge the operation and characteristics of particular electronics devices with a specific purpose.
- Comprehend the characteristics, operation and stability of transistor.
- Understand the construction and operation of FET & UJT.
- Appreciate the small signal amplifier at low frequency.

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First Year	**NON MAJOR ELECTIVE COURSE I**	**Semester II**
	PHYSICS FOR EVERYONE	
Code:	**(Theory)**	**Credit: 2**

COURSE OBJECTIVES:

- To understand the fundamental principles and basics of physics.
- To know the light sources in our environment with concepts of physics.
- To impart knowledge on energy sources in diverse fields.

UNIT – I MATTER:

Structure of the atom – Bohr atom Model – Somerfield's Relativistic Atom Model – The Vector Atom Model – Coupling Schemes – Pauli Exclusion Principle – Bonding in Crystals – Ionic, Covalent, Metallic, Molecular, and Hydrogen Bond – Few simple crystal structure.

UNIT – II LIGHT:

Light as an electromagnetic wave – Light velocity in various media – Polarization – Wavelength, Amplitude, Phase, Period, Frequency - Sources of Light – Huygen's principle – Interference, Reflection, Refraction, Diffraction, Scattering – Lenses – Concave, Convex – LED – Laser.

UNIT – III SOUND:

Intensity - Loudness of Sound - Decibel - Free, damped and forced vibrations – Resonance – Reverberation – Absorption coefficient – Damping and Damping Materials – Piezo electric effect – Ultrasonic waves – Transducer, Production and Detection of ultrasonic waves.

UNIT – IV HEAT:

Modes of heat transfer – Conduction, Convection, Radiation – Effect of temperature on thermal conductivity of different solids, liquid and gases - General laws of heat transfer – Black and White body – Emissive power and emissivity, laws of radiation – Planck's Constant.

UNIT – V ENERGY:

Energy Resources – Conventional and Renewable Energy – Energy Conversion – Solar Energy – Solar thermal applications – heating, cooling, desalination, drying, cooking, etc. – Photovoltaic conversion of solar energy, Types of solar cells – Biomass resources and their classification – Pyrolysis and liquefaction – Biodiesel production – Urban waste to energy conversion.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Ohms law – battery - fuel cells - Methods of generating electrical power: diesel engine - steam engine - Hydro-electric - Nuclear and gas turbine. Layout and main components of electricity distribution-transformers, feeders.

REFERENCES:

1. R. Murugesan, *Modern Physics* (S. Chand, New Delhi, 2018).
2. B. Lal and N. Subrahmanyam, *Heat, Thermodynamics and Statistical Physics* (S. Chand, New Delhi, 2008).
3. R. Murugesan, *Properties of Matter* (S. Chand, New Delhi, 2017).
4. G. N. Tiwari, *Solar Energy: Fundamentals, Design, Modelling and Applications* (Narosa, New Delhi, 2016).
5. M. S. Longhair, *Theoretical Concepts in Physics* (Cambridge University Press, Cambridge, 2020).
6. D. Franceschetti, *Principles of Physics* (Salem Press, New York, 2016).
7. A. H. Cook, *Physics of the Earth and Planets* (Macmillan, London, 1973).
8. B. Gutenberg, *Physics of the Earth's Interior* (Academic Press, Cambridge, 1986).
9. https://ocw.aprende.org/courses/physics/

COURSE OUTCOME:

On the successful completion of the course, students will be able to

- Apply Physics concepts in day-to-day life activities.
- Appreciate the knowledge of light and sound.
- Use the concept of heat in various modes.
- Comprehend energy storage and how to use it as electricity.
- Acquire the knowledge on fundamental Physics ideas for diverse applications.

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Second Year **CORE COURSE V** **Semester III**

THERMODYNAMICS AND STATISTICAL MECHANICS

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To understand what is temperature and how to calculate it.
- To give an exposure to various statistical ensembles and their applications in physics.
- To get familiar with the foundations and applications of quantum statistics.

UNIT – 1 EQUILIBRIUM THERMODYNAMICS:

Review of Laws of thermodynamics and thermodynamic potentials – Microstates and Macrostates of classical and quantum systems – Phase space – μ-space and Γ-space – Density of states – Expression for density of states in energy space and momentum space – Introduction to Ensembles – Ensemble average – Principle of a priori probability – Thermodynamic probability – Boltzmann entropy relation- Liouville's theorem – Equilibrium solutions.

UNIT – II MICROCANONICAL ENSEMBLE:

Introduction – Microcanonical distribution – Microcanonical Average – Entropy (S) – Derivation of S = k log W – Entropy of a Perfect Gas in a Microcanonical Ensemble – Gibbs Paradox – Thermodynamic Quantities in Microcanonical Ensemble.

UNIT – III CANONICAL ENSEMBLE:

Introduction – Canonical Distribution – Canonical Average – Canonical Ensemble Partition Function – Importance of the Canonical Ensemble Partition Function – Maxwell Velocity Distribution – Maxwell Energy Distribution – Most Probable Velocity – Mean Kinetic Energy – Thermodynamic Function – Classical System in a Canonical Ensembles – Ideal Gas – Microcanonical versus Canonical Ensembles.

UNIT – 4 GRAND CANONICAL ENSEMBLE:

Introduction – Grand Canonical Distribution – Grand Canonical Average – Grand Canonical Partition Function – Quantum Statistics – Thermodynamic Functions in Grand canonical Ensemble – Classical System – Ideal Gas in Grand Canonical Ensemble – Density and Energy Fluctuations – Comparison of Various Ensembles.

UNIT – V QUANTUM STATISTICS:

Need for Quantum Statistics – Difference between classical and quantum statistics – Identical Particles – Bosons and Fermions – Symmetric and anti-symmetric wave functions – Difference between Bose-Einstein and Fermi-Dirac statistics – Calculating the partition function for Bosons and Fermions –

Derivation of Bose-Einstein and Fermi-Dirac distributions – Definition of thermal wavelength – Bose-Einstein Condensation - Applications – Black body radiation (Bose system) – Fermi gas at low temperature – Fermi momentum.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

The Boltzmann Distribution: Convergence of the stochastic dynamics – Monte-Carlo Simulation – Simulated annealing – Boltzmann machines – Sampling – Interactions – Optimization – Inference – Learning – Restricted Boltzmann machines. Bayesian networks – q-bit systems – Quantum annealing.

