

**4-YEAR UNDERGRADUATE PROGRAM (FYUGP)  
WITH MAJOR IN PHYSICS  
UNDER THE NEW CURRICULUM AND  
CREDIT FRAMEWORK, 2022**

**UNDERGRADUATE PHYSICS  
SYLLABUS**

**University of North Bengal  
2023**

**COURSE STRUCTURE**  
**Major Discipline: Physics**  
**Semester I - II**

<b>SEM</b>	<b>Paper Code</b>	<b>Course Paper</b>
Sem-I	UPHYMAJ 11001	Mathematical Physics-I
Sem-II	UPHYMAJ 12002	Mechanics -I
Sem-I	UPHYSEC 11001	Basic Electrical Circuits and Measurements
Sem-II	UPHYSEC 12002	Renewable Energy and Energy Harvesting

**Minor Discipline: Physics**  
**Semester I - II**

<b>SEM</b>	<b>Course</b>	<b>Course Paper</b>
Sem-I	UPHYMIN 10001	Mechanics
Sem-II	UPHYMIN 20002	Mechanics

**Multidisciplinary Course**  
**Semester II**

<b>SEM</b>	<b>Course</b>	<b>Course Paper</b>
Sem-II	UPHYMDC 10001/10002	Introduction to Astronomy

## **Major Subjects Syllabus** **(Credits: Theory-03, Practical-01)**

### **UPHYMAJ 11001 (Theory): Mathematical Physics-I** **45 Lectures; 3 Credits**

#### **Unit 1: Vector Algebra [10 hours]**

Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume, respectively. Scalar and Vector fields.

#### **Unit 2: Vector Calculus [12 hours]**

Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities. Vector Integration: Ordinary Integrals of Vectors. Multiple integrals. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of vector fields. Flux of a vector field. Gauss's divergence theorem, Green's and Stokes Theorems and their applications.

#### **Unit 3: Orthogonal Curvilinear Coordinates [8 hours]**

Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

#### **Unit 4: Differential Equations [15 hours]**

First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for initial value problems.

#### **Reference Books:**

- Mathematical Methods for Physicists, G. B. Arfken, H. J. Weber, F. E. Harris, 2013, Elsevier.
- An introduction to ordinary differential equations, E. A. Coddington, 2009, PHI learning.
- Differential Equations, George F. Simmons, 2007, McGraw Hill.
- Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
- Mathematical methods for Scientists and Engineers, D. A. McQuarrie, 2003, Viva Book.
- Advanced Engineering Mathematics, D. G. Zill and W. S. Wright, Jones and Bartlett Learning.
- Mathematical Physics, Goswami, 1st edition, Cengage Learning.
- Engineering Mathematics, S. Pal and S. C. Bhunia, 2015, Oxford University Press.
- Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
- Essential Mathematical Methods, K. F. Riley & M. P. Hobson, 2011, Cambridge Univ. Press.
- Mathematical methods in the Physical Sciences, M. L. Boas, 2005, Wiley.

## **UPHYMAJ 11001 (Practical): Mathematical Physics-I Lab**

### **30 Lectures; Credit-1**

#### **Errors and Error Analysis in scientific computing:**

Floating point numbers, single and double precision arithmetic, underflow & overflow. Truncation and round-off errors, Absolute and relative errors.

#### **Introduction to programming in Python:**

Introduction to programming: constants, variables and data types, dynamical typing, operators and expressions, modules, I/O statements, iterables, compound statements, indentation in python, the if-elif-else block, for and while loops, nested compound statements, lists, tuples, dictionaries and strings, basic file handling, basic ideas of object oriented programming.

#### **Basic Programs in Python along with algorithms: (Without using any library function)**

- Input a list of numbers and obtain their sum & average
- Finding odd/even from a list of numbers
- Find the largest / smallest number of the list and its location in the list
- Sorting a list of numbers in ascending and descending order
- Finding sum and product of a series (e.g.  $\sum_n n^2$ ,  $\sum_i x^i$ ,  $\prod_n x^n$ , etc.)
- Simple problems in matrix: Addition, subtraction, multiplication, equality, etc.
- Dot product, cross product, triple product of vectors
- Verify vector identities
- Print the Fibonacci sequence, Factorial of Number
- Find the frequency of each element in an array, etc.
- Sort words in alphabetical order, Remove punctuation from a string, Reverse a string
- Convert list to string, Concatenate two strings

