Syllabus

PHY-75T-301- Electronics & Solid State Devices

Semester	Code of the Course	Title of the Course/Paper	NHEQF Level	Credits
V	PHY-75T-301	Electronics & Solid State Devices	7	4

Level of Course	Type of the Course	Credit Distribution			Course Delivery Method
		Theory	Practical	Total	
High Level Course	MJR	4	0	4	Lectures

Regular Students-

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks (CA + EoSE)	Minimum Passing Marks (CA + EoSE)
Theory	PHY-75T-301 Electronics & Solid State Devices	CA- 1Hrs EoSE -3Hrs	CA- 20 Marks EoSE- 80 Marks	CA- 08 Marks EoSE-32 Marks

Objectives of the Course:	The syllabus for Electronics and Solid-State Devices aims to equip undergraduate students with a comprehensive understanding of circuit analysis, semiconductor device operation, and digital logic. It covers DC and AC circuits, semiconductor characteristics, BJTs and FETs configurations, and biasing techniques essential for amplifier and oscillator design. Students will also explore operational amplifiers and the foundational principles of Boolean algebra and logic gates. The course prepares students for practical applications and theoretical analysis in modern electronics

Unit I

Circuit Analysis:

Electric Networks: Definitions loop and nodal equations for D.C. and A.C. circuits (Kirchhoff's Laws).

Four-Terminal Electric Network: Ampere-volt conventions, open, closed, and hybrid parameters of four-terminal networks; input, output, and mutual impedance for active four- terminal networks.

Circuit Theorems: Superposition, Thevenin, Norton, reciprocity, compensation, maximum power transfer, and Miller theorems. **(15 Lectures)**

P-N Junction: Charge densities in N and P Semiconductors; conduction by drift and diffusion of charge carriers; P-N diode equation; capacitance effects.

Rectifiers: Half-wave, full-wave, and bridge rectifiers; Ripple factor, efficiency, Peak Inverse Voltage and regulation; Series inductor, shunt capacitor, L-section, and π-section filters.

Voltage Regulation: Zener diode, Voltage regulation using Zener diodes; voltage multipliers. **(15 Lectures)**

Unit II

Transistor Fundamentals: Notations, Configurations: CB, CE, CC. operation and characteristic curves for bipolar junction transistors (BJTs); Concept of load line and operating point, hybrid parameters.

Transistor Biasing: Need for biasing and stability of Q point, stability factors; Types of bias circuits for thermal bias stability: fixed bias, collector-to-base feedback bias, and four-resistor bias.

Field Effect Transistors (FETs): Introduction and merits demerits over BJT, biasing, and volt- ampere characteristics; Source follower, operation of FET as a variable voltage resistor.

(15 Lectures)

Unit III

Amplifiers: Analysis of transistor amplifiers using hybrid parameters, gain-frequency response; Cascade amplifiers, basic ideas of direct-coupled and R-C coupled amplifiers and analysis, differential amplifiers.

Amplifiers with feedback: Concept of feedback, positive and negative feedback, voltage and current feedback circuits, Advantages of negative feedback.

Operational Amplifier: Definition and history of operational amplifiers, Ideal Op-Amps, Input offset voltage and current, Common-mode rejection ratio (CMRR), Power supply rejection ratio (PSRR), Input and output impedance, Open-loop gain and frequency response, Slew rate; Inverting Amplifier, Non-Inverting Amplifier, Voltage Follower (Buffer).

(15 Lectures)

Unit IV

Oscillators: Criteria for self-excited and self-sustained oscillation, Circuit conditions for self-excited oscillations; Basic transistor oscillator circuit and its analysis; Colpitts's and Hartley oscillators, R.C. oscillators, crystal oscillators and their advantages.

Logic Operations: Fundamentals of Boolean Algebra, Boolean variables and functions, De Morgan's Theorems, basic logic gates (AND, OR, NOT, NAND, NOR, XOR, XNOR), symbols, truth tables, Boolean expressions, Diode-Transistor Logic (DTL) concept and configuration, Transistor-Transistor Logic (TTL) concept and evolution from DTL.

(15 Lectures)

Textbooks:

1. Basic Electronics and Linear Circuits by N.N. Bhargava, D.C. Kulshreshtha; S.C. Gupta.
2. Solid State Electronic Devices" by Ben G. Streetman and Sanjay Kumar Banerjee
3. Introduction to Semiconductor Devices" by M.S. Tyagi

Reference books:

1. Electronic Principles" by Albert Malvino and David Bates
2. Semiconductor Physics and Devices" by Donald A. Neamen
3. Integrated Electronics: Analog and Digital Circuits and Systems" by Jacob Millman and Christos C. Halkias
4. "Electronic Devices" by Thomas L. Floyd
5. Electronic Devices and Circuit Theory" by Robert L. Boylestad and Louis Nashelsky