REFERENCES:

1. K. Agarwal and M. Eisner, Statistical Mechanics (New Age International, New Delhi, 2020).
2. R.K. Pathria and P.D. Beale, Statistical Mechanics (Academic Press, Cambridge, 2021).
3. S. L. Kakani and C. Hemrajani, Statistical Mechanics (Viva Books Private Limited, New Delhi, 2017).
4. K. Saxena, An Introduction to Thermodynamics and Statistical Mechanics (Alpha Science International, New Delhi, 2010).
5. Satya Prakash, Statistical Mechanics (Kedar Nath Ram Nath, Meerut, 2008).
6. S.Chandra and M. K. Sharma, A Textbook on Statistical Mechanics (CBS Publisher, New Delhi, 2016).
7. S.C. Garg, R. M. Bansal and C. K. Ghosh, Thermal Physics: Kinetic Theory, Thermodynamics and Statistical Mechanics (McGraw Hill, New Delhi, 2013).
8. D.A. Mc Quarrie, Statistical Mechanics (Viva Books India, New Delhi, 2018).
9. F. Reif, Fundamentals of Statistical and Thermal Physics (Sarat Books, Kolkata, 2010).
10. Engel and C. V. D. Broeck, Statistical Mechanics of Learning (Cambridge University Press, Cambridge, 2001).
11. W. Greiner, L. Neise and H. Stocker**,** Thermodynamics and Statistical Mechanics (Springer, New York, 2001).
12. http://www.damtp.cam.ac.uk/user/tong/statphys/sp.pdf
13. https://nptel.ac.in/courses/104103112

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

- Calculate the thermo dynamical quantities, theoretically, using different methods.
- Construct partition function for a system in thermal equilibrium and calculate the corresponding thermo dynamical quantities.
- Apply ensemble approach to solve classical and quantum thermodynamic systems.
- Explain Bose-Einstein condensation and its applications.
- Demonstrate the ensemble approach to different physical problems like Black body radiation, white dwarfs, etc.

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Second Year	CORE COURSE VI SOLID STATE PHYSICS	Semester III
Code:	**(Theory)**	**Credit: 5**

COURSE OBJECTIVES:

- To give exposure to structural properties of crystals and the X-ray diffraction principle.
- To enhance understanding of the properties of conductors and semiconductors.
- To build a strong foundation for the materials' lattice dynamics and thermal, dielectric and electrical properties of materials.

UNIT – I CRYSTAL STRUCTURE:

Crystal symmetry – symmetry elements- symmetry operations- Bravais lattices – Miller indices – X-ray diffraction – Bragg's law – Experimental methods of X-ray diffraction: Rotating crystal method and Debye – Scherrer powder method. Scattered wave amplitude: Fourier analysis- reciprocal lattice vector – Diffraction condition – Laue equations- Brillouin zones – reciprocal lattices to SC and BCC lattices – structure factor of BCC lattice – Atomic form factor.

UNIT – II CONDUCTORS AND SEMICONDUCTORS:

Conductors: Free electron theory – Classical and Quantum theory – Band theory of solids – Density of states – K-space – Bloch theorem – Kronig-Penny model – Electrical conductivity and Ohm's law: Experimental electrical resistivity of metals – Umklapp scattering. Semiconductors: Intrinsic and Extrinsic semiconductors – Band gap – Effective mass – Carrier concentration – Electrical conductivity – Wiedmann-Franz law – Hall effect – Determination of type of conductivity – Carrier concentration – Mobility – Resistivity.

UNIT – III MAGNETIC AND DIELECTRIC PROPERTIES:

Langevin's classical theory of diamagnetism and paramagnetism – Quantum theory of paramagnetism – Weiss theory of ferromagnetism – Origin of domains – Hysteresis – Domain theory – Curie temperature and Neel temperature. Dielectrics – Macroscopic electric field – Local electric field – Clausius-Mosotti relation - Dielectric constant and polarizability – Types of polarization – Determination of dielectric constant – Parallel plate method.

UNIT – IV SUPERCONDUCTIVITY:

Zero resistance – Behaviour in magnetic field – Meissner effect – Heat capacity – Energy gap – Microwave and infrared properties – Isotopic effect –Type I and Type II superconductors – Entropy –Thermal conductivity – Thermodynamics of superconducting transmission - London equations – Coherence length– BCS theory – Penetration depth – Josephson Effect – AC and DC – Quantum tunneling –High Tc super conductors.

UNIT – V OPTICAL PROPERTIES AND NEW MATERIALS:

Photoconductivity – Simple model of photoconductor – Traps – Influence of traps – Luminescence and its types – Photoluminescence – Cathodoluminescence –

Chemiluminescence and Thermo-luminescence and glow curve. Shape memory alloys – Types – Structure – Temperature induced transformation – Stress induced transformation – Functional properties – Shape memory effect – Super elasticity.

UNIT VI CURRENT CONTOURS (For continuous internal assessment only):

Applications of superconductors –SQUID - Maglev. Electron transport in semiconductors and nanostructures – Semiconductor quantum wells – Molecular materials – Nonlinear optics.

REFERENCES:

1. N. Singh, Solid State Physics (Wiley India, New Delhi, 2021).
2. S. L. Gupta and V. Kumar, Solid State Physics (Kedar Nath Ram Nath, Meerut, 2000).
3. R. L. Singhal, Solid State Physics (Kedar Nath Ram Nath, Meerut, 2005).
4. M. Arumugam, Material Science (Anuratha Agencies, Chennai, 2002).
5. J. P. Srivastava, Elements of Solid State Physics (Prentice Hall of India, New Delhi, 2014).
6. M. A. Wahab, Solid State Physics: Structure of Properties of Materials (Narosa, New Delhi, 2001).
7. S. L. Kakani and A. Kakani, Materials Science (New Age International, New Delhi, 2016).
8. Kittel, Introduction to Solid State Physics (Wiley, New Delhi, 2019).
9. Omar, Elementary Solid State Physics (Pearson, New Delhi, 1999).

a. Gupta and N. Islam, Solid State Physics and Electronics (Books & Allied, Kolkatta, 2012).

10. M. A. Wahab, Numerical Problems in Solid State Physics (Narosa, New Delhi, 2019).
11. Kumar, Introduction to Solid State Physics (Prentice Hall of India, New Delhi, 2010).
12. V. V. Mitin, V. A. Kochelap and M. A. Stroscio, Introduction to Nanoelectronics (Cambridge University Press, Cambridge, 2012).
13. K. S. Thorne and R. D. Blandford, Modern Classical Physics (Princeton University Press, Princeton, 2018).
14. http://physics.bu.edu/~okctsui/PY543/3_notes_Crystals_2013.pdf
15. http://www.phys.nthu.edu.tw/~spin/course/106F-2/Chapter%203.pdf
16. https://nptel.ac.in/courses/115105099

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

- Apply the knowledge of crystal structure to various types of crystalline solids, electrical and magnetic materials.
- Differentiate various solid materials based on their properties and the learnt theories.
- Analyse the magnetic dielectric and optical properties of materials.
- Understand the peculiar properties of superconducting materials.
- Know new materials and their practical applications.

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Second Year | **CORE CHOICE COURSE III** | **Semester III**

1. ADVANCED QUANTUM MECHANICS

Code: | **(Theory)** | **Credit: 5**

COURSE OBJECTIVES:

- To get acquainted with approximation methods for time-independent and time-dependent Hamiltonians.
- To provide a sound knowledge of atomic and molecular structure through quantum formalism.
- To give a basic understanding of the theory of relativistic quantum mechanics.