**File handling tools may also be used for the above programs**

#### **Reference Books:**

- Introduction to Numerical Analysis, S. S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
- Learning with Python-how to think like a computer scientist, J. Elkner, C. Meyer, and A. Downey, 2015, Dreamtech Press.
- Introduction to computation and programming using Python, J. Guttag, 2013, Prentice Hall India.
- Effective Computation in Physics- Field guide to research with Python, A. Scopatz and K. D. Huff, 2015, O'Rielly.
- A first course in Numerical Methods, U. M. Ascher & C. Greif, 2012, PHI Learning.
- Elementary Numerical Analysis, K. E. Atkinson, 3 rd Edn., 2007, Wiley India Edition.
- Numerical Methods for Scientists & Engineers, R. W. Hamming, 1973, Courier Dover Pub.
- An Introduction to Computational Physics, T. Pang, 2nd Edn., 2006, Cambridge Univ. Press.
- Computational Physics, Darren Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.

## **UPHYMAJ 12002 (Theory): Mechanics -I**

**45 Lectures; 3 Credits**

### **Unit 1: Fundamentals of Dynamics [9 hours]**

Reference frames. Inertial frames – Review of Newton’s laws of motion. Galilean transformations; Galilean invariance. Momentum of variable-mass system: motion of rocket. Dynamics of a system of particles – conservation of linear momentum, Centre of mass. Conservative and non-conservative forces. Potential energy. Stable and unstable equilibrium. Force as gradient of potential energy. Law of conservation of energy.

### **Unit 2: Rotational dynamics [10 hours]**

Rotation about a fixed axis – Moment of Inertia, Kinetic energy, Angular momentum and Torque. Conservation of angular momentum. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Motion involving both translation and rotation.

### **Unit 3: Elasticity [6 hours]**

Hooke’s law, Stress-strain diagram, Elastic moduli – relation between elastic constants, Poisson’s ratio – expression of Poisson’s ratio in terms of elastic constants. Work done in stretching and twisting a wire.

### **Unit 4: Gravitation and Central Force Motion [12 hours]**

Law of gravitation. Gravitational potential energy, self-energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere. Motion of a particle under the central force field. Two-body problem, its reduction to one-body problem and its solution. Effective potential of a particle in gravitational field, Trajectory of a particle in inverse-square force potential. Kepler’s laws. Escape velocity, satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness.

### **Unit 5: Non-Inertial Systems [8 hours]**

Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems.

#### **Reference Books:**

- An introduction to mechanics, D. Kleppner, R. J. Kolenkow, 1973, McGraw-Hill.
- Mechanics, Berkeley Physics, Vol.1, C. Kittel, W. Knight, et.al. 2007, Tata McGraw-Hill.
- Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
- Analytical Mechanics, G. R. Fowles and G. L. Cassiday. 2005, Cengage Learning.
- Feynman Lectures, Vol. I, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education
- Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
- Mechanics, D. S. Mathur, S. Chand and Company Limited, 2000
- University Physics. F. W Sears, M. W Zemansky, H. D. Young 13/e, 1986, Addison Wesley

- Physics for scientists and Engineers with Modern Phys., J. W. Jewett, R. A. Serway, 2010, Cengage Learning
- Theoretical Mechanics, M. R. Spiegel, 2006, Tata McGraw Hill.

## **UPHYMAJ 12002 (Practical): Mechanics-I Lab**

### **30 Lectures; Credit-1**

1. Measurements of volume of a hollow cylinder using Vernier calipers, Screw gauge and Traveling microscope.
2. To determine the height of a building using a Sextant.
3. To study the motion of a spring and calculate (a) Spring Constant (b) Value of  $g$ .
4. To determine the Moment of Inertia of a Flywheel.
5. To determine  $g$  and velocity for a freely falling body using Digital Timing Technique.
6. To determine the moment of inertia of a) cylindrical, b) rectangular bar about an axis passing through its C.G. using static method.
7. To determine the moment of inertia of a) cylindrical, b) rectangular bar about an axis passing through its C.G. using dynamic method.
8. To determine the value of  $g$  by Bar Pendulum.
9. To determine the value of  $g$  by Kater's Pendulum.
10. Determination of rigidity modulus of the material of a wire by static method.
11. Determination of rigidity modulus of the material of a wire by dynamic method.
12. To determine the modulus of rigidity of a wire by Maxwell's needle.
13. To determine the Young's Modulus of a wire by Optical Lever method.
14. To determine the elastic constants of a wire by Searle's method.

