Syllabus and Model Papers

M.Sc. Physics
2nd Semester

Under Choice Based Credit System (CBCS)
[Effective from 2021-2022 Admitted Batches]

Department of Physics
College of Science and Technology
Andhra University
Visakhapatnam.

M.Sc. Physics
Course Curriculum under CBCS

M.Sc. Physics – II Semester – FIRST YEAR
[Effective from the admitted batch 2021-2022]

THEORY	P 201	Electrodynamics
	P 202	Statistical Mechanics
	P 203	Atomic & Molecular Physics
	P 204	Nuclear and Particle Physics
LABORATORIES	P 205	Modern Physics Lab 2
	P 206	Electronics Lab 2

SCHEME OF INSTRUCTION AND EXAMINATION UNDER CBCS

M.Sc. Physics – II Semester – FIRST YEAR
[Effective from the admitted batch 2021-2022]

Theory Code	Title of the Paper	T	P	Semester End Exam Marks	Mid Exam Marks	Total Marks	Pass Minimum	Credits
P-201	Electrodynamics	4	-	80	20	100	40	4
P-202	Statistical Mechanics	4	-	80	20	100	40	4
P-203	Atomic & Molecular Physics	4	-	80	20	100	40	4
P-204	Nuclear and Particle Physics	4	-	80	20	100	40	4
P-205	Modern Physics Lab 2 (Practical-80 & Record-20)	-	3	100		100	50	4
P-206	Electronics Lab 2 (Practical-80 & Record-20)	-	3	100		100	50	4
	Total					**600**		**24**

(**T**- Theory Hrs /Week, **P**- Practical Hrs/Week)

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M.Sc. Degree Examination
Physics

SYLLABUS

Second Semester

P 201 – Electrodynamics
(Effective from the admitted batch of 2021-2022-CBCS)

Course Objectives:

1. To evaluate fields and forces and potentials in Electrodynamics and Magneto dynamics using basic scientific method.
2. To make the students understand the propagation behavior of electromagnetic waves in different media.
3. To be capable of understanding the physical interpretation of Maxwell's Equations.
4. To provide concepts of relativistic electrodynamics and its applications in branches of Physical Sciences.

Course Outcomes:

1. The students will be able to explain and solve advanced problems based on classical electrodynamics using Maxwell's equation.
2. The students will be able to analyze radiation systems in which the electric dipole, magnetic dipole or electric quadruple dominate.
3. The students will have an understanding of the covariant formulation of electrodynamics and the concept of retarded time for charges undergoing acceleration.
4. This course will lay the foundation for the modern optics, photonics, telecommunications and ionosphere.

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UNIT-I: Gauss's law and its applications, Poisson equation, Laplace equations, Uniqueness theorem, boundary value problems, separation of variables, solution to Laplace's equation in Cartesian, spherical, and cylindrical coordinates, use of Laplace's equation in the solutions of electrostatic problems.

UNIT-II: Biot-Savart law, Ampere's theorem, Faraday's law of electromagnetic induction, magnetic vector potential, displacement current, Maxwell's equations, differential and integral forms, physical significance of Maxwell's equations, Maxwell's equations in free space, Maxwell's equations inside matter, boundary conditions on the fields at interfaces.

UNIT-III: Wave equation, plane electromagnetic waves in free space, in non-conducting isotropic medium, in conducting medium, electromagnetic vector and scalar potentials, uniqueness of electromagnetic potentials and concept of gauge, Lorentz gauge, Coulomb gauge, motion of charged particles in uniform electric field, charged particles in homogenous and non-homogeneous magnetic fields, charged particles in simultaneous electric and magnetic fields.

UNIT-IV: Lienard-Wiechert potentials from a moving charge, electromagnetic fields from Lienard-Wiechert potentials of a moving charge, electromagnetic fields of a uniformly moving charge, radiation from moving charges and dipoles, radiation from an accelerating charge, Bremsstrahlung radiation, Cherenkov radiation and application.

UNIT-V: Lorentz transformations, transformation of electromagnetic potentials, E and B fields from Lorentz transformations, covariance and contra variance, Electromagnetic field tensor and Lorentz invariance of Maxwell's equations.

Text books:

1. Classical Electrodynamics - J. D. Jackson
2. Introduction to Electrodynamics - D.R. Griffiths

Reference Books:

1. Electromagnetic Theory and Electrodynamics - Satyaprakash
2. Electrodynamics - K.L Kakani

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Model Question Paper

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M.Sc. Degree Examination

Physics

Second Semester

P 201 – Electrodynamics

(Effective from the admitted batch of 2021-2022-CBCS)

Answer one question from each unit

All questions carry equal marks

Time: 3 Hrs. **Max.Marks:80 (16 X 5 = 80)**

Unit – I

1. a) State and prove Gauss Theorem.
   b) Derive Laplace's and Poisson's equations from the Gauss law.

(OR)

2. a) Explain the method of separation of variables in spherical polar Co-ordinates.
   b) Obtain potentials inside and outside a dielectric sphere in a uniform electric field.

Unit – II

3. a) State and prove Biot – Savart law.
   b) What is Faraday's law of electromagnetic induction?

(OR)

4. a) Describe the Maxwell equations in differential and integral forms.
   b) Explain their physical significance.

Unit – III

5. a) Explain how the electromagnetic waves behaves in free space, conducting medium.
   b) Define Lorentz gauge.

(OR)

6. a) Derive the equation of motion of charged particles in uniform electric field.
   b) Derive the equation of motion of charged particles in homogenous magnetic field.

Unit – IV

7. a) What are Lienard – Weichert potentials?
   b) Calculate the electric and magnetic field vectors for a uniformly moving point charge using these potentials.

(OR)

8. a) Give an account on Bremsstrahlung radiation.
   b) What is meant by Cherenkov radiation?

Unit – V

9. a) Explain what is meant by Lorentz Transformations?
   b) Derive the electric and magnetic fields from the Lorentz Transformations.

(OR)

10. a) Give an account on covariance and contra variance of electric and magnetic fields.
    b) Explain briefly about the Electromagnetic field Tensor.

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SYLLABUS

Second Semester

P 202 – Statistical Mechanics
(Effective from the admitted batch of 2021-2022-CBCS)

Course Objectives:

1. The course gives an introduction to statistical mechanics and includes the concepts of phase space, ensembles and calculations of thermodynamic parameters using the concepts of ensembles.
2. The course also discusses partition functions and their properties and its applications.
3. It explains quantum statistics such as Maxwell-Boltzmann statistics, Bose-Einstein and Fermi-Dirac statistics, Bose-Einstein condensation, theory of dwarf stars.
4. The course also describes phase transitions and calculation of partition function for non-ideal classical gas.

Course Outcomes:

On completion of course:

1. The student should be able to understand the concepts of phase space, different kinds of ensembles and how to obtain the thermodynamic parameters using these concepts.
2. They are also able to know what Gibb's paradox is and how to resolve it.
3. They are able to differentiate types of quantum statistics and able to know the difference between ideal and non-ideal classical gas.
4. They are able to understand types of orders of phase transitions.

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UNIT-I: Basic Methods and Results of Statistical Mechanics:
Phase space, Isolated systems, Basic postulates, concept of ensembles, different types of ensembles – probability calculations according to micro canonical, canonical and grand canonical ensemble (system with an indefinite number of particles & system in macroscopic motion), simple applications of canonical distribution, system with specified mean energy, calculation of mean values in a canonical ensemble, connection with thermodynamics, Liouvilles theorem, Energy fluctuations in the canonical ensemble. Density and energy fluctuations in the grand canonical ensemble. Thermodynamic equivalence of ensembles.
Reif Chapter: 6.

UNIT-II: Simple Applications of Statistical Mechanics:
Partition functions and their properties. Calculation of thermo dynamic quantities to an ideal mono atomic gas. Gibbs paradox, validity of the classical approximation. Proof of the equipartition theorem. Simple applications – mean K.E. of a molecule in a gas. Brownian motion. Harmonic Oscillator, Partition function for polyatomic molecules, electronic energy, vibrational energy and rotational energy of a diatomic molecule. Effect of Nuclear spin-ortho and para Hydrogen.
Reif Chapter: 7 & 9.12

UNIT-III: Quantum Statistics:
Formulation of the statistical problem. Maxwell–Boltzmann statistics. Photon statistics, Bose-Einstein statistics, Fermi–Dirac statistics, Quantum statistics in the classical limit, calculation of dispersion for MB, BE & FD statistics Equation of state of an Ideal Bose Gas, Bose-Einstein condensation.
Reif Chapter: 9

UNIT-IV: Non Ideal Classical Gas:
Calculation of the partition function for low densities. Equation of state and virial coefficients, Alternative derivation of Van Der Walls equation. Black body radiation, Thermionic emission. The theory of white dwarf stars
Reif Chapter: 10.3, 10.4

UNIT – V: Phase Transitions
Phase transitions, conditions for Phase equilibrium, First order Phase transition – the Clausius–Clayperon equation, Second order phase transition, the critical indices, Van der Waals theory of liquid gas transition. Order parameter, Landau theory.
Sinha Chapter:10

Text Books

1. Fundamentals of Statistical and Thermal Physics - F. Reif

Reference Books:

1. Statistical Mechanics, Theory and Applications - S. K. Sinha
2. Statistical Mechanics - R. K. Pathria
3. Statistical Mechanics - KersonHuang
4. Statistical Mechanics - Gupta Ram

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Model Question Paper

Andhra University

M.Sc. Degree Examination

Physics

Second Semester

P 202 – Statistical Mechanics

(Effective from the admitted batch of 2021-2022-CBCS)

Answer one question from each unit

All questions carry equal marks

Time: 3 Hrs. **Max.Marks:80 (16 X 5 = 80)**

Unit – I

1. a) Explain the concept of ensemble.
   b) Mention the different types of ensembles and their properties.

(OR)

2. a) Derive and explain the Liouville’s theorem.
   b) What is the thermodynamic equivalence of ensembles?

Unit – II

3. a) State and prove the equipartition theorem.
   b) Calculate the mean kinetic energy of a molecule in a gas.

(OR)

4. a) Derive the equation for the vibrational and rotational energy of a diatomic molecule.
   b) Define Gibb’s Paradox.

Unit – III

5. a) Distinguish between Maxwell, Bose – Einstein and Fermi Dirac Statistics.
   b) Obtain an expression for Fermi – Dirac distribution.

(OR)

6. a) Give an account on Bose – Einstein condensation.
   b) Calculate the Maxwell – Boltzmann statistics equation for an ideal Bose gas.

Unit – IV

7. a) Calculate the partition function for low densities.
   b) Derive the equations for the Virial coefficients.

(OR)

8. a) Derive an alternative derivation for Van Der Walls equation.
   b) What is the theory of white dwarf stars?

Unit – V

9. a) Define Phase transition.
   b) What are the conditions for phase equilibrium?

(OR)

10. a) Derive the first and second order equations for phase transitions.
    b) Describe the Landau theory.

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M.Sc. Degree Examination
Physics

SYLLABUS

Second Semester

P 203 – Atomic and Molecular Physics
(Effective from the admitted batch of 2021-2022-CBCS)

Course Objectives:

1. To provide an understanding of the fundamental aspects of atomic and molecular physics.
2. To make the students understand various couplings effects.
3. To study spectroscopy of the one electron, one valence electron, multi-electron atoms and diatomic molecules.
4. To make the students understand about various absorption/emission spectroscopic transitions.
5. To make the students understand Quantum mechanical phenomenon at the atomic and molecular level.
6. To make the students understand the molecular orbits using Electronic Spectroscopy and Resonance Raman Spectra.

Course Outcomes:

1. The students will be able to understand the normal and anomalous splitting of atomic and molecular energy levels.
2. The students will have an understanding of quantum behavior of atoms in external electric and magnetic fields.
3. The students will be capable to understand infrared spectroscopy.
4. The students will understand the spectroscopy of molecules using Raman Effect.
5. The students will be able to understand the molecular vibrations using the Group Theory.

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UNIT-I: One Electron Atoms

Derivation of Quantum numbers, Term values, Relation between Magnetic dipole moment and angular momentum of an orbiting electron, Spin- orbit interaction, relativistic kinetic energy correction and dependence of energy on J value only, Selection rules. Fine structure of Hydrogen spectra, Fowler series of ionized Helium, Hyperfine structure of Hα line of hydrogen (I = ½).

One Valence Electron Atoms:

Modified term values (quantum defect) due to lifting of orbital degeneracy by core penetration (penetrating orbits), core polarization (non-penetrating orbits) by nl electrons. Term values, Fine structure of chief spectral series of sodium, Intensity rules and application to doublets of sodium. Hyperfine structure of ^{2}P-^{2}S transition of sodium (I= 3/2).

UNIT-II: Many Electron Atoms

Indistinguishable particles, bosons, fermions, Pauli's principle, Ground states, LS coupling and Hund's rules based on Residual columbic interaction and spin-orbit interaction, Lande's interval rule, Equivalent and non-equivalent electrons, Spectral terms in LS and JJ coupling (ss,s2 ,pp,p2 configurations), Exchange force and Spectral series of Helium.

UNIT - III

Atoms in External Magnetic Field: Normal Zeeman effect, Anomalous Zeeman effect and Paschen-Back effects and application to ^{2}P-^{2}S, ^{3}P-^{3}S, transitions.

Atoms in External Electric Field: Linear stark pattern of Hα line of hydrogen, Quadratic stark pattern of D1 and D2 lines of Sodium.

UNIT-IV: Diatomic Molecules

Molecular quantum numbers, Bonding and anti-bonding orbitals from LCAO's, Explanation of bond order for N2 and O2 and their ions, Rotational spectra and the effect of isotopic substitution, Effect of nuclear spin functions on Raman rotation spectra of H2 (Fermion) and D2 (Boson), Vibrating rotator and its spectrum, Combination relations and evaluation of rotational constants (infrared and Raman), Intensity of vibrational bands of an electronic band system in absorption.(The Franck-Condon principle), Sequences and progressions, Deslandre's table and vibrational constants.

UNIT- V: Molecular Vibrations

Symmetry elements, operations and identification of point Groups of AH_2, A_2H_2, ABH_2, AB_2H_2, AH_3, and ABH3 type molecules, Properties of irreducible representations and C2v character table. Reducible representation and symmetry in fundamental vibrations of H_2O. Structure determination of AB_2 type molecules from observed and expected fundamental bands of Raman and IR Spectra.

Molecular orbitals:

Walsh diagram, electronic spectroscopy, Herzberg – Teller effect, Resonance Raman Scattering, Fluorescence and Resonance Raman Spectra, Nonlinear effects and Raman Spectra.

Text Books:

1. Introduction to Atomic Spectra - H. E. White
2. Atomic and Molecular Spectra - Rajkumar
3. Fundamentals of Molecular Spectroscopy - C. N. Banwell
4. Group Theory - K. V. Raman

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Model Question Paper

Andhra University

M.Sc. Degree Examination

Physics

Second Semester

P 203 – Atomic and Molecular Physics

(Effective from the admitted batch of 2021-2022-CBCS)

Answer one question from each unit

All questions carry equal marks

Time: 3 Hrs. **Max.Marks:80 (16 X 5 = 80)**

Unit – I

1. a) Describe Spin Orbit interaction.
   b) Derive an expression for the relativistic kinetic energy correction.

(OR)

2. a) What are penetrating and non-penetrating orbitals?
   b) Draw the fine structure of chief spectral series of sodium.

Unit – II

3. a) State and explain Pauli's exclusion principle.
   b) Derive the Hund's rules based on residual coulomb and exchange interactions.

(OR)

4. a) Describe Lande's interval rule.
   b) Explain in detail the LS and JJ couplings.

Unit – III

5. a) Explain the Anomalous Zeeman effect.
   b) Apply the quantum theory of Zeeman Effect to the case of 2p-2s transition.

(OR)

6. a) What is meant by Stark effect?
   b) Discuss the quadratic stark pattern of Sodium D1 and D2 lines.

Unit – IV

7. a) What are bonding and anti-bonding orbitals?
   b) Give the theory of Linear combination of atomic orbitals.

(OR)

8. a) State and explain Frank-Condon principle.
   b) Discuss the intensity distribution of vibrational spectra of a diatomic molecule.

Unit – V

9. a) What are the properties of irreducible representations?
   b) Derive its C2v character table.

(OR)

10. a) Draw the Walsh diagram.
    b) Give an account on electronic spectroscopy and Herzberg – Teller effect.

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SYLLABUS

Second Semester

P 202 – Statistical Mechanics
(Effective from the admitted batch of 2021-2022-CBCS)

Course Objectives:

1. To familiarize about the essential properties of the nucleus such as its shape, size, radius, density, magnetic moment, electric quadruple moment etc.
2. In order to probe these properties several models have been proposed such as liquid drop model, shell models, collective models.
3. The most useful part of this knowledge is the nuclear energy which has immense applications.
4. The concept behind this energy was first given by Hans Bethe in the form of semi-empirical mass formula which is in the course content.
5. Carbon dating, modern medical applications, radio-physics all require the knowledge of radio-activity.
6. It is a well-known fact that all kind of interactions which we perceive in our life are essentially four in number viz. gravitational, electromagnetic, weak and strong.
7. The ultimate aim of particle physics is to unify these interactions.

Course Outcomes:

1. Demonstrate knowledge of fundamental aspects of the structure of the nucleus, radioactive decay, nuclear reactions and the interaction of radiation and matter.
2. Discuss nuclear and radiation physics connection with other physics disciplines – solid state, elementary particle physics, radiochemistry.
3. Discuss nuclear and radiation physics applications in medical diagnostics and therapy, energetic, geology, archaeology.
4. Describe experimental techniques used (or developed) for nuclear physics purposes (gamma cameras, semiconductor detectors) and discuss their influence on development of new technologies.
5. Explore an application of nuclear and/or radiation physics and communicate their understanding to a group of their peers in a short presentation.
6. The students will be able to do higher studies in this field.
7. The students may get employment opportunities in radiology and medical field.

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UNIT – I: Introduction: Objective of Studying Nuclear Physics, Nomenclature, nuclear radius, mass & Binding energy, angular momentum, magnetic dipole moment, Electric quadrupole moment, parity and symmetry, domains of instability, mirror nuclei.

Nuclear Forces: Simple theory of the deuteron, scattering cross-sections, qualitative discussion of neutron-proton and proton- proton scattering, exchange forces, Yukawa's Potential, Characteristics of Nuclear Forces.

UNIT – II

Nuclear Models: Liquid drop model: Weissacker's semi-emperical mass formula, Mass – parabolas. Nuclear shell model: Spin orbit interaction, magic numbers, prediction of angular momenta and parities for ground states, Collective model. More-relistic models.

Nuclear Decay: Aplha decay process, Energy release in Beta-decay, Fermi's Theory of β -decay, parity violation in β -decay, detection and properties of neutrino. Energetics of gamma decay, selection rules, angular correlation, Mossbauer Effect.

UNIT – III

Nuclear Reactions: Types of reactions and conservation laws, the Q – equation, Optical model.

Nuclear Energy: Stability limit against spontaneous fission, Characteristics of fission, delayed neutrons, four factor formula for controlled fission, nuclear fusion, prospects of continued fusion energy.

UNIT – IV

Nuclear Radiation Detectors: Interaction of radiation with matter. Gas filled counters, scintillation detectors, semiconductor detectors, energy measurements, coincidence measurements and time resolution, magnetic spectrometers.

Accelerators: Electrostatic accelerators, cyclotron accelerators, synchrotrons, linear accelerators, colliding beam accelerators.

Applications: Trace Element Analysis, Rutherford Back-scattering, Diagnostic Nuclear Medicine, Therapeutic Nuclear Medicine.

UNIT – V

Elementary Particles: Particle interactions and families, conservation laws (energy and momentum, angular momentum, parity, Baryon number, Lepton number, isospin, strangeness quantum number (Gellmann and Nishijima formula) and charm, Elementary ideas of CP aand CPT invariance, Quark model.

Text Books:

1. Introductory Nuclear Physics - Kenneth S. Krane
2. Elementary Particle Physics – M J Longo

Reference Books:

1. Introduction to Nuclear Physics - Harald A.Enge
2. Concepts of Nuclear Physics - Bernard L.Cohen.
3. Introduction to High Energy physics - D.H. Perkins
4. Introduction to Elementary Particles - D. Griffiths

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Model Question Paper
Andhra University
M.Sc. Degree Examination
Physics

Second Semester
P 204 – Nuclear and Particle Physics
(Effective from the admitted batch of 2021-2022-CBCS)

Answer one question from each unit
All questions carry equal marks

Time: 3 Hrs. **Max.Marks:80 (16 X 5 = 80)**

Unit – I

1. a) Explain briefly about the magnetic dipole moment and electric quadrupole moment.
   b) What are the characteristics of nuclear forces?

(OR)

2. a) Describe the simple theory of deuteron and quantitatively.
   b) Discuss the neutron – proton and proton – proton scatterings.

Unit – II

3. a) Discuss the formulation of Semi – empirical mass formula.
   b) Obtain the condition for stable isotope.

(OR)

4. a) Give a brief account of Fermi's theory of β –decay.
   b) Explain in detail the Mossbauer effect.

Unit – III

5. a) What are different types of nuclear reactions?
   b) Derive the Q- equation for the nuclear reaction.

(OR)

6. a) What are the characteristics of nuclear fission?
   b) Derive the four-factor formula for controlled fission.

Unit – IV

7. a) Explain how the radiation interacts with matter.
   b) What are the different types of nuclear radiation detectors?

(OR)

8. a) Give an account on Cyclotron and linear accelerators.
   b) Explain briefly about the Rutherford Back Scattering technique.

Unit – V

9. a) Discuss the conservation laws that explain the behavior of elementary particles.
   b) Define Baryon and Lepton numbers.

(OR)

10. a) Briefly explain the elementary ideas of CP and CPT invariance.
    b) What is Quark Model?

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SYLLABUS

Second Semester

P 205 – Modern Physics Laboratory - 2
(Effective from the admitted batch of 2021-2022-CBCS)

Course Objectives:

1. The aim of this laboratory course is to make the students perceive some of the fundamental laws of Physics through experiments.

Course Outcomes:

1. At the end of this laboratory course, the students will be capable of handling sophisticated instruments besides learning the Physics concepts behind these experiments.

LIST OF EXPERIMENTS

1. He-Ne Laser
2. Band Gap of a Semiconductor (Two probe Method)
3. Determination of Curie Temperature
4. Characteristics of LED and Laser Diode
5. Reciprocal Dispersion Curve
6. Vibrational Analysis of ALO Band Spectrum

Reference Books:

1. Advanced Practical Physics, B.L. Worsnop & H.T. Flint.
2. A Text Book of Practical Physics, I.Prakash & Ramakrishna.
3. Practical Physics, Geeta Sanon, R. Chand & Co.Publishers.
4. Advanced Practical Physics, S P Singh, Pragati Prakashan.
5. Practical Physics, Gupta & Kumar, Pragati Prakashan.
6. An Advanced Course in Practical Physics, D Chattopadhyay & P C Rakshit, Central Pub.

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SYLLABUS

Second Semester

P 206 – Electronics Laboratory - 2
(Effective from the admitted batch of 2021-2022-CBCS)

Course Objectives:

1. To make the students familiar with analog electronic components.
2. To provide hands-on experience to the students to make them familiar with the working and handling of the analog electronic devices and circuits.

Course Outcomes:

1. At the end of this laboratory, the students will be skilled enough to handle and understand the use of analog devices.

LIST OF EXPERIMENTS

1. Active low, High and Band Pass Filters (IC 741)
2. Twin – T Filter (IC 741)
3. Logarithmic Amplifier (IC 741)
4. Wein Bridge Oscillator (IC 741)
5. Monostable Multivibrator (IC 555)
6. Voltage Regulator (IC 723)

Reference Books:

1. The Art of Electronics, P. Horowitz & W. Hill.
2. Microelectronics, J. Millman & A. Grabel.
3. Electronic Devices and Circuits, Schaum's Outline Series, J.J. Cathey.
4. Basic *Electronics*: *A Text-Lab Manual*, Paul Zbar & Albert P Malvino.
5. Experiments in Electronics, S V Subrahmanyam.
6. Operational Amplifiers & Linear ICs, S V Subrahmanyam.

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