UNIT – I TIME INDEPENDENT PERTURBATION THEORY:

Stationary theory – Non-degenerate case: First and Second order corrections - Normal Helium atom — Degenerate case: Energy correction - Stark effect in Hydrogen atom and Hydrogen molecule — Zeeman effect without electron spin.

UNIT – II TIME DEPENDENT PERTURBATION THEORY:

Constant perturbation – Transition probability - Fermi Golden Rule –Harmonic perturbation – Adiabatic and sudden approximation. Semi classical theory of Radiation: Application of the Time dependent perturbation theory to semi classical theory of radiation.

UNIT – III VARIATION METHOD:

Variation principle – Upper bound states – Ground state of Helium atom – Hydrogen Molecule – WKB approximation – Schrödinger equation – Asymptotic solution – Validity of WKB approximation – Solution near a turning point – Connection formula for perturbation barrier.

UNIT – IV RELATIVISTIC QUANTUM MECHANICS:

Klein-Gordon equation - Charge and current densities – Interaction with electromagnetic field – Hydrogen like atom – nonrelativistic limit – Dirac relativistic equation: Dirac relativistic Hamiltonian – Probability density – Dirac matrices – Plane wave solution – Eigen spectrum – Spin of Dirac particle – Significance of negative eigenstate – electron in a magnetic field – Spin magnetic moment.

UNIT – V MANY ELECTRON SYSTEMS:

The Hartree - Fock self-consistent field method – Electron correlation – The atomic Hamiltonian – The Cordon State rules – The Born – Oppenheimer – Approximation – The Hydrogen molecule ion – Approximate treatment of $H2^+$ ground state – Molecular orbitals theory – The Hydrogen molecule ion – H_2^+. s

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Lagrangian and Hamiltonian formulation of classical fields – Quantization of fields – Quantization of the Schrödinger equation – Klein Gordan and Dirac field – Quantization of electromagnetic fields.

REFERENCES:

1. Satya Prakash, Advanced Quantum Mechanics (Kedar Nath Ram Nath, Meerut, 2014).
2. P. M. Mathews and K. Venkatesan, Quantum Mechanics (McGraw Hill, New Delhi, 2010).
3. N. Levine, Quantum Chemistry (Pearson, New Delhi, 2016).
4. K. D. Krori, Principles of Non-Relativistic and Relativistic Quantum Mechanics (Prentice Hall of India, New Delhi, 2012).
5. Ajit Kumar, Fundamental of Quantum Mechanics (Cambridge University Press, Cambridge, 2018).
6. S. Rajasekar and R. Velusamy, Quantum Mechanics I: The Fundamentals (CRC Press, Boca Raton, 2022).
7. V. K. Thankappan, Quantum Mechanics (New Age International, New Delhi, 2003).
8. K. Ghatak and S. Lokanathan, Quantum Mechanics, (Trinity, New Delhi, 2019).
9. D. J. Griffiths, Introduction to Quantum Mechanics (Cambridge University Press, Cambridge, 2020).
10. N. Zettili, Quantum Mechanics: Concepts and Application (Wiley, New Delhi, 2022).
11. L. I. Schiff, J. Bandhyopadhyay, Quantum Mechanics (McGraw Hill, New York, 2017).
12. https://nptel.ac.in/courses/115103104
13. https://theory.physics.manchester.ac.uk/~judith/AQMI/PHYS30201.pdf

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

- Understand three approximation methods.
- Compute the correction in energy using the approximation technique.
- Apply the approximation method to the stationary state problem.
- Appreciate the relativistic effect in quantum mechanics.
- Acquire basic knowledge of atomic and molecular structures.

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Second Year	**CORE CHOICE COURSE III** **2. QUANTUM COMPUTATION**	**Semester III**
Code:	**(Theory)**	**Credit: 5**

COURSE OBJECTIVES:

- To introduce the fundamental concepts of Quantum Computing.
- To familiarize Quantum gates and Quantum circuits.
- To create basic ideas about Quantum algorithms and quantum error corrections.

UNIT – 1 INTRODUCTION TO QUANTUM COMPUTATION:

Review of Quantum Mechanics – Linear Algebra – Postulates of Quantum Mechanics – Quantum States and Qubits – Quantum Measurement – Bloch Sphere – Density Operator and Density Matrix – Algebra for Quantum Computing.

UNIT – II QUANTUM COMPUTATION MODELS AND COMPLEXITY CLASSES:

Elementary idea of complexity of an algorithm – Turing machine: Deterministic Turing machine – Probabilistic Turing machine – Reversible Turing machine – Quantum Turing machine - Circuit Model of computation – Computational Complexity and related issues.

UNIT – III QUANTUM GATES AND QUANTUM CIRCUITS:

Single Qubit gate: Pauli gates – Handmade gate – Phase gate – Rotation gates – Square root of NOT gates – Two Qubit gates; Controlled U gate – Three qubit gates: Toffoli gate and Fredkin gate – Deutsch gate – Quantum circuits– Two Qubit gates – Three Qubit gates – a little more on Quantum gates – Quantum Circuits – Visualisation of Quantum Gates.

UNIT – IV QUANTUM ALGORITHMS:

Deutsch's algorithm – Deutsch Jozsa (DJ) algorithm – Simon's Algorithm: Classical Approach, Quantum approach, Complexity analysis - Shor's Algorithm: Euclid's Algorithm – Period of the modular exponential function – Continued fraction representation – The strategy – Quantum Fourier transformations – Quantum part of the algorithm.

UNIT – V QUANTUM ERROR CORRECTIONS:

Quantum Error correction – Basic idea of an error model: Correcting classical errors – Difference between classical and quantum error – Correcting quantum errors – Fault Tolerant Quantum computation – Threshold theorem for Quantum computation – Decoherence and Decoherence free subspace – DiVincenzo Criteria.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Quantum Teleportation – Quantum cryptography – Teleportation schemes – Probabilistic Teleportation – Controlled teleportation – Modified teleportation – Superdense Coding – Jargon related to Cryptographs – Classical ciphers – Different aspects of Quantum Cryptography. Quantum processing unit – QPU primitives –Quantum Fourier Transform.

REFERENCES:

1. D. McMahon, Quantum Computing Explained (Wiley, New York, 2016).
2. W. H. Steeb and Y. Hardy, Problems and Solutions in Quantum Computing and Quantum Information (World Scientific, Singapore, 2020).
3. M. M. Wilde, Quantum Information Theory Explained (Cambridge University Press, Cambridge, 2017).
4. M. Nielsen and I. Chuang, Quantum Computation and Quantum Information (Cambridge University Press, Cambridge, 2010).
5. Pathak, Elements of Quantum Computation and Communication (CRC Press, Boca Raton, 2019).
6. E. R. Johnston, N. Harrigan and M. G. Segovia, Programming Quantum Computers (O'Reilly, California, 2019).
7. M. Pavicic, Quantum Computation and Quantum Communication (Wiley, New Delhi, 2006).
8. https://nptel.ac.in/courses/106106232

COURSE OUTCOME:

On the successful completion of the course, students will be able to

- Familiarize with the fundamental elements needed for Quantum computing.
- Understand the complexity of Quantum computational models.
- Acquire knowledge about quantum circuits and quantitative measures of their quality.
- Develop the applications of Quantum computing from elementary operations.
- Get acquainted with basic algorithms and error corrections in Quantum computing.