E-Resources:

1. **NPTEL (National Programme on Technology Enhanced Learning)**:
   Website: https://nptel.ac.in/courses
2. **MIT Open Course Ware**:
   Website:https://ocw.mit.edu/courses/6-002-circuits-and-electronics-spring-2007/;
   https://ocw.mit.edu/courses/6-002-circuits-and-electronics-spring-2007/video_galleries/video-lectures/
3. **Course**: Website: Coursera - Electronics Courses
4. **edX**: Electronics Courses
   Website: https://www.edx.org/learn/electronics
5. **IEEE Xplore Digital Library**:
   Website: IEEE Xplore Digital Library

Learning Outcomes:

1. Understand and apply Kirchhoff's laws for analyzing DC and AC circuits.
2. Analyze four-terminal networks and calculate open, short-circuited, and hybrid parameters.
3. Apply circuit theorems like Superposition, Thevenin, and Norton to simplify circuits.
4. Comprehend the behavior of P-N junctions and their application in rectifiers and voltage regulation.
5. Explain the operation and characteristics of BJTs and FETs, including biasing techniques.
6. Design and analyze transistor amplifiers and understand feedback in amplifiers.
7. Utilize operational amplifiers in various configurations and understand practical limitations.
8. Design oscillators and understand the conditions for sustained oscillations.
9. Understand Boolean algebra and logic gates, and apply them in digital logic circuits.

Syllabus
PHY-75P-302- Physics Lab-V

Semester	Code of the Course	Title of the Course/Paper			NHEQF Level	Credits
V	PHY-75P-302	Physics Lab-V			7	2
Level of Course	Type of the Course	Credit Distribution			Course Delivery Method	
		Theory	Practical	Total		
High Level Course	MJR	0	2	2	Practical	

Regular Students-

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks (CA + EoSE)	Minimum Passing Marks (CA + EoSE)
Practical	PHY-75P-302 Physics Lab-V	CA- 1Hrs EoSE -4Hrs	CA- 10 Marks EoSE- 40 Marks	CA- 04 Marks EoSE-16 Marks

Objectives of the Course:	The objectives of the practical in the Electronics and Solid-State Devices syllabus aim to provide hands-on experience and deepen understanding of key electronics concepts. Students will verify Kirchhoff's laws and the maximum power transfer theorem, explore the characteristics of semiconductor devices such as transistors, junction diodes, Zener diodes, and FETs, and determine the band gap in semiconductors. Practical exercises will include the analysis of temperature dependence of resistance, designing single-stage transistor audio amplifiers, amplifiers with negative feedback, and studying power supply circuits, rectifiers with various filters, and Zener regulated power supplies. Advanced experiments will cover designing oscillators like Hartley and Colpitts oscillators, investigating

30/7/25

30/7/25

Kamlesh Sharma

30/7/25

Exam Scheme-

Students will have to perform one practical in the exam. The duration of practical exam will be 4 hours.

Marks distribution

Student category	Experiments	Viva-voice	Record	Maximum marks
Regular Student	20	10	10	40

Marking distribution in practical

Student category	Theory/formula	Figure/circuit	Observation	Calculation	Results/Error	Precautions
Regular	3	2	6	5	3	1

List of Practical:

1. Verify Kirchhoff's laws using breadboard circuits with resistors and voltage sources.
2. Verify the maximum power transfer theorem.
3. Study the characteristics of a given transistor (PNP/NPN) in common emitter, common base, and common collector configurations.
4. Determine the band gap of a semiconductor using a junction diode.
5. Study the variation of gain with frequency in a single-stage transistor audio amplifier.
6. Study the temperature dependence of resistance in a semiconductor using the four-probe method.
7. Study the characteristics of a junction diode and a Zener diode.
8. Study the characteristics of a field effect transistor (FET) and design an amplifier with finite gain.
9. Study a power supply using full wave rectifier or a bridge wave rectifier with various filter circuits.
10. Study a half wave rectifier with L and π section filters.
11. Design a Zener regulated power supply and studies the regulation with various loads.
12. Study the frequency response of a transistor amplifier and obtain the input and output

04/10/24

impedance.

13. Design and study an R-C phase shift oscillator and measure the output impedance (frequency response with change of R and C components).
14. Study a voltage multiplier circuit to generate high voltage D.C. from A.C.
15. Study OR, AND, and NOT logic gates using discrete components and compare them with TTL integrated circuits (ICs).
16. Design a Hartley oscillator and study its frequency stability and waveform.
17. Design a Colpitts oscillator and study its frequency stability and waveform.
18. Investigate the effect of negative feedback on amplifier performance.