### **Reference Books:**

- Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4<sup>th</sup> Edition, reprinted 1985, Heinemann Educational Publishers.
- Engineering Practical Physics, S. Panigrahi & B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
- Physics through experiments, B. Saraf, Vikas Publications, 2013
- A lab manual of Physics for undergraduate classes, 1st Edition, Vikas Publications.
- B.Sc. Practical Physics Revised Ed, C. L. Arora, S. Chand & Co. 2007

## **Skill Enhancement Course**

**(Credits: Theory-02, Practical/Tutorial/Field Visit/Demonstration-01)**

### **UPHYSEC 11001 (Theory): Basic Electrical Circuits and Measurements**

**30 Lectures; 2 Credits**

#### **Unit 1: Basic Electricity Principles [4 hours]**

Voltage, Current, Resistance and Power. Ohm's law. Series, parallel, and series-parallel combinations. AC Electricity and DC Electricity. Familiarization with Voltmeter, Ammeter and Multimeter.

#### **Unit 2: Understanding Electrical Circuits [6 hours]**

Main electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase alternating current sources. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money.

#### **Unit 3: Generators and Transformers [5 hours]**

DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers.

#### **Unit 4: Solid-State Devices [5 hours]**

Resistors, inductors and capacitors. Diode and rectifiers. Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources.

#### **Unit 5: Electrical Protection [5 hours]**

Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Interfacing DC or AC sources to control elements (relay protection device).

#### **Unit 6: Electrical Wiring [5 hours]**

Different types of conductors and cables. Basics of wiring – Star and Delta connection. Voltage drop and losses across cables and conductors. Instruments to measure current, voltage, power in DC and AC circuits. Insulation. Solid and stranded cable. Conduits. Cable trays. Splices: wire nuts, crimps, terminal blocks, split bolts, and solder. Preparation of the extension board.

#### **Reference Books**

- A textbook in Electrical Technology, B. L. Theraja, S. Chand & Co.
- A textbook of Electrical Technology, A. K. Theraja
- Performance and design of AC machines, M. G. Say ELBS Edn.
- A. K. Sawhney, A Course in Electrical & Electronic Measurements & Instrumentation, Dhanpatrai & Co. (P) Ltd.

- A. D. Helfrick & W. D. Cooper, Modern Electronic Instrumentation and Measurement Techniques PHI, 2016.
- D. C. Kulshreshtha, Basic Electrical Engineering, Mc Graw Hill Publications, 2019.
- David G. Alciatore and Michel B. Histan, Introduction to Mechatronics and Measurement Systems, 3rd, Tata McGraw Hill Education Private Limited, New Delhi., 2005.
- Vincent Del Toro, Electrical Engineering Fundamentals, Prentice Hall India 2009

## **UPHYSEC 11001 (Practical): Basic Electrical Circuits and Measurements-Lab**

### **30 Lectures; Credit-1**

#### **Experiments:**

(Teaching of soldering skills for constructing electrical circuits is recommended)

1. Designing a Voltmeter using a Galvanometer.
2. Designing an Ammeter using a Galvanometer.
3. Measurement of Resistance using P. O. Box.
4. Measurement of Resistance using Meter Bridge.
5. Measurement of e.m.f. of a cell using Potentiometer.
6. Designing Half-wave / Full-wave / Bridge rectifier circuits with and without filter and determination of percentage regulation.
7. Measurement of Capacitance using an A. C. Bridge.
8. Measurement of Inductance using an A. C. Bridge.

#### **Reference Books:**

- A. K. Sawhney, A Course in Electrical & Electronic Measurements & Instrumentation, Dhanpatrai & Co. (P) Ltd.
- Helfrick & Cooper, Modern Electronic Instrumentation and Measurement Techniques, Prentice Hall India Learning Private Limited.

## **UPHYSEC 12002 (Theory): Renewable Energy and Energy Harvesting**

### **30 Lectures; 2 Credits**

#### **Unit 1: Fossil fuels and Alternative Sources of energy [5 hours]**

Fossil fuels and nuclear energy, their limitations, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind energy, Tidal energy, Wave energy systems, Ocean Thermal Energy Conversion, Solar energy, biomass, Biogas generation, Geothermal energy, Tidal energy, Hydroelectricity.