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Second Year **CORE PRACTICAL III** **Semester III**

MICROPROCESSOR AND PROGRAMMING IN C++

Code: **(Practical)** **Credit: 3**

COURSE OBJECTIVES:

- To develop programming skills in microprocessor and C++ programming to solve some mathematical problems and learn their applications.

A. Microprocessor (8085)

1. Finding the largest and smallest numbers in a data array.
2. Arranging a set of numbers in ascending and descending orders.
3. Study of multibyte decimal addition and subtraction.
4. Study of seven segment display.
5. Study of DAC interfacing (DAC 0900).
6. Study of ADC interfacing (ADC 0809).
7. Study of programmable interrupt controller (IC 8259).
8. Traffic control system.
9. Digital clock.
10. Generation of square and sine waves using DAC 0800.
11. Digital thermometer (temperature controller).
12. Control of stepper motor using microprocessor.

B. C++ Programming

1. Least-squares curve fitting – Straight-line fit.
2. Least-squares curve fitting – Exponential fit.
3. Real roots of one-dimensional nonlinear equations - Newton Raphson method.
4. Complex roots of one-dimensional nonlinear equations - Newton-Raphson method.
5. Interpolation – Lagrange method.
6. Numerical integration – Composite trapezoidal rule.
7. Numerical integration – Composite Simpson's 1/3 rule.
8. Solution of a second-order ODE – Euler method.
9. Solution of a first-order ODE – Fourth-order Runge-Kutta method.
10. Gaussian random number generation – Box and Muller method.
11. Calculation of mean and standard deviation of a set of uniform random numbers.
12. Computation of eigenvalues of linear harmonic oscillator by numerically solving Schrödinger equation.

REFERENCES:

1. Nagoorkani, *8085 Microprocessor and its Applications* (McGraw Hill, New Delhi, 2017).
2. Stroustrup, *Programming: Principles and Practice Using C++* (Addison Wesley, Massachusetts, 2014).

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

- Acquire hands-on knowledge of Microprocessor programming
- Understand DAC and ADC interfacing.
- Gain Knowledge of Traffic control systems.
- Acquire hands-on knowledge of C++ Programming.
- Determine the eigenvalues of the harmonic oscillator numerically.

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Second Year | **ELECTIVE COURSE III** | **Semester III**

1. PHYSICS OF NONOMATERIALS

Code: | **(Theory)** | **Credit: 4**

COURSE OBJECTIVES:

- To provide an introduction to nanomaterials and their peculiar properties.
- To describe various techniques for the preparation of nanomaterials.
- To introduce various applications and characterization techniques.

UNIT – I INTRODUCTION TO NANOTECHNOLOGY:

Emergence of nanotechnology – Nanomaterials – Classification of nanomaterials based on composition, number of dimensions in nanoscale and morphology – Characteristics of nanomaterials – Surface area to volume ratio – Its effect on properties of nanomaterials – Nanoparticles – Nanoclusters – Nanocomposites – Nanohybrids.

UNIT – II QUANTUM DOTS AND CARBON NANOTUBES:

Quantum dots (QDs) – Excitons confinement in quantum dots – Production and applications of QDs –Quantum wires – Quantum wells – Carbon allotropes – Discovery of C60 – Fullerenes –Types of fullerenes – Bucky balls – Carbon nanotubes (CNTs) – Single walled CNTs – Multi-walled CNTs – Properties of CNTs – Synthesis of CNTs – Plasma-arc discharge method –Laser ablation technique – Chemical vapour deposition method – CNT emitters- Potential applications of CNTs.

UNIT – III PREPARATION OF NANOMATERIALS:

Nanomaterials preparation: Top-down method – Working principles, merits and demerits of Ball milling – Photolithography–Electron beam lithography – Molecular beam epitaxy – Bottom-up technique – Soft-chemical method – Sol-gel synthesis – Electro chemical deposition – Atomic layer deposition – Langmuir - Blodgett film (2D nanostructure) preparation – Green synthesis.

UNIT – IV ANALYTICAL TECHNIQUES FOR NANOMATERIALS CHARACTERIZATION

Structural characterization: Principle of X-ray powder diffraction – Determination of structural parameters – Optical studies: UV-Vis-NIR spectrometry – Band gap determination by Tauc's plot method – Surface morphological analysis: Scanning electron microscopy (SEM) – Scanning tunnelling microscope (STM) –Transmission Electron Microscope (TEM) –X-ray photoelectron spectroscopy (XPS).

UNIT – V APPLICATIONS OF NANOMATERIALS:

Nanoelectronics – Molecular diodes and transistors – Quantum electronic devices – Nano photonics – Photonic crystals – Nano electromechanical systems (NEMS) – Nanomaterials in energy conversion and storage – Nanomaterials as antibacterial agents –Nanomaterials as photo catalysts – Energy efficient windows – Nanomaterial in industrial applications – Bio-medical applications: Targeted drug delivery.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Potential applications of nanomaterials**:** CNTs Air and Water Filtration - Conductive Plastics – Conductive adhesives- CNT ceramic materials – Nano porous filters - Electron transport in semiconductors and nanostructures – Nanostructure devices.

REFERENCES:

1. K. Ravichandran, K. Swaminathan, P. K. Praseetha and P. Kavitha, Introduction to Nanotechnology (Jazym Publications, Tiruchirappalli, 2019).
2. R. Anand, Essentials of Nanotechnology (Scientific International, New Delhi, 2017).
3. G. Cao, Nanostructures and Nanomaterials, Synthesis, Properties and Applications (World Scientific, Singapore, 2011).
4. K. P. Mathur, Nanoscience and Technology (Rajat Publications, New Delhi, 2009).
5. P. Poole and F. J. Owens, Introduction to Nanoscience and Nanotechnology (Wiley, New Delhi, 2020).
6. K. K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Nanotechnology (Prentice Hall of India, New Delhi, 2014).
7. M. Ratner, Nanotechnology: A Gentle introduction (Pearson, New Delhi, 2006).
8. M. Wilson, K. Kannangara, G. Smith, M. Simmons and B. Raguse, Nanotechnology: Basic Science and Emerging Technologies (CRC Press, Boca Raton, 2002).
9. S. Edelstein and R. C. Cammaratra, Nanomaterials: Synthesis, Properties and Applications (Taylor and Francis, Oxford, 1996).
10. J. H. Davies, The Physics of Low Dimensional Semiconductors (Cambridge University Press, Cambridge 1998).
11. V. V. Mitin, V. A. Kochelap and M. A. Stroscio, Introduction to Nanoelectronics (Cambridge University Press, Cambridge, 2012).
12. http://engineeringphysics.weebly.com/uploads/8/2/4/3/8243106/unit_8__nano_materials_1.pdf
13. https://nptel.ac.in/courses/118102003

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

- Explain how the Nano-sized materials differ from bulk materials.
- Classify the synthesizing techniques suitable for different Nano-structured materials.
- Make use of the available instruments to study the properties of nanomaterials.
- Assess the effect of grain sizes on various properties of nanomaterials.
- Interpret the results of physical and chemical properties measurements.