Reference books:

1. "Electronic Devices and Circuit Theory" by Robert L. Boylestad and Louis Nashelsky
2. "Microelectronic Circuits" by Adel S. Sedra and Kenneth C. Smith
3. "Solid State Electronic Devices" by Ben G. Streetman and Sanjay Kumar Banerjee
4. "The Art of Electronics" by Paul Horowitz and Winfield Hill
5. "Electronic Principles" by Albert Malvino and David Bates
6. "Electronic Devices and Circuits" by David A. Bell
7. "Basic Electronics for Scientists and Engineers" by Dennis L. Eggleston
8. "Foundations of Analog and Digital Electronic Circuits" by Anant Agarwal and Jeffrey H. Lang
9. "Electronic Instrumentation and Measurements" by David A. Bell
10. "Operational Amplifiers and Linear Integrated Circuits" by Robert F. Coughlin and Frederick F. Driscoll

Learning Outcomes:

Upon completion, students will be able to verify Kirchhoff's laws and the maximum power transfer theorem. They will analyze transistor characteristics in various configurations, determine semiconductor band gaps, and study the variation of amplifier gain with frequency. Students will measure temperature-dependent resistance, understand diode and FET characteristics, design power supplies and rectifiers, explore oscillator designs and voltage multipliers, and investigate the impact of negative feedback on amplifiers, effectively bridging theoretical concepts with practical skills.

04/10/24

Syllabus

PHY-76T-303- Quantum Mechanics & Spectroscopy

Semester	Code of the Course	Title of the Course/Paper			NHEQF Level	Credits
VI	PHY-76T-303	Quantum Mechanics & Spectroscopy			7	4
Level of Course	Type of the Course	Credit Distribution			Course Delivery Method	
		Theory	Practical	Total		
High Level Course	MJR	4	0	4	Lectures	

Regular Students-

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks (CA + EoSE)	Minimum Passing Marks (CA + EoSE)
Theory	PHY-76T-303 Quantum Mechanics & Spectroscopy	CA- 1Hrs EoSE -3Hrs	CA- 20 Marks EoSE- 80 Marks	CA- 08 Marks EoSE-32 Marks

Objectives of the Course:	This course aims to introduce the basic features of quantum mechanics and its Applications in various physical phenomena. It will help students explore the core concepts, experiments, and the mathematical framework of quantum mechanics. • A central theme of the course is the Schrödinger wave equation, which Explains the behavior of quantum systems. • Students will learn how to solve the Schrödinger wave equation for various Types of potential, as well as for the hydrogen atom. • They will also learn about the concept of orbital angular momentum and its quantization. • The final section introduces students to rotational and vibrational energy levels and spectra

20/7/25

20/7/25

Kamlesh Sharma

30/7/25

Unit – I

Evolution of quantum physics

1. Difficulties of classical mechanics to explain: the black-body emission spectrum, specific heat of solids. Plank quanta concept and radiation law, Photo electric effect and Einstein's explanations. Compton Effect, de-Broglie hypothesis, diffraction experiments for wave particles (Davisson-Germer experiment).
2. Uncertainty principle: position and momentum, angle and angular moment, energy, and time. Application of uncertainty principle: (i) Ground state energy of hydrogen atom, (ii) ground state energy of simple harmonic oscillator. (iii) Natural width of spectral lines, (iv) Non-existence of electron in nucleus.
3. Operators: linear operators, product of two operators, commuting and non-commuting operators. Simultaneous Eigen function and eigenvalues, orthogonal wave functions, Hermitian operators, their eigenvalues. Hermitian adjoint operators. Eigenvalues and Eigen function; expectation values of operators: position, momentum, energy; Ehrenfest theorem and complementarity, Concept of group and phase velocity, wave packet, Gaussian wave packet, bra-ket notation.

(15 Lectures)

Unit – II

Schrödinger wave equation and its solutions

1. Schrödinger wave equation: general equation of wave propagation, propagation of matter waves, time dependent and time-independent Schrödinger equation, wave function representation (ψ), physical meaning of ψ. properties and conditions on ψ, postulates of wave mechanics, operators, observable and measurements; probability current density.
2. Time independent Schrödinger equation, stationary state solution, one dimensional problem: particle in one dimensional box, Eigen functions and eigenvalues, discrete levels, generalization into three dimension and degeneracy of energy levels, concept of a potential well and barrier, step potential, penetration through rectangular barrier, reflection and transmission coefficients, barriers with special shapes (graphical representation), quantum mechanical tunneling effect. (alpha decay). **(15 Lectures)**

Unit – III

Schrödinger equation solutions in special cases

1. Symmetric Square well potential, reflection and transmission coefficients, resonant scattering, bound state problems: particle in one dimensional infinite potential well

04/10/24

and finite depth potential well, energy eigenvalues and Eigen functions, transcendental equation and its solution; Simple harmonic oscillator. Schrödinger equation for simple harmonic oscillator and its solution, eigenfunction, eigenvalues, zero-point energy, quantum and classical probability density, parity, symmetric and antisymmetric wave functions with graphical representation.

