Syllabus

First Semester Courses in MSc (Physics)

2023-2024

Contents:

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ST. XAVIER'S COLLEGE
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MUMBAI - 400 001.

APPROVED SYLLABUS

ST. XAVIER'S COLLEGE AUTONOMOUS
MUMBAI-400 001

Syllabus

First Semester Courses in MSc (Physics)

2023-2024

Contents:

MSc-I (Physics) Course Code: PSPHY6001EL1

Experimental and Numerical Physics

Credits: 4 (Theory 2 - Total 30 hours, Practical 2 - Total 60 hours)
Number of lectures: Two hours per week for 15 weeks

Prerequisite: Students who have completed a Three-Year Bachelor Degree in Science with Physics Major (Level 5.5)

Course Objectives:
1. To develop an understanding of digital electronics and digital image processing.
2. To learn the computational techniques and numerical methods for solving physics problems.

Course Outcomes (COs):
On completing the course, the student will be able to:
1. Understand electronic communication systems and analyse various techniques to overcome electronic error in data encryption/decryption.
2. Understand and develop controller-based electronic systems for data acquisition in various physics experiments.
3. Apply the fundamental concepts of digital image processing.
4. Develop fundamental ability of Python programming.
5. Develop skills to solve problems in physics using computational methods.
6. Master the fundamentals of numerical methods, computer algorithms and programming languages.

Unit 1 (10 lectures)

Digital Electronics

1. **Review**: Logic families TTL and CMOS devices, Tri-State Devices, Flip flops, Registers and Counters, Concept of Control lines Such as Read/Write Chip Enable.
2. Encoders, Decoders, Latch, Multiplexers and their use in Combinational Logic design, Demultiplexers and their use in Combinational Logic design, De-multiplexer tree. Memory Classification, Charge Coupled Device memory.
3. **Data transmission system**: Network models (OSI), layers in OSI model, Addressing modes, Analog and digital signals, D to A, A to D conversion, data rate limit, data transmission modes.

Unit 2 (10 lectures)

Digital systems and introduction to Python

1. **Modulation and detection in analog and digital systems**; Sampling and data reconstructions; Quantization & coding; Time division and frequency division multiplexing; Equalization.
2. **Information Encoding, Error Detection and Correction**: Introduction, representing different symbols, Minimising errors, Error classification, types of errors, redundancy, detection versus correction, hamming distance, cyclic redundancy check, checksum.

3. **Introduction to Core Python**: Variables, Strings, Tuples, Lists, Arithmetic Operators, Comparison Operators, Conditionals, Loops, Type Conversion, Mathematical Functions, Reading Input, Printing Output, Error Control, Functions and Modules, Matrix manipulations, String manipulations, File manipulations.

Unit 3 (10 lectures)

Numerical methods

1. **Linear Algebra**: Solution of system of equations, Vector manipulations and plotting. Interpolation and extrapolation. Numerical differentiation and integration.
2. **Mathematics Modules and Libraries**: maths Module, cmath Module, numarray Module, Creating an Array, Accessing and Changing Array Elements, Operations on Arrays, Array Functions, Copying Arrays, Scoping of Variables, Writing and Running Programs.
3. **Basic numerical methods**: Approximation of a function, Numerical calculus, Solving Ordinary differential equations, Numerical methods for matrices, Spectral analysis and Gaussian quadrature, Introduction only: The Hartree–Fock method, Density functional theory, Modelling continuous systems, Monte Carlo simulations, Numerical renormalization.

List Of Recommended Reference Books

1. Malvino and Leach, Digital Principles and Applications, TMH Publication, Fourth edition
2. R.P. Jain, Modern digital electronics, TMH Publication, Fourth edition
3. B.A. Forouzan, Data communications and networking, TMH Publications, Fourth edition
4. Kennedy and Davis, Electronic communication systems, Fourth edition.
5. Image Processing: Principles and applications by Tinku Acharya and Ajoy K. Ray, A John Wiley & Sons, Inc., Publication.
6. Digital image processing, Third edition, Gonzalez and Woods, Pearson, Prentice Hall.
7. Numerical Methods in Engineering with Python by Jaan Kiusalaas, Cambridge University Press, 2005.
8. An Introduction to Computational Physics, Second Edition, Tao Pang, Cambridge University Press.

Practicals

1. Minimum eight practicals in the complete semester from the following list:
    a. Matrix manipulation in digital image processing
    b. Point operations in digital image processing
    c. Convolution in digital image processing
    d. Study of multiplexer, demultiplexer, encoder and decoder circuits
    e. Fundamental programs in Python.
    f. Simple numerical applications using Python (including simple integrations).
    g. Multidimensional matrix manipulation using Python.
    h. RK-4 method for solution of first order differential equations.
2. Project:
   In a complete semester, a student must perform two projects related to the course.