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Second Year **ELECTIVE COURSE III** **Semester III**

2. METHODS OF SPECTROSCOPY

Code: **(Theory)** **Credit: 4**

COURSE OBJECTIVES:

- To give an exposure to the methods of spectroscopy.
- Make them understand the essential elements of spectroscopy and its applications.
- To impart knowledge on the applications of Spectroscopy.

UNIT 1: ATOMIC AND MOLECULAR STRUCTURE

Molecular spectroscopy – Introduction – Experimental methods – Central field approximation — Spin-orbit interaction -Doublet separation – Intensities – Complex atoms – Coupling schemes – Energy levels – Selection rules and intensities in dipole transition — Heitler London theory – Atomic and molecular hybrid orbitals – Hartree-Fock equations – Method of self-consistent field.

UNIT – II RAMAN AND IR SPECTROSCOPY:

FT Raman spectroscopy – Degree of depolarization- Basic principle – Quantum theory of Raman effect- Experimental techniques of Raman spectroscopy-IR spectra of polyatomic molecules-Experimental techniques of IR- IR imaging-vibrational frequencies analysis-determination of molecular structure –XY, XY2 and XY3 type molecules using IR and Raman spectra - Nonlinear Raman spectroscopy.

UNIT – III FLUORESCENCE AND PHOSPHORESCENCE SPECTROSCOPY:

Electronic excitation and vibrational analysis of diatomic molecules - Deslander's Table - Intensity distribution-Franck Condon principle - Electronic bands - Resonance and normal fluorescence - Intensities of transitions- Phosphorescence - Population of triplet state – Experimental methods - Applications of Fluorescence and Phosphorescence.

UNIT – IV NMR AND NQR SPECTROSCOPY:

NMR spectroscopy -Basic principles - Classical and quantum mechanical treatments - Bloch equations - Spin-spin and spin-lattice relaxation– Experimental technique – Single coil and double coil method - Principle and working of high resolution NMR spectrometer - Chemical shift - Applications.
NQR spectroscopy: Basic principle and fundamental requirements – Quadruple Hamiltonian – Nuclear quadruple energy levels for axial and non-axial symmetry.

UNIT – V ESR AND MOSSBAUER SPECTROSCOPY:

ESR spectroscopy -Basic principles -ESR spectrometer -Nuclear interaction and hyperfine structure – Relaxation effects - 'g' factor - Experimental set up for ESR-biological applications. Mossbauer spectroscopy: Mossbauer Effect – Recoil less emission and absorption - Doppler velocity shift-experimental arrangement –

Mossbauer spectrum - Chemical isomer shift - Magnetic hyperfine and electric quadrupole splitting – Applications.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Electron and neutron spectroscopy - Ultrafast laser spectroscopy - Respiratory gas analysis in hospitals - Gamma ray spectroscopy - Non-destructive elemental analysis by X-ray fluorescence (Introduction only) - Molecular photophysics – Laser spectroscopy.

REFERENCES:

1. B. P. Straughan and S. Walkar, Spectroscopy Vols.1, 2 (Chapman and Hall, Boca Raton, 1994).
2. R. Chang, Basic Principles of Spectroscopy (McGraw Hill, New York, 1980).
3. D. A. Long, Raman Spectroscopy (McGraw Hill, New York, 1977).
4. H. E. White, Introduction to Atomic Spectra (McGraw Hill, New Delhi, 2016).
5. S. L. Gupta, V. Kumar and H. V. Sharma, Elements of Spectroscopy (Pragati Prakashan, Mumbai, 2017).
6. C. N. Banwell, Fundamentals of Molecular Spectroscopy (McGraw Hill, New Delhi, 2016)
7. G. Aruldhas, Molecular Structure and Spectroscopy (Prentice Hall of India, New Delhi, 2014).
8. M. Chandra, Atomic Spectra and Chemical Bond (Dreamtech Press, New Delhi, 2019)
9. G. Herzberg, Molecular Spectra and Molecular Structure (Dover, New York, 2008).
10. P. C. Poole and H. A. Farach, Theory of Magnetic Resonance (Wiley, New Delhi, 1987).
11. J. Workman and A. Springsteen, Applied Spectroscopy (Boston Academic Press, Massachusetts, 1998).
12. D. L. Andrews and R. H. Lipson, Molecular Photophysics and Spectroscopy (IOP Publishing, Bristol, 2021).
13. P. N. Ghosh, Laser Physics and Spectrocopy (CRC Press, Boca Raton, 2018).
14. https://resources.saylor.org/wwwresources/archived/site/wp-content/uploads/2012/07/Chapter1011.pdf
15. https://nptel.ac.in/courses/104106122

COURSE OUTCOME:

On the successful completion of the course, students will be able to

- Acquire knowledge and problem-solving skills in atomic and molecular spectroscopy.
- Understand the applications of spectroscopy in day-to-day life.
- Gain knowledge about the Quantum behaviour of atoms in external electric and magnetic fields.
- Interpret the electromagnetic spectra and the interaction of radiation with matter.
- Get familiar with the light sources and spectroscopic techniques to explain the structure of materials.

Second Year **NON MAJOR ELECTIVE II** **Semester III**

RENEWABLE ENERGY SOURCES

Code: **(Theory)** **Credit: 2**

COURSE OBJECTIVES:

- To understand the necessity of using solar energy.
- To learn the fundamentals of solar energy conversion systems.
- To comprehend the challenges in sustainable energy processes.

UNIT – I BASICS OF SOLAR ENERGY:

Energy resources- conventional and non-conventional energy sources- World's future energy-energy sources and their availability-prospects of renewable energy sources - Sun as a source of energy - Solar radiation – Effects of atmosphere on solar radiation – Solar radiation at the Earth's surface - Sunshine recorder – Importance of solar energy.

UNIT – II SOLAR THERMAL AND PHOTOVOLTAIC SYSTEMS:

Solar thermal power plant – OTEC- Solar cookers – Solar hot water systems – Solar greenhouses – Space heating - Conversion of solar energy into electricity – Photovoltaic effect – Solar photovoltaic cell – Electrical characteristics - Efficiency - Solar photovoltaic applications – Battery chargers – Domestic lighting – Street lighting – Water pumping and irrigation - Solar cooling.

UNIT – III WIND ENERGY:

Basic principles – Global wind – Local wind – Nature of wind - Basic components of wind energy conversion systems - Wind turbine sitting – Energy estimation - Major applications of wind power – Horizontal axis wind turbine – Environmental aspects.

UNIT – IV BIOMASS ENERGY:

Introduction – Useful forms of biomass, their composition and fuel properties – Biomass resources – Biomass gasification – Wet and dry process - Biogas production from waste biomass – Advantages of anerobic digestion-Availability of raw materials and gas yield.