#### **Unit 2: Solar energy [6 hours]**

Solar energy, its importance, storage of solar energy, solar pond, non-convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, sun tracking systems.

#### **Unit 3: Wind Energy [7 hours]**

Fundamentals of Wind energy, Wind turbines and different electrical machines in wind turbines.

#### **Unit 4: Hydro Energy [5 hours]**

Hydropower resources, Hydropower technologies, Environmental impact of hydropower sources.

#### **Unit 5: Geothermal Energy [4 hours]**

Geothermal resources, Geothermal technologies

#### **Unit 6: Energy budget [3 hours]**

Electrical load estimation of an establishment and energy audit.

#### **Reference Books:**

- Non-conventional energy sources, G. D. Rai, Khanna Publishers, New Delhi.
- Solar energy, M. P. Agarwal, S Chand and Co. Ltd.
- Solar energy, Suhas P. Sukhative, Tata McGraw-Hill Publishing Company Ltd.
- Godfrey Boyle, Renewable Energy, Power for a sustainable future”, 2004, Oxford University Press, in association with The Open University.
- Dr. P. Jayakumar, Solar Energy: Resource Assessment Handbook, 2009.
- J. Balfour, M. Shaw and S. Jarosek, Photovoltaics, Lawrence J. Goodrich (USA).

**UPHYSEC12002 (Practical): Renewable Energy and Energy Harvesting –  
Tutorial/ Project / Field work  
30 Lectures; Credit-1**

*(Students will have to deliver a presentation in addition to and related to any one of the following)*

1. Project report on Solar energy.
2. Project report on Hydro energy.
3. Project report on Wind energy.
4. Report on field trip to nearby Hydroelectric stations.
5. Report on field trip to nearby Solar energy parks.

# Minor Subjects Syllabus

(Credits: Theory-03, Practicals-01)

## UPHYMIN 10001 (Theory): Mechanics

45 Lectures; 3 Credits

### Unit 1: Vectors [5 hours]

Vector algebra. Scalar and vector products. Vector differentiation.

### Unit 2: Ordinary Differential Equations [5 hours]

1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients.

### Unit 3: Laws of Motion [8 hours]

Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass.

### Unit 4: Momentum and Energy [5 hours]

Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets.

### Unit 5: Rotational Motion [7 hours]

Angular velocity and angular momentum. Torque. Conservation of angular momentum.

### Unit 6: Oscillations [9 hours]

Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations.

### Unit 7: Elasticity [6 hours]

Hooke's law – Stress-strain diagram, Elastic moduli – Relation between elastic constants, Poisson's ratio, Expression for Poisson's ratio in terms of elastic constants, Work done in stretching and twisting a wire – Twisting couple on a cylinder.

### Reference Books:

- University Physics. F. W. Sears, M. W. Zemansky and H. D. Young, 13/e, 1986. Addison-Wesley.
- Mechanics Berkeley Physics, V.1: Charles Kittel, *et al.* 2007, Tata McGraw-Hill.
- Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley.
- Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford University Press.
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

## **UPHYMIN 10001 (Practical): Mechanics-Lab**

### **30 Lectures; Credit-1**

1. Measurements of volume of a hollow cylinder using Vernier calipers, Screw gauge and Traveling microscope.
2. To determine the height of a building using a Sextant.
3. To study the motion of a spring and calculate (a) Spring Constant (b) Value of  $g$ .
4. To determine the Moment of Inertia of a Flywheel.
5. To determine  $g$  and velocity for a freely falling body using Digital Timing Technique.
6. To determine the moment of inertia of a) cylindrical, b) rectangular bar about an axis passing through its C.G. using static method.
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- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4<sup>th</sup> Edition, reprinted 1985, Heinemann Educational Publishers.
- Engineering Practical Physics, S. Panigrahi & B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
- Physics through experiments, B. Saraf, Vikas Publications, 2013
- A lab manual of Physics for undergraduate classes, 1st Edition, Vikas Publications.
- B.Sc. Practical Physics Revised Ed, C. L. Arora, S. Chand & Co. 2007

## **UPHYMIN 10002 (Theory): Mechanics**

**45 Lectures; 3 Credits**

### **Unit 1: Vectors [5 hours]**

Vector algebra. Scalar and vector products. Vector differentiation.

### **Unit 2: Ordinary Differential Equations [5 hours]**

1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients.

### **Unit 3: Laws of Motion [8 hours]**

Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass.

### **Unit 4: Momentum and Energy [5 hours]**

Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets.

### **Unit 5: Rotational Motion [7 hours]**

Angular velocity and angular momentum. Torque. Conservation of angular momentum.

### **Unit 6: Oscillations [9 hours]**

Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations.

### **Unit 7: Elasticity [6 hours]**

Hooke's law – Stress-strain diagram, Elastic moduli – Relation between elastic constants, Poisson's ratio, Expression for Poisson's ratio in terms of elastic constants, Work done in stretching and twisting a wire – Twisting couple on a cylinder.

### **Reference Books:**

- University Physics. F. W. Sears, M. W. Zemansky and H. D. Young, 13/e, 1986. Addison-Wesley.
- Mechanics Berkeley Physics, V.1: Charles Kittel, *et al.* 2007, Tata McGraw-Hill.
- Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley.
- Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford University Press.
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

## **UPHYMIN 10002 (Practical): Mechanics-Lab**

### **30 Lectures; Credit-1**

1. Measurements of volume of a hollow cylinder using Vernier calipers, Screw gauge and Traveling microscope.
2. To determine the height of a building using a Sextant.
3. To study the motion of a spring and calculate (a) Spring Constant (b) Value of  $g$ .
4. To determine the Moment of Inertia of a Flywheel.
5. To determine  $g$  and velocity for a freely falling body using Digital Timing Technique.
6. To determine the moment of inertia of a) cylindrical, b) rectangular bar about an axis passing through its C.G. using static method.
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- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4<sup>th</sup> Edition, reprinted 1985, Heinemann Educational Publishers.
- Engineering Practical Physics, S. Panigrahi & B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
- Physics through experiments, B. Saraf, Vikas Publications, 2013
- A lab manual of Physics for undergraduate classes, 1st Edition, Vikas Publications.
- B.Sc. Practical Physics Revised Ed, C. L. Arora, S. Chand & Co. 2007

# Multidisciplinary Course

(Credits: 03)

## UPHYMDC 10001/10002 (Theory): Introduction to Astronomy

45 Lectures

### Unit 1: Astronomical Scales [7 hours]

Astronomical Distance, Mass and time scales. Parallax, Distance measurement. Distance between Earth and Sun (Astronomical unit), Light year, Parsec, Pinhole camera for measurement of radius of the sun. Celestial Spheres. Astronomical Coordinate Systems. Construction of Galilean Telescope, other optical Telescopes and magnification power. Celestial objects visible with them.

### Unit 2: Eclipse [6 hours]

Solar eclipse, Lunar eclipse, Total, annular and partial eclipses.

### Unit 3: Sun [6 hours]

Transient phenomenon : Sun spot, Solar storm, Diamond ring in the Sun and the source of energy in the Sun, Tides

### Unit 4: Night sky [9 hours]

Name of constellations, Nebula, Comets, Kuiper belt, Solar system, Planets with habitable conditions, Search for Extra Terrestrial Intelligence (S.E.T.I.).

### Unit 5: Stars and its classifications [5 hours]

HR diagram, Normal Stars, White dwarf, Neutron star, Black hole

### Unit 6: The Milky way [7 hours]

Basic structure and properties of the Milky Way.

### Unit 7: Galaxies [5 hours]

Elliptical, Spiral and Lenticular galaxies, Galactic halo.

### Reference Books:

- Modern Astrophysics, B. W. Carroll & D. A. Ostlie, Addison-Wesley Publishing Co.
- Introductory Astronomy and Astrophysics, M. Zeilik and S. A. Gregory, Saunders College Publishing.
- The physical universe: An introduction to astronomy, F. Shu, Mill Valley: University Science Books.
- Fundamentals of Astronomy (Fourth Edition), H. Karttunen *et al.* Springer.
- Astro Physics a modern perspective-K. S. Krishnasamy, ( New Age International (P) Ltd, 2002)
- An introduction to Astrophysics - Baidyanath Basu, (Prentice-Hall of India Private limited, 2001).
- Textbook of Astronomy and Astrophysics with elements of cosmology, V. B. Bhatia, Narosa Publication.