# SEMESTER-V

## Course Code: DSC-13 CHEMISTRY- V

## Course Title: Coordination Chemistry and Organometallics

**Total Credits: 04 (Credits: Theory-02, Practical-02)**

**Total Lectures: Theory- 30, Practical-60**

**Objectives:** The course introduces the students to basics of coordination chemistry and organometallics which are of immense importance to biological systems, qualitative and quantitative analysis, catalysis, medicines, paints and pigments etc. Nomenclature, isomerism, bonding in coordination compounds has been dealt with in sufficient detail along with special emphasis on important coordination compounds in the biological system. In organometallic chemistry, the students are introduced to classification of organometallic compounds, the concept of hapticity and the 18-electron rule governing the stability of a wide variety of organometallic species with special emphasis on metal carbonyls.

**Learning Outcomes:**

By the end of the course, the students will be able to:

- Understand terms: ligand, denticity of ligands, chelate, coordination number.
- Systematically name coordination compounds.
- Discuss the various types of isomerism possible in Octahedral and Tetrahedral coordination compounds.
- Use Valence Bond Theory to predict the structure and magnetic behaviour of metal complexes and understand the terms inner and outer orbital complexes.
- Explain the meaning of the terms $\Delta o.$, $\Delta t$, pairing energy, CFSE, high spin and low spin and how CFSE affects thermodynamic properties like lattice enthalpy and hydration enthalpy.
- Explain magnetic properties and colour of complexes on basis of Crystal Field Theory
- Apply 18-electron rule to rationalize the stability of metal carbonyls and related species.
- Learn how IR data can be used to understand extent of back bonding in metal carbonyls

### Unit I: Introduction to Coordination compounds Lectures: 06

Brief discussion with examples of types of ligands, denticity and concept of chelate. IUPAC system of nomenclature of coordination compounds (mononuclear and binuclear) involving simple monodentate and bidentate ligands. Structural and stereoisomerism in complexes with coordination numbers 4 and 6.

**UNIT II: Bonding in coordination compounds** **Lectures: 14**

Valence Bond Theory (VBT): Salient features of theory, concept of inner and outer orbital complexes, Drawbacks of VBT.

Crystal Field Theory: Splitting of d orbitals in octahedral symmetry. Crystal field effects for weak and strong fields, Crystal field stabilization energy (CFSE), concept of pairing energy, Factors affecting the magnitude of Δ, Spectrochemical series, Splitting of d orbitals in tetrahedral symmetry, Comparison of CFSE for octahedral and tetrahedral fields, tetragonal distortion of octahedral geometry, Jahn-Teller distortion

**UNIT III: Organometallic chemistry** **Lectures: 10**

Definition and classification with appropriate examples based on nature of metal-carbon bond (ionic, sigma, pi and multicentre bonds), Structure and bonding of methyl lithium and Zeise's salt, Structure and bonding of ferrocene, mononuclear and polynuclear carbonyls of 3d metals, 18-electron rule as applied to carbonyls, π-acceptor behaviour of carbon monoxide (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.

**Practical:** **Credits:02**
**(Laboratory periods: 60 )**

1. Estimation of $Mg^{2+}$ by direct complexometric titrations using EDTA.
2. Estimation of $Zn^{2+}$ by direct complexometric titrations using EDTA.
3. Estimation of $Ca^{2+}$ by direct complexometric titrations using EDTA.
4. Estimation of total hardness of a given sample of water by complexometric titration.
5. Determination of the composition of the $Fe^{3+}$ - salicylic acid complex / $Fe^{2+}$-1, 10- phenanthroline complex in solution by Job's method.
6. Determination of the composition of the $Fe^{3+}$ - salicylic acid complex / $Fe^{2+}$-1,10-phenanthroline complex in solution by mole ratio method
7. Preparation of the following inorganic compounds:

   a). Tetraamminecopper(II) sulphate

   b). Potassium trioxalatoferrate(III) trihydrate

   c) Chrome alum

d). *Cis*- and *trans*-Potassium diaquadioxalatochromate(III)