Evaluation (Theory): Total marks per course – 50

I. Formative Assessment 'for' Learning (continuous internal assessment - CIA to improve learning).
CIA - 20 marks
(Written test/ Field trip/ Sit-in exams/ Research article review/ Assignments/ Presentations/ MCQs)

II. Summative Assessment 'of' Learning (focus on outcomes, quantitative data for outcomes of instruction).
End Semester Examination – 30 marks

Evaluation (Practical): Total marks per course - 100

Project work with report – 25+25 = 50 marks
End Semester Practical Examination – 20+20 = 40 marks
Journal – 5 marks
Co-curricular activity – 5 marks

Template for the End Semester examination in Semester I for the Elective course

UNITS	KNOWLEDGE	UNDERSTANDING	APPLICATION and ANALYSES	TOTAL MARKS- Per unit
1	3	4	3	10
2	3	4	3	10
3	3	4	3	10
-TOTAL- Per objective	9	12	9	30
% WEIGHTAGE	30%	40%	30%	100%

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Syllabus

Second Semester Courses in MSc (Physics)

2023-2024

Contents:

MSc-I (Physics) Course: PSPHY6002EL1

Observational Astronomy and the Solar System

Credits: 4 (Theory 3 - Total 45 hours, Practical 1 - Total 30 hours)
Number of lectures: Three hours per week for 15 weeks

Prerequisite: Students who have completed a Three-Year Bachelor Degree in Science with Physics Major (Level 5.5)

Course Objectives:
1. To understand celestial mechanics and the tools of observational astronomy.
2. To introduce basic astronomical and physical principles in the study of the solar system.

Course Outcomes (COs):
On completing the course, the student will be able to:

1. Have knowledge of the expanse of the solar system and the Universe, and the physical nature of the planets.
2. Understand how astronomical coordinate systems are used to identify the positions of celestial objects.
3. Apply mathematical tools and physics laws to understand the nature of the bodies in the solar system and use analytical skills to solve quantitative problems.
4. Evaluate the astronomical observational tools and techniques applied at different wavelengths.
5. Develop creative applications of knowledge of astronomy and telescopes in daily life.
6. Develop an understanding of the Indian Knowledge System in the context of astronomy.

Unit 1 (15 lectures)

Positional and Observational Astronomy

1. **The geometry of the sphere:** Spherical geometry and trigonometry
2. **The celestial sphere – coordinate systems:** The horizontal, equatorial, ecliptic and Galactic coordinate systems, transformation of one coordinate system into another, southern hemisphere, circumpolar stars, Sun's geocentric behaviour
3. **The celestial sphere – timekeeping systems:** Sidereal time, mean solar time and relationship between the two, civil day and timekeeping, Greenwich date and zone time, Julian date, twilight
4. **Positional observations:** Geocentric and stellar parallax, semi-diameter of a celestial object, stellar, diurnal and planetary aberrations, precession and nutation
5. **Indian astronomy (IKS component)**: Constellations in the Indian tradition, astronomical and cultural significance of monuments in India, Indian equivalent of modern astronomical understanding, brief overview of astronomy in other ancient cultures.

Unit 2 (15 lectures)

Tools of Astronomy

1. **The optics of telescopes:** Resolving power, aberrations, refractors and reflectors, magnifying power, visual resolving power, magnification limits, limiting magnitude
2. **Detectors for optical telescopes:** Spectral sensitivity, quantum efficiency, Historical perspective of the photographic and photoelectric devices, charge coupled devices
3. **Astronomical optical measurements:** Standard magnitude systems, colour indices, bolometric magnitudes, the atmosphere, image photometry, spectrometry, spectroscopy, active and adaptive optics, measurements at high angular resolution
4. **Radio telescopes:** Antennas, antenna design, parabolic dishes, horn collectors, interferometry
5. **Telescope mountings:** Optical and radio telescopes, equatorial mountings, telescope domes
6. **Instruments for multi-messenger astronomy:** X-ray, gamma-ray, UV, IR and millimetre astronomy, neutrino astronomy, gravitational radiation

Unit 3 (15 lectures)

Solar and extra-solar system

1. **Basics of planetary science:** Kepler's laws and planetary motion, interiors, surfaces and atmospheres, classical mechanics applied to the solar system
2. **The Sun, Earth and Moon:** Introduction to the structure of the Sun, solar wind and other solar activity, overview of space weather and Earth's magnetosphere, tides, tidal friction, Roche and instability limits, properties and evolution of the Earth-Moon system
3. **The planetary system:** Mercury, Venus, Mars