UNIT – V GEOTHERMAL ENERGY:

Introduction – Applications – Origin and distribution of geothermal energy – Tidal energy - Origin and nature of tidal energy – Limitations of tidal energy – Ocean thermal energy – Ocean thermal energy conversion technology-OTEC – Open cycle and closed cycle.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Recent power production techniques-from water - Hydrogen fuel cell - Alternate power production systems - Lithium ion battery- Water pumping and irrigation in India – Wind energy programme in India - Biomass energy programme in India – Advantages of OTEC.

REFERENCES:

1. F. Krieth and J. F. Kreider, Principles of Solar Engineering (McGraw Hill, New York, 1978).
2. Meinel and A. P. Meinel, Applied Solar Energy (Addison Wesley, Massachusetts, 1976).
3. G. D. Rai, Solar Energy Utilization (Khanna Publishers, New Delhi, 1995).
4. S. P. Sukhatme, Solar Energy: Principles of Thermal Collection and Storage (McGraw Hill, New Delhi, 2009).
5. M. P. Agarwal, Solar Energy (S. Chand, New Delhi, 1983).
6. P. Kothari, K. C. Singal and R. Ranjan, Renewable Energy Sources and Emerging Technology (Prentice Hall of India, New Delhi, 2016).
7. G. N. Tiwari, Solar Energy: Fundamentals, Design, Modelling and Applications (Narosa, New Delhi, 2002).
8. S. Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications (Prentice Hall of India, New Delhi, 2015).
9. Goel, M. A. Khot and S. Patil, Wind and Solar Energy (Technical Publications, Pune, 2021).
10. B H. Khan, Non-Conventional Energy Resources (McGraw Hill, New Delhi, 2016).
11. H. P. Garg, J. Prakash, Solar energy: Fundamentals and Applications (McGraw Hill, New Delhi, 2021).
12. R. S. Khurmi, Material Science (S. Chand, New Delhi, 2014).
13. https://nptel.ac.in/courses/121106014
14. http://www.ener-supply.eu/downloads/ENER_handbook_en.pdf

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

- Design photovoltaic systems for different applications meeting residential and industrial needs.
- Understand the manufacturing processes of solar energy-based devices.
- Utilize solar energy for future energy needs.
- Use all sorts of energy.
- Expand the availability and proper utility of non-conventional energy sources.

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Second Year	CORE COURSE VII	Semester IV
	CRYSTAL GROWTH AND THIN FILM PHYSICS	
Code:	**(Theory)**	**Credit: 5**

COURSE OBJECTIVES:

- To introduce the knowledge of crystal growth and its characterization.
- To understand the basic ideas of thin film fabrication.
- To impart knowledge about working principles of various analytical techniques.

UNIT – I NUCLEATION THEORIES:

Importance of crystal growth – Classification of crystal growth methods – Nucleation Theory - Kinds of nucleation – Homogeneous nucleation - Heterogeneous nucleation - Secondary nucleation -Classical theory of nucleation: Gibbs Thomson equations for vapour and solution – Kinetic theory of nucleation – Becker and Doring concept on nucleation rate – Energy of formation of a spherical nucleus - Statistical theory on nucleation: Equilibrium concentration of critical nuclei, Free energy of formation.

UNIT – II CRYSTAL GROWTH TECHNIQUES:

Growth from low temperature solution: Selection of solvents and solubility – Meir's solubility diagram – Saturation and supersaturation – Metastable zone width – Growth by restricted evaporation of solvent, slow cooling of solution and temperature gradient methods - Gel Growth Technique: Principle – Various types – Structure of gel – Importance of gel – Experimental procedure – Chemical reaction method – Single and double diffusion method. Melt Growth Techniques: Bridgman technique – Czochralski technique– Verneuil method – Merits and demerits.

UNIT – III FUNDAMENTALS AND APPLICATIONS OF THIN FILMS:

Introduction – Advantages of thin film devices over their bulk counterparts – Thin film growth stages: Nucleation stage – Island stage – Coalescence stage – Channel, hole and continuous film stage – Properties of thin films: Sheet resistance – Porosity – Surface roughness – Adhesion – Applications of thin films: Thin films in photovoltaic technologies dye sensitised solar cells – Thin films in electronic devices – Thin films in disinfectant technologies – Optical coatings – Chemical and mechanical applications.

UNIT - PHYSICAL DEPOSITION AND CHEMICAL DEPOSITION METHODS:

Basics of vacuum – Physical Vapour Deposition (PVD) – Thermal evaporation – Electron beam evaporation – Pulsed Laser Ablation – Molecular Beam Epitaxy – Sputtering techniques - DC and RF sputtering – Ion plating Chemical methods – Electro deposition and electroless plating – Chemical bath deposition – Spray pyrolysis – Spin coating – Dip coating – SILAR – Electro spinning –Hydrothermal – Sol - gel synthesis – Metal organic (Chemical vapour deposition).

UNIT – V CHARACTERISATION TECHNIQUES:

X-Ray Diffraction (XRD) – Powder and single crystal – Fourier transform Infrared – Raman analysis (FT-IR) –UV-Visible spectrometer – Photoluminescence - Vickers Micro hardness - Chemical Etching- Surface Profilometry -Energy dispersive analysis of X-ray (EDAX) – Atomic force microscopy (AFM) – Thermo gravimetric analysis (TGA) – Differential thermal analysis (DTA).

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Demonstration of solution growth instruments and solubility measurements - Demonstration of vertical Bridgmann growth and Czochralski growth process and ampoule designing for Bridgmann growth - Demonstration of characterisation techniques.

REFERENCES:

1. J. C. Brice, *Crystal Growth Processes* (Wiley, New York, 1986).
2. P. S. Ragavan and P. Ramasamy, *Crystal Growth Processes and Methods* (KRU Publications, Kumbakonam, 2001).
3. K. Ravichandran, K. Swaminathan, B. Sakthivel and A. T. Ravichandran, *Introduction to Thin Films and Crystal Growth* (Jazym Publications, Tiruchirappalli, 2019).
4. V. Markov, *Crystal Growth for Beginners: Fundamentals of Nucleation, Crystal Growth and Epitaxy* (World Scientific Publishing, Singapore, 2017).
5. S. Zhang, L. Li and A. Kumar, *Materials Characterization Techniques* (CRC Press, Bota Raton, 2009).
6. R. F. Bunshah, *Handbook of Deposition Technologies for Films and Coatings, Science, Technology and Applications* (Noyes Publications, New York, 1994).
7. M. Ohring, *Materials Science of Thin Films: Deposition and Structure* (Academic Press, Cambridge, 2002).
8. Goswami, *Thin Film Fundamental*s (New Age International, New Delhi, 1996).
9. T. S. Sudarsan, *Surface Modification Technologies* (The Minerals, Metals & Materials Society, Pittsburgh, 1989).
10. E. N. Kaufmann, *Characterization of Materials* (Wiley, New Delhi, 2003)
11. K. Ravichandran, K. Swaminathan and B. Sakthivel, *Introduction to Thin Films* (Research India Publications, New Delhi, 2013).
12. http://www.issp.ac.ru/ebooks/books/open/Modern_Aspects_of_Bulk_Crystal_and_Thin_Film_Preparation.pdf
13. https://onlinecourses.nptel.ac.in/noc20_mm19/preview

COURSE OUTCOME:

On the successful completion of the course, students will be able to

- *Understand the various techniques of crystal growth.*
- *Acquire knowledge in the fields of thin films.*
- *Gain the knowledge of thin film preparation processes through physical and chemical methods.*
- *Know the working principles of characterization techniques.*
- *Comprehend the properties and applications of thin films.*

Second Year **CORE COURSE VIII** **Semester IV**

NUCLEAR AND PARTICLE PHYSICS

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To understand the nature of nuclear forces.
- To have an idea of the nuclear shell model.
- To gain knowledge of nuclear reaction and Quark structure.