8. Any suitable experiment (other than the listed ones) based upon complexation reactions.

## References:

### Theory:


1. Huheey, J.E.; Keiter, E.A., Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry- Principles of Structure and Reactivity**, Pearson Education
2. Shriver, D.D.; Atkins, P.; Langford, C.H. (1994), **Inorganic Chemistry 2nd Ed.**, Oxford University Press.
3. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), **Inorganic *Chemistry*, 5th Edition**, W. H. Freeman and Company.
4. Cotton, F.A.; Wilkinson, G.; Gaus, P.L. **Basic Inorganic Chemistry, 3rd Edition**, Wiley India.
5. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), **Concepts and Models of Inorganic Chemistry**, John Wiley & Sons.
6. Greenwood, N.N.; Earnshaw, A. (1997), **Chemistry of the Elements**, 2nd Edition, Elsevier.


### Practical:


1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989),**Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.
2. Marr, G.; Rockett, B.W. (1972), **Practical Inorganic Chemistry**, Van Nostrand Reinhold.


## Teaching Learning Process:

- Conventional chalk and board teaching,
- Class interactions and discussions
- Power point presentation on important topics.

## Assessment Methods:

- Presentations by Individual Student/ Group of Students
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester University Theory Examination


**Keywords:** Crystal field theory, Dq, CFSE, Nomenclature, Valence bond theory, Crystal field theory, Magnetic properties, 18 electron rule, metal carbonyls, hapticity

5. Chattopadhyay, K.K.; Banerjee, A. N. (2009), **Introduction to Nanoscience and Technology**, PHI.

**Practical:**

1. Orbaek, W.; McHale, M.M.; Barron, A. R.; **Synthesis and Characterization of Silver Nanoparticles for An Undergraduate Laboratory**,J. Chem. Educ. 2015, 92, 339−344.
2. MacDiarmid, G.; Chiang, J.C.; Richter, A.F.; Somasiri, N.L.D.(1987), **Polyaniline: Synthesis and Characterization of the Emeraldine Oxidation State by Elemental Analysis**, L. Alcaeer (ed.), Conducting Polymers, 105-120, D. Reidel Publishing.
3. Cheng, K.H.; Jacobson, A.J.; Whittingham, M.S. (1981),**Hexagonal Tungsten Trioxide and Its Intercalation Chemistry, Solid State Ionics**, 5, 1981, 355-358.
4. Ghorbani H.R.; Mehr, F.P; Pazoki, H; Rahmani, B.M.; **Synthesis of ZnO Nanoparticles by Precipitation Method**, Orient J Chem 2015, 31(2).

**Teaching Learning Process:**

- Conventional chalk and board teaching,
- Class interactions and discussions
- Power point presentation on important topics.
- Using Excel and other software to plot graphs and analyse results

**Assessment Methods:**

- Presentations by Individual Student/ Group of Students
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester University Theory and practical Examination

**Keywords:** Nanomaterials, Quantum dots, Quantum confinement, Surface plasmon resonance, Applications of nanomaterials, electron microscopy.

## Course Code: DSE -3 CHEMISTRY

## Course Title: Inorganic Materials of Industrial Importance

**Total Credits: 04 (Credits: Theory-02, Practical-02)**

**Total Lectures: Theory- 30, Practical-60**

**Objectives:**

The course introduces learners to the importance of Inorganic compounds in Industries. It gives an insight into how the inorganic materials form a basis of the products used in day-to-day life like silicates, fertilizers, surface coatings. The course helps develop the interest of students in the frontier areas of inorganic and material chemistry.

## Learning Outcomes:

**By the end of the course, the students will be able to:**

- Learn the composition and applications of the different kinds of glass.
- Understand glazing of ceramics and the factors affecting their porosity.
- Give the composition of cement and discuss the mechanism of setting of cement.
- Explain the suitability of fertilizers for different kinds of crops and soil.
- Explain the process of formulation of paints and the basic principle behind the protection offered by the surface coatings.

### Unit 1: Silicate Industries Lectures:10

Glass: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, different types of safety glass, borosilicate glass, fluorosilicate glass, coloured glass, photosensitive glass, photochromic glass, glass wool and optical fibre.