2. Schrödinger equation in spherical coordinates, Schrödinger equation for one electron atom in spherical coordinates, separation into radial and angular variables, solution of radial equation and angular equation, qualitative discussion of spherical harmonics, series solution and energy eigenvalues, stationary state wave function. Wave-functions of H-atom for ground and first excited states, average radius of H-atom, Bohr correspondence principle, orbital angular momentum and its quantization, commutation relation, eigenvalues and Eigen functions **(15 Lectures)**

UNIT IV

H-atom, Atomic and Molecular spectroscopy

1 Energy level derivation for H-atom, quantum features of hydrogen spectra and hydrogen like spectra, Stern-Gerlach experiment, electron spin, spin magnetic moment. Spin-orbit coupling. Qualitative explanation of fine structure, Franck-Hertz experiment. Zeeman Effect, normal Zeeman splitting, Qualitative explanation of Stark effect.

2. Molecular spectroscopy: concept of rigid rotator, rotational energy levels, rotational spectra, selection rules, intensity of spectral lines, isotopic effect; Vibrational energy levels, vibrational spectra, selection rules, isotopic effect, effect of anharmonicity in vibrational spectra, vibrational-rotational spectra of CO and HCl molecules. **(15 Lectures)**

Suggested Books and Reference-

1. Griffiths, Introduction to Quantum Mechanics, 2nd edition.
2. R. Shankar, Principles of Quantum Mechanics, 2nd edition.
3. Arthur Beiser, Perspective of modern Physics, 6th edition.
4. AK Ghatak and S Lokanathan, Quantum Mechanics: Theory and application.
5. HS Mani, GK Mehta, Introduction to modern Physics.
6. C.N. Banwell and E.M. McCash, Fundamental of Molecular Spectroscopy, 4th edition.
7. H.E. White, Introduction to atomic physics,

Suggested E-sources:

Video Lectures:

MIT Open Course ware - 8.04 Quantum Physics I https://ocw.mit.edu/courses/8-04-quantum-physics-i-spring-2016/ Lecture Series on Quantum Physics by Prof.V.Balakrishnan, Department of Physics, IIT Madras.

04/10/24

Syllabus

PHY-76P-304- Physics Lab-VI

Semester	Code of the Course	Title of the Course/Paper			NHEQF Level	Credits
VI	PHY-76P-304	Physics Lab-VI			7	2
Level of Course	**Type of the Course**	**Credit Distribution**			**Course Delivery Method**	
		Theory	**Practical**	**Total**		
High Level Course	MJR	0	2	2	Practical	

Regular Students-

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks (CA + EoSE)	Minimum Passing Marks (CA + EoSE)
Practical	PHY-76P-304 Physics Lab-VI	CA- 1Hrs EoSE -4Hrs	CA- 10 Marks EoSE- 40 Marks	CA- 04 Marks EoSE-16 Marks

Objectives of the Course:	The Objective of this course is to make the students gain practical knowledge to Co-relate with the theoretical studies. To achieve perfectness in experimental skills and Measure fundamental constants and probe material properties in the lab

30/7/25

30/7/25

Kamlesh Sharma

30/7/25

Marking distribution in practical

Student category	Theory/formula	Figure/circuit	Observation	Calculation	Results/Error	Precautions
Regular	3	2	6	5	3	1

List of experiments

[1] Determination of Planck's constant by photo cell (retarding potential method using optical filters, preferably five wavelengths).

[2] Determination of Planck's constant using solar cell.

[3] Determination of Stefan's constant (Black body method).

[4] Study of the temperature dependence of resistivity of a semiconductor using four probe-methods.

[5] Study of Iodine spectrum with the help of grating and spectrometer and ordinary bulb light.

[6] Study of characteristics of a GM counter and verification of inverse square law for the same strength of a radioactive source.

[7] Study of β-absorption in Al foil using GM Counter to find endpoint energy.

[8] To find the magnetic susceptibility of a paramagnetic solution using Quincke's method.

[9] Determination of coefficient of rigidity as a function of temperature using torsional oscillator (resonance method).

[10] Study of polarization by reflection from a glass plate with the help of Nicol's prism and photocell and verification of Brewster's Law and Malus's Law.

[11] e/m measurement by helical method.

[12] Measurement of magnetic field using ballistic galvanometers and search coil (using earth inductor for calibration of galvanometer). Study of variation of magnetic field of an electromagnet with current.

[13] Measurement of electric charge by Millikan's oil drop method.

Learning outcomes -

This course covers a wide range of topics in physics. Upon completion, students will be able to: i. Quantify fundamental physical constants ii. Characterize material properties iii. Analyze radiation and its interactions iv. Investigate light polarization v. Develop proficiency in handling laboratory instrumentation.

04/10/24