UNIT – I TWO BODY PROBLEM AND NUCLEAR FORCES:

Ground state of the Deuteron - Wave equation for the deuteron and its solution. Excited states of the deuteron, Normalization of the deuteron wave Function, Low energy Neutron – Proton Scattering, Scattering length. Spin dependence of n-p Interaction, Effective range theory. Non-Central Force - Quadrupole moment of the deuteron, Magnetic moment of the deuteron. Neutron-Neutron scattering, Exchange interaction and saturation of the nuclear force.

UNIT – II NUCLEAR MODELS:

Constitution of the nucleus- Fermi gas model of the nucleus. Nuclear shell structure-single particle states in nuclei- Spin-orbit interaction. Applications of extreme single particle shell model. Single particle shell model - Individual particle model-Collective model. Liquid drop model-Bohr-Wheeler Theory.

UNIT – III RADIOACTIVITY:

Alpha-decay and barrier penetration- Gamow's theory of alpha decay. Beta decay-Pauli's hypothesis- Fermi's theory of β-decay-Selection rules-Parity in β-decay-Helicity of Neutrino-Electron capture. Gamma-rays-Interaction of γ rays with matter-Photo-electric absorption-Electron-Positron pair production-Multipole radiations - Selection rules-Conservation of parity-Internal conversion.

UNIT – IV NUCLEAR REACTION:

Types of nuclear reactions- Conservation laws-Nuclear reaction kinematics. Nuclear cross section-Classical analysis of cross-section. Partial wave analysis of reaction cross-section. Inverse reaction-Principle of detailed balance (Reciprocity theorem). Compound nucleus- Disintegration of a Compound nucleus. Resonance cross-sections: Bright-Wigner dispersion formula. Direct reactions-Plane wave Born Approximation Theory of direct interactions. Nuclear Shock waves. Nuclear Reactors- Production reactors, Power reactors-Peaceful Nuclear Explosions-Nuclear Power production in India.

UNIT – V ELEMENTARY PARTICLES:

Classification of elementary particles-Conservation laws-CPT Theorem. Graviton, Photon, Gluon. Muons -Production-Nature of muon decay-muon interaction-muonium. Resonance particles, Symmetry classification of elementary particles-

SU(2) Symmetry-SU(3) Symmetry-Gell-Mann-Okubo mass formula for SU(3) multiplets. Quark hypothesis-Quark structures of mesons and baryons. Quantum Chromodynamics. Charmed quark-Beauty and Truth. Higgs Bosons.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Neutrinos- Sources of neutrinos – Types of neutrino-Deduction of neutrino-Neutrino Oscillations in matter-Neutrino communication. Scintillation detectors – Positron Emission Tomography – X-ray Computed Tomography – Magnetic Resonance Imaging – Neutrino Telescopes.

REFERENCES:

1. S. N. Ghoshal, *Nuclear Physics* (S. Chand, New Delhi, 2018).
2. M. L. Pandya and R. P. S. Yadav, *Elements of Nuclear Physics* (Kedar Nath Ram Nath, Meerut, 2020).
3. D. C. Tayal, *Nuclear Physics* (Himalaya, Mumbai, 2020).
4. Gupta and H. Roy, *Physics of the Nucleus* (Books and Allied, Kolkata, 2011).
5. J. Singh, *Fundamentals of Nuclear Physics* (Pragati Prakashan, Mumbai, 2012).
6. K. S. Krane*, Introductory Nuclear Physics* (Wiley, New York, 1987)
7. S. B. Patel, *Nuclear Physics: An Introduction* (Wiley, New Delhi, 1991).
8. R. D. Evans, *The Atomic Nucleus* (McGraw Hill, New York, 1955).
9. R. A. Serway and J. W. Jewett, *Physics for Scientists and Engineers with Modern Physics* (Cengage, Massachusetts, 2010).
10. Beiser, *Concepts of Modern Physics* (McGraw Hill, New York, 1995).
11. R. A. Powsner, M. R. Palmer and E. R. Powsner*, Essentials of Nuclear Medicine Physics, Instrumentation and Radiation Biology* (Wiley, New Jersey, 2021).
12. P. De Los Heros, *Probing Particle Physics with Neutrino Telescopes* (World Scientific, Singapore, 2020).
13. https://nptel.ac.in/courses/115103101

COURSE OUTCOME:

On the successful completion of the course, students will be able to

- Know the ground state of deuteron and the nature of nuclear forces.
- Understand the nuclear models.
- Appreciate the theory behind the nuclear decay process.
- Comprehend the physics of nuclear reaction.
- Have some idea about the Symmetry classification of elementary particles and quarks**.**

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Second Year	ENTREPRENEUSHIP / INDUSTRY BASED COURSE	Semester IV

ANALYTICAL CHARACTERIZATION TECHNIQUES

Code:	(Theory)	Credit: 5

COURSE OBJECTIVES:

- To provide fundamental features of analytical instrumentation to the students.
- To impart knowledge about the fundamental properties of the instrumental analysis and experimental and theoretical aspects of the characterization techniques.
- To know the basic theory of characterization techniques and application.

UNIT - I STRUCTURAL CHARACTERIZATION

Principle of X-ray spectrometer technique – Small angle X-ray scattering – X-ray photoelectron spectroscopy – Auger relation of core hole – Application, strength and limitations of X-ray photoelectron spectroscopy

UNIT – II SPECTRAL CHARACTERIZATION:

Laser sources – Laser Raman Spectrometer – Radiation sources – Fourier Transform Interferometer – NMR basic principles – NMR spectrometer – ESR basic principles – Instrumentation of ESR

UNIT – III OPTICAL CHARACTERIZATION:

Instruments for absorption photometry – Photoluminescence principles – Instrumentation and Application – Ultraviolet absorption spectroscopy – Principle behind IR spectroscopy – Fourier Transform Infrared spectroscopy (FTIR) – Strength of FTIR spectroscopy

UNIT – IV THERMAL AND MECHANICAL CHARACTERIZATION:

Thermal methods – Thermogravimetric analysis – Differential Thermal analysis – Mechanical principles: Static and Dynamic measurement – Instrumentation of Extensometer analysis – Bending properties of materials – In-Plane Impact testing

UNIT – V MORPHOLOGICAL CHARACTERIZATION:

Basic principles – Instrumentations: Scanning Electron Microscopy (SEM) – Operation modes – Transmission Electron Microscopy (TEM) – Scanning Tunneling Microscopy (STM)

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Basic principles – Instrumentations: X-ray photoelectron spectroscopy (XPS) – Ultraviolet photoelectron spectroscopy (UPS) –Branauer Emett Teller (BET) theory.

Hall effect measurement system – Analytical scanning electron microscope – In-site electrical characterization – Neutron scattering.

REFERENCES:

1. N. Banwell, Fundamentals of Molecular and Spectroscopy (McGraw Hill, New Delhi, 2008).
2. P. S. Sindu, Molecular Spectroscopy (Newage, New Delhi, 2006).
3. H. H. Willard and L. L. Merritretal, International Methods of Analysis (CBS Publication, New Delhi, 2008).
4. S. Zhang, L. Li and A. Kumar, Materials Characterization Techniques (CRC Press, Bota Racon, 2009).
5. E. N. Kaufmann, Characterization of Materials, Volume-I (Wiley, New Jersey, 2012).
6. M. Sardela, Practical Materials Characterization (Springer, Heidelberg, 2014).
7. P. R. Khangaonkar, An Introduction to Material Characterization (Penram, Mumbai, 2008).
8. Y. Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods (Wiley, New Jersey, 2008).
9. https://nptel.ac.in/courses/113105101

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

- Understand the various processes of structural characterizations.
- Realize how to use the instruments practically and theoretically.
- Understand spectral, optical, and thermal characterizations.
- Use advanced characterizations for analyzing particles.
- Characterize the sample with appropriate characterization techniques.

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Second Year **PROJECT** **Semester-IV**

Code: **Credit: 5**

Each candidate shall be required to take up a Project Work and submit it at the end of the final year. The Head of the Department shall assign the Guide who, in turn, will suggest the Project Work to the student in the beginning of the final year. A copy of the Project Report will be submitted to the University through the Head of the Department on or before the date fixed by the University.

The Project will be evaluated by an internal and an external examiner nominated by the University. The candidate concerned will have to defend his/her Project through a Viva-voce.

ASSESSMENT /EVALUATION /VIVA-VOCE:

1. PROJECT REPORT EVALUATION (Both Internal & External):

I. Plan of the Project - 20 marks

II. Execution of the Plan/collection of Data / Organisation of Materials / Hypothesis, Testing etc and presentation of the report. - 45 marks

III. Individual initiative - 15 marks

2. VIVA-VOCE / INTERNAL& EXTERNAL - 20 marks

TOTAL **- 100 marks**

PASSING MINIMUM:

Project	**Vivo-Voce 20 Marks** 40% out of 20 Marks (i.e. 8 Marks)	**Dissertation 80 Marks** 40% out of 80 marks (i.e. 32 marks)

A candidate shall be declared to have passed in the Project work if he/she gets not less than 40% in each of the Project Report and Viva-voce but not less than 50% in the aggregate of both the marks for Project Report and Viva-voce.

A candidate who gets less than 40% in the Project must resubmit the Project Report. Such candidates need to defend the resubmitted Project at the Viva-voce within a month. A maximum of 2 chances will be given to the candidate.

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Second Year | **VALUE ADDED COURSE II** | **Semester IV**

MEDICAL INSTRUMENTATION

Code: | **(Theory)** | **Credit: 5**

COURSE OBJECTIVES:

- To introduce the basic knowledge on Biomedical instrumentation.
- To know about measurement of certain important electrical and non-electrical parameters.
- To have a basic knowledge in life assisting and therapeutic devices.

UNIT – I HUMAN PHYSIOLOGICAL SYSTEMS AND BIO-POTENTIAL ELECTRODES

Transport of ions through the cell membrane – Resting and action potentials – Bio-electric potentials – Design of Medical instruments – Components of the biomedical instrument system – Half cell potential –Types of electrodes –Micro electrodes – Depth and needle electrodes – Surface electrodes – Transducers – Active transducers – magnetic induction type transducers (only).

UNIT – II BIO-SIGNAL ACQUISITION AND PHYSIOLOGICAL ASSIST DEVICES

Required conditions for physiological signal amplifiers – Isolation amplifiers – ECG Isolation Amplifier Circuit – Medical preamplifier design – Bio-signal analysis – Physiological Assist Devices: Pacemakers – Typical ranges of pacemaker parameters - External and implanted pacemakers (comparison) – Ventricular asynchronous pacemakers - Defibrillators – DC Defibrillator – Oxygenators – Bubble oxygenators.

UNIT – III BIO-POTENTIAL RECORDERS:

Bio signal Recorders: Characteristics of the recording system – Electrocardiography (ECG) – Physiological nature of ECG waveform – ECG Recording setup - Echocardiography – Electroencephalography (EEG) – Origin of EEG – Simple block diagram of EEG recording setup – Electroretinography (ERG).

UNIT – IV OPERATION THEATRE EQUIPMENT:

Surgical diathermy- Shortwave diathermy – Ventilators – Pressure limited ventilators – Anesthesia machine – Blood flow meters – Electromagnetic blood flowmeter – Cardiac Output measurements – Fick's method – Spirometer – Gas analyzers – Infrared CO_2 analyzer – pH meter – Oxymeters.

UNIT – V SPECIALIZED MEDICAL EQUIPMENTS:

Blood Cell counters – Automatic blood cell counter – Digital thermometer – Audiometers – X-rays tube – X-ray machine – Angiography – Bio-telemetry – Elements of Biotelemetry system – Design of Bio-telemetry system – Physiological effects of 50Hz current passage – Micro shock and macro shock – Magnetic Resonance Imaging – principle – MRI Instrumentation.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Radio graphic and fluoroscopic techniques – Computer tomography – Ultrasonography – Endoscopy – Thermography - Retinal Imaging - Imaging application in Biometric systems.

REFERENCES:

1. M. Arumugan, *Biomedical Instrumentation* (Anurada Agencies, Chennai, 1992).
2. R. S. Khandpur, *Handbook on Biomedical Instrumentation* (McGraw Hill, New Delhi, 2014).
3. J. G. Webster and A. J. Nimunkar, *Medical Instrumentation Application and Design* (Wiley, Singapore, 1999).
4. L. Cromwell, F. J. Weibell and E. A. Pfeiffer, *Biomedical Instrumentation and Measurements* (Pearson, New Delhi, 2016).
5. J. J. Carr and J. M. Brown, *Introduction to Biomedical Equipment Technology* (Pearson, New Delhi, 2001).
6. https://nptel.ac.in/courses/108105101
7. https://nptel.ac.in/courses/102105090

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

- Gain knowledge on various sensing and measurement devices of electrical origin.
- Understand the Bio potential recorders.
- Learn modern methods of imaging techniques and their analysis.
- Explain the medical assistance/techniques and therapeutic equipments.
- Recognize the significance of biomedical instrumentation field of study.

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