Ceramics: Brief introduction to types of ceramics. glazing of ceramics.

Cement: Manufacture of Portland cement and the setting process, Different types of cements: quick setting cements, eco-friendly cement (slag cement), pozzolana cement.

### Unit 2: Fertilizers Lectures:08

Different types of fertilizers (N, P and K). Importance of fertilizers, chemistry involved in the manufacture of the following fertilizers: urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates, superphosphate of lime, potassium chloride and potassium nitrate. Environmental impact of fertilizers.

### Unit 3: Surface Coatings Lectures:12

Brief introduction to and classification of surface coatings, paints and pigments: formulation, composition and related properties, pigment volume concentration (PVC)and critical pigment volume concentration (CPVC), fillers, thinners, enamels and emulsifying agents. Special paints: heat retardant, fire retardant, eco-friendly paints, plastic paints, water and oil paints. Preliminary methods for surface preparation, metallic coatings (electrolytic and electroless with reference to chrome plating and nickel plating), metal spraying and anodizing. Contemporary surface coating methods like physical vapor deposition, chemical vapor deposition, galvanising, carburizing, sherardising, boriding, nitriding and cementation.

**PRACTICALS:** **Credits: 02**

**(Laboratory periods: 60)**

1. Detection of constituents of CAN fertilizer (Calcium, Ammonium and Nitrate ions) fertilizer and estimation of Calcium content.
2. Detection of constituents of Superphosphate fertilizer (Calcium and Phosphate ions) and estimation of phosphoric acid content.
3. Detection of constituents of Dolomite (Calcium, Magnesium and carbonate ions) and determination of composition of Dolomite (Complexometric titration).
4. Analysis of (Cu, Ni) in alloy or synthetic samples (Multiple methods involving Complexometry, Gravimetry and Spectrophotometry).
5. Analysis of (Cu, Zn) in alloy or synthetic samples (Multiple methods involving Iodometry, Complexometry and Potentiometry).
6. Preparation of following Inorganic Pigments:

   a). Barium white

   b). Chrome Yellow

   c). Malachite

   d). Chromium oxide

   e). Prussian Blue

7. Any suitable experiment other than the listed ones.

**References:**

**Theory:**


1. West, A. R. (2014), **Solid State Chemistry and Its Application**, Wiley & sons.
2. Smart, L. E.; Moore, E. A. (2012), **Solid State Chemistry An Introduction**, CRC Press Taylor & Francis.
3. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A.(2010), **Inorganic Chemistry**, W. H. Freeman and Company.
4. Kent, J. A. (ed**)** (1997), **Riegel's Handbook of Industrial Chemistry**, CBS Publishers, New Delhi.
5. Jain P.C., Jain M., **Engineering Chemistry**, Dhanpat Rai & Sons, Delhi.
6. Gopalan R., Venkappaya D.,Nagarajan S., **Engineering Chemistry**, Vikas Publications, New Delhi.
7. Sharma, B.K., **Engineering Chemistry**, Goel Publishing House, Meerut.
8. *Kingery W.D., Bowen H. K., Uhlmann, D.R., (1976*), **Introduction to Ceramics**, Wiley & sons, Delhi.

**Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.**

# B.Sc. (Prog.)/ BA (Prog.) Semester-V with Mathematics as non-Major

***Category-III***

**DISCIPLINE SPECIFIC CORE COURSE – 5 (Discipline A-5): ELEMENTS OF REAL ANALYSIS**

**CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| Elements of Real Analysis | 4 | 3 | 1 | 0 | Class XII pass with Mathematics | NIL |

**Learning Objectives:** The primary objective of this course is to introduce:

- The real line with algebraic, order and completeness properties.
- Convergence and divergence of sequences and series of real numbers with applications.

**Learning Outcomes:** This course will enable the students to:

- Understand the basic properties of the set of real numbers, including completeness and Archimedean with some consequences.
- Recognize bounded, convergent, monotonic and Cauchy sequences
- Learn to apply various tests such as limit comparison, ratio, root, and alternating series tests for convergence and absolute convergence of infinite series of real numbers.

**SYLLABUS OF DISCIPLINE A-5**

**UNIT-I: Basic Properties of the Set of Real Numbers (12 hours)**

Field and order properties of $\mathbb{R}$, basic properties and inequalities of the absolute value of a real number, bounded above and bounded below sets, Suprema and infima, The completeness axiom and the Archimedean property of $\mathbb{R}$.

**UNIT-II: Real Sequences (18 hours)**

Convergence of a real sequence, Algebra of limits, The squeeze principle and applications, Monotone sequences, Monotone convergence theorem and applications, Cauchy sequences, Cauchy criterion for convergence and applications.

**UNIT-III: Infinite Series of Real Numbers (15 hours)**

Convergence and divergence of infinite series of real numbers, Necessary condition for convergence, Cauchy criterion for convergence of series, Tests for convergence of positive term series, Applications of the integral test, Comparison tests, D'Alembert's ratio test, Cauchy's *n*th root test, Raabe's test; Alternating series, Leibniz alternating series test, Absolute and conditional convergence.

## Essential Reading

1. Denlinger, Charles G. (2011). Elements of Real Analysis. Jones & Bartlett India Pvt. Ltd. Student Edition. Reprinted 2015.

## Suggestive Readings

- Bartle, Robert G., & Sherbert, Donald R. (2011). Introduction to Real Analysis (4th ed.). John Wiley & Sons. Wiley India Edition 2015.
- Bilodeau, Gerald G., Thie, Paul R., & Keough, G. E. (2010). An Introduction to Analysis (2nd ed.). Jones & Bartlett India Pvt. Ltd. Student Edition. Reprinted 2015.

Administration of drugs, Differential equation of chemical process and predator-prey model (Function response: Types I, II and III).

**UNIT – II: Epidemic Model: Formulation and Analysis (15 hours)**

Introduction to infectious disease, The SIS, SIR and SEIR models of the spread of an epidemic, Analyzing equilibrium states, Phase plane analysis, Stability of equilibrium points, Classifying the equilibrium state; Local stability, Limit cycles, Poincaré-Bendixson theorem.

**UNIT – III: Bifurcation, Chaos and Modeling Molecular Evolution (15 hours)**

Bifurcation, Bifurcation of a limit cycle, Discrete bifurcation and period-doubling, Chaos, Stability of limit cycles, Introduction of the Poincaré plane; Modeling molecular evolution: Matrix models of base substitutions for DNA sequences, Jukes-Cantor and Kimura models, Phylogenetic distances.

## Essential Readings


4. Robeva, Raina S., et al. (2008). An Invitation to Biomathematics. Academic press.
5. Jones, D. S., Plank, M. J., & Sleeman, B. D. (2009). Differential Equations and Mathematical Biology (2nd ed.). CRC Press, Taylor & Francis Group.
6. Allman, Elizabeth S., & Rhodes, John A. (2004). Mathematical Models in Biology: An Introduction. Cambridge University Press.


## Suggestive Readings


- Linda J. S. Allen (2007). An Introduction to Mathematical Biology. Pearson Education.
- Murray, J. D. (2002). Mathematical Biology: An Introduction (3rd ed.). Springer.
- Shonkwiler, Ronald W., & Herod, James. (2009). Mathematical Biology: An Introduction with Maple and MATLAB (2nd ed.). Springer.


## DISCIPLINE SPECIFIC ELECTIVE COURSE-3(ii): MATHEMATICAL PYTHON

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| Mathematical Python | 4 | 3 | 0 | 1 | Class XII pass with Mathematics | Basic knowledge of Python |

**Learning Objectives:** The Learning Objectives of this course are as follows:

- To be able to model and solve mathematical problems using Python Programs.
- To experience utility of open-source resources for numerical and symbolic mathematical software systems.

**Learning Outcomes:** This course will enable the students to use Python:

- For numerical and symbolic computation in mathematical problems from calculus, algebra, and geometry.
- To tabulate and plot diverse graphs of functions and understand tracing of shapes, geometries, and fractals.
- To prepare smart documents with LaTeX interface.

**SYLLABUS OF DSE - 3(ii)**

**Theory**

**UNIT – I: Drawing Shapes, Graphing and Visualization (15 hours)**

Drawing diverse shapes using code and Turtle; Using matplotlib and NumPy for data organization, Structuring and plotting lines, bars, markers, contours and fields, managing subplots and axes; Pyplot and subplots, Animations of decay, Bayes update, Random walk.

**UNIT – II: Numerical and Symbolic Solutions of Mathematical Problems (18 hours)**

NumPy for scalars and linear algebra on *n*-dimensional arrays; Computing eigenspace, Solving dynamical systems on coupled ordinary differential equations, Functional programming fundamentals using NumPy; Symbolic computation and SymPy: Differentiation and integration of functions, Limits, Solution of ordinary differential equations, Computation of eigenvalues, Solution of expressions at multiple points (lambdify), Simplification of expressions, Factorization, Collecting and canceling terms, Partial fraction decomposition, Trigonometric simplification, Exponential and logarithms, Series expansion and finite differences, Solvers, Recursive equations.

**UNIT – III: Document Generation with Python and LaTeX (12 hours)**

Pretty printing using SymPy; Pandas API for IO tools: interfacing Python with text/csv, HTML, LaTeX, XML, MSExcel, OpenDocument, and other such formats; Pylatex and writing document files from Python with auto-computed values, Plots and visualizations.

**Practical (30 hours):** Software labs using IDE such as Spyder and Python Libraries.

- Installation, update, and maintenance of code, troubleshooting.
- Implementation of all methods learned in theory.
- Explore and explain API level integration and working of two problems with standard Python code.

**Essential Readings**


1. Farrell, Peter (2019). Math Adventures with Python. No Starch Press. ISBN Number: 978-1-59327-867-0.
2. Farrell, Peter and et al. (2020). The Statistics and Calculus with Python Workshop. Packet Publishing Ltd. ISBN: 978-1-80020-976-3.
3. Saha, Amit (2015). Doing Math with Python. No Starch Press. ISBN: 978-1-59327-640-9

**Suggestive Readings**


- Morley, Sam (2022). Applying Math with Python (2nd ed.). Packet Publishing Ltd. ISBN: 978-1-80461-837-0
- Online resources and documentation on the libraries, such as:
  - https://matplotlib.org
  - https://sympy.org
  - https://pandas.pydata.org
  - https://numpy.org
  - https://pypi.org
  - https://patrickwalls.github.io/mathematicalpython/


**Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.**

## DISCIPLINE SPECIFIC ELECTIVE COURSE-3(iii): MECHANICS

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| Mechanics | 4 | 3 | 1 | 0 | Class XII pass with Mathematics | Discipline A-1: Topics in Calculus<br>Discipline A-3: Differential Equations |

**Learning Objectives:** The main objective of this course is to:

- Starting Newtonian laws, learning various technical notions which explains various states of motion under given forces.
- Deals with the kinematics and kinetics of the rectilinear and planar motions of a particle including constrained oscillatory motions of particles, projectiles, and planetary orbits.
- Understand hydrostatic pressure and thrust on plane surfaces.

**Learning Outcomes:** This course will enable the students to:

- Understand necessary conditions for the equilibrium of particles acted upon by various forces and learn the principle of virtual work for a system of coplanar forces.
- Apply the concepts of center of gravity, laws of static and kinetic friction.
- Learn that a particle moving under a central force describes a plane curve and know the Kepler's laws of the planetary motions.
- Evaluate the hydrostatic pressure at any given depth in a heavy homogeneous liquid at rest under gravity.

**SYLLABUS OF DSE-3(iii)**

# DISCIPLINE SPECIFIC CORE COURSE – PHYSICS DSC 5: ELEMENTS OF MODERN PHYSICS

| Course Title & Code | Credits | Credit distribution of the course | | | Eligibility Criteria | Pre-requisite of the course |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical | | |
| Elements of Modern Physics<br><br>PHYSICS DSC – 5 | **4** | **2** | **0** | **2** | Class XII pass with Physics and Mathematics as main subjects | NIL |

## LEARNING OBJECTIVES

This course introduces modern development in Physics. Starting from Planck's law, it develops the idea of probability interpretation and then discusses the formulation of Schrodinger equation. This paper aims to provide knowledge about atomic physics, hydrogen atoms and X-rays. It also introduces concepts of nuclear physics and accelerators

## LEARNING OUTCOMES

After getting exposure to this course, the following topics would be learnt.

- Main aspects of the inadequacies of classical mechanics as well as understanding of the historical development of quantum mechanics. Heisenberg's Uncertainty principle and its applications, photoelectric effect and Compton scattering
- The Schrodinger equation in 1-d, wave function, probability and probability current densities, normalization, conditions for physical acceptability of wave functions, position and momentum operators and their expectation values. Commutator of position and momentum operators.
- Time Independent Schrodinger Equation, derivation by separation of variables, wave packets, particle in a box problem, energy levels.
- Modification in Bohr's Quantum Model: Sommerfeld theory of elliptical orbits
- Hydrogen atom energy levels and spectra emission and absorption spectra.
- X-rays: their production and spectra: continuous and characteristic X-rays, Moseley Law.
- Basic Properties of Nuclei, nuclear binding energy, semi-empirical mass formula, nuclear force and meson theory.
- Types of Accelerators, Van de Graaff generator, linear accelerator, cyclotron, synchrotron

## SYLLABUS OF PHYSICS DSC – 5

## THEORY COMPONENT

**Unit - I** **(8 Hours)**

**Origin of Quantum Theory:** Black Body Radiation and failure of classical theory, Planck's Quantum Hypothesis, Planck's Radiation Law, Quantitative treatment of Photo-electric effect and Compton scattering. Wave properties of particles: de Broglie hypothesis, Group and Phase velocities and relation between them. Heisenberg's Uncertainty Principle, Gamma ray microscope thought experiment, Position-Momentum Uncertainty, consequences of uncertainty principle.

**Unit - II** **(7 Hours)**

**The Schrodinger Equation:** The Schrodinger equation in 1-d, statistical interpretation of wave function, probability and probability current densities. Normalization, conditions for physical acceptability of wave functions with examples, position and momentum operators and their expectation values; Commutator of position and momentum operators

**Unit – III** **(5 Hours)**

**Time Independent Schrodinger Equation:** Demonstration of separation of variable method for time independent Schrodinger equation: Free particle wave function, wave packets, application to energy eigen values and stationary states for particle in a box problem, energy levels.

**Unit – IV** **(5 Hours)**

**Atomic Physics:** Beyond the Bohr's Quantum model: Sommerfeld theory of elliptical orbits; hydrogen atom energy levels and spectra emission and absorption spectra
Correspondence principle
X-rays: Method of production, X-ray spectra: Continuous and characteristic X-rays, Moseley Law.

**Unit – V** **(5 Hours)**

**Basic Properties of Nuclei:** Introduction (basic idea about nuclear size, mass, angular momentum, spin), semi-empirical mass formula, nuclear force and meson theory.
Accelerators: Accelerator facility available in India: Van de Graaff generator, linear accelerator, cyclotron (principle, construction, working, advantages and disadvantages), discovery of new elements of the periodic table

**References:**

**Essential Readings:**


1) Concepts of Modern Physics, A. Beiser, 2002, McGraw-Hill.
2) Modern Physics, R. A. Serway, C. J. Moses and C. A. Moyer, 2012, Thomson Brooks Cole, Cengage
3) Schaum's Outline of Modern Physics, R. Gautreau and W. Savin, 2020, McGraw Hill LLC
4) Modern Physics for Scientists and Engineers, S. T. Thornton Rex, 4th edition, 2013, Cengage Learning
5) Introduction to Modern Physics, R. Meyer, Kennard, Coop, 2002, Tata McGraw Hill
6) Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010.
7) Learning Modern Physics, G. Kaur and G.R. Pickrell, 2014, McGraw Hill.
8) Modern Physics, R. Murugeshan, S Chand & Co. Ltd
9) Schaum's Outline of Beginning Physics II | Waves, electromagnetism, Optics and Modern Physics, Alvin Halpern, Erich Erlbach, McGraw Hill.
10) Theory and Problems of Modern Physics, Schaum's outline, R. Gautreau and W. Savin, 2nd edition, Tata McGraw-Hill Publishing Co. Ltd.
11) Quantum Physics, Berkeley Physics, Vol.4. E. H. Wichman, 1971, Tata McGraw-Hill
12) Quantum Mechanics: Theory and Applications, A. Ghatak and S. Lokanathan, 2004, Macmillan Publishers India Limited
13) Introduction to Quantum Mechanics, D. J. Griffith, 2005, Pearson Education
14) Concepts of nuclear physics, B. Cohen, 2003, McGraw-Hill Education
15) Atomic Physics, Ghoshal, 2019, S. Chand Publishing House
16) Atomic Physics, J. B. Rajam & foreword by Louis De Broglie, 2010, S. Chand & Co.

17) Nuclear Physics, S. N. Ghoshal, S. Chand Publishers
18) Atomic and Molecular Physics, Rajkumar, RBSA Publishers

**Additional Readings:**

1) Six Ideas that Shaped Physics: Particles Behave like Waves, T. A. Moore, 2003, McGraw Hill.
2) Thirty years that shook physics: The story of quantum theory, G. Gamow, Garden City, NY: Doubleday, 1966.

## PRACTICAL COMPONENT

**(15 Weeks with 4 hours of laboratory session per week)**

Mandatory activity:

- Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the lab
- Familiarization with Schuster`s focusing; determination of angle of prism.

At least six experiments to be performed from the following list

1) Measurement of Planck's constant using black body radiation and photo-detector
2) Photo-electric effect: photo current versus intensity and wavelength of light, maximum energy of photo-electrons versus frequency of light
3) To determine the work function of material of filament of directly heated vacuum diode.
4) To determine the Planck's constant using LEDs of at least 4 different colours.
5) To determine the wavelength of the H-alpha emission line of Hydrogen atoms.
6) To determine the ionization potential of mercury.
7) To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
8) To show the tunneling effect in tunnel diodes using I-V characteristics.
9) To determine the wavelength of a laser source using diffraction of a single slit.
10) 10. To determine the wavelength of a laser source using diffraction of double slits.
11) 11. To determine angular spread of He-Ne laser using plane diffraction grating
12) One innovative experiment designed by the teacher relevant to the syllabus.

**References for laboratory work**:

1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2) A Text Book of Practical Physics, I. Prakash and Ramakrishna, 11th edition, 2011, Kitab Mahal.
3) Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th edition, reprinted, 1985, Heinemann Educational Publishers.
4) A Laboratory Manual of Physics for Undergraduate Classes, D. P. Khandelwal, 1985, Vani Publisher.
5) B.Sc. Practical Physics, H. Singh, S Chand & Co Ltd
6) B.Sc. Practical Physics, G. Sanon, R. Chand and Co.

# DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 15b: DIGITAL ELECTRONICS

| Course Title & Code | Credits | Credit distribution of the course | | | Eligibility Criteria | Pre-requisite of the course |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical | | |
| Digital Electronics<br><br>PHYSICS DSE – 15b | **4** | **2** | **0** | **2** | Class XII pass with Physics and Mathematics as main subjects | NIL |

## LEARNING OBJECTIVES

The objective of the course is to introduce digital electronics and its simple applications to physics program students. The course is designed to familiarize the students with the different number systems (binary, octal and hexadecimal), laws of Boolean algebra, logic gates and combinational and sequential logic circuits utilised in designing counters and registers.

## LEARNING OUTCOMES

After studying this paper students will become familiar with,

- Digital signals, positive and negative logic, Boolean variables, truth table, various number system codes and their inter-conversions.
- Students will be able to learn to minimise a given Boolean function using laws of Boolean algebra and Karnaugh map to minimise the hardware requirement of digital logic circuits
- Understand the working mechanism of data processing circuits, arithmetic circuits, sequential logic circuits, register and their applications.

## SYLLABUS OF PHYSICS DSE 15b

## THEORY COMPONENT

**Unit – I - Integrated Circuits (qualitative treatment only) (2 Hours)**

Advantages and drawbacks of ICs, scale of integration, SSI, MSI, LSI and VLSI (basic idea and definitions only), classification of ICs, examples of linear and digital lCs

**Unit – II - Digital circuits and Boolean Aalgebra (13 Hours)**

Binary numbers, decimal to binary and binary to decimal conversion, octal and hexadecimal numbers, NAND and NOR gates as universal gates, XOR and XNOR gates and their application as parity checkers

Boolean algebra: De Morgan's theorems, Boolean laws, idea of minterms, simplification of logic circuit using Boolean algebra and Karnaugh map

**Unit – III - Combinational logic Circuits (7 Hours)**

Data processing circuits: Multiplexers and its applications, de-multiplexers, decoders, encoders

Arithmetic circuits: Binary addition, binary subtraction using 2's complement, half and full adders, half and full subtractor

**Unit – IV - Sequential Circuits (8 Hours)**

Flip Flops: SR, D, and JK, clocked (edge triggered) flip-flops, race-around conditions in JK flip-flop, application of flip flops in designing shift register (serial -in- parallel out) and 2- bit (MOD-4) up-down asynchronous counter

**References:**

**Essential Readings:**


1) Digital Principles and Applications, A. P. Malvino, D. P. Leach and Saha, 7th edition, 2011, Tata McGraw
2) Fundamentals of Digital Circuits, A. Kumar, 2nd edition, 2009, PHI Learning Pvt. Ltd.
3) Digital Fundamentals, T. L. Floyd, 1994, Pearson Education Asia
4) Digital Principles and Applications, D. P. Leach and A. P. Malvino, 1995, Tata McGraw Hill
5) Digital Design, M. M. Mano and M. D. Ciletti, 2007, Pearson Education Asia
6) Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
7) Digital Electronics, G. K. Kharate, 2010, Oxford University Press


**Additional Readings:**


1) Logic circuit design, S. P. Vingron, 2012, Springer
2) Digital Principles, Schaum's Outline Series, R. L. Tokheim, 1994, Tata McGraw-Hill
3) Solved Problems in Digital Electronics, S. P. Bali, 2005, Sigma Series, Tata McGraw-Hill
4) Digital Electronics: An Introduction To Theory And Practice, W. H. Gothmann, 2000, Prentice Hall of India
5) Modern Digital Electronics, R. P. Jain, 2003, Tata McGraw-Hill
6) Digital Electronics, S. Ghoshal, 2012, Cengage Learning.
7) Digital Electronics, S. K. Mandal, 2010, 1st edition, McGraw Hill


## PRACTICAL COMPONENT

**(15 Weeks with 4 hours of laboratory session per week)**

Either (1) At least 6 experiments or (II) 4 experiments and one project equivalent to two experiments and all designing should be done on the bread boards.

1) Study of truth tables of basic logic gates, universal logic gates XOR and XNOR logic gates
2) (a)To design a combinational logic system for a specified truth table.
   (b) To convert Boolean expression into logic circuit and design it using basic logic gate ICs
3) To minimize a given logic circuit using K-map and design using NAND gates.
4) Designing of Half Adder and Half Subtractor using NAND gates.
5) Designing of Full adder/Full Subtractor using NAND gates
6) Designing of 4-bit binary adder using adder IC.
7) To build Flip-Flop (RS, Clocked RS) circuits using NAND gates.
8) To build Flip-Flop ( D-type and JK) circuits using NAND gate
9) To build a 2-bit Asynchronous Counter using D-type/JK Flip-Flop ICs and study timing diagrams.
10) To make a 3-bit Shift Register (serial in- and parallel out) using D-type/JK Flip-Flop ICs.

**References for laboratory work:**


1) Digital Fundamentals, T. L. Floyd, 1994, Pearson Education Asia
2) Digital Principles and Applications, D. P. Leach and A. P. Malvino, 1995, Tata McGraw

Hill
3) Digital Design, M. M. Mano and M. D. Ciletti, 2007, Pearson Education Asia
4) Digital Circuits and Systems, Venugopal, 2011, Tata McGraw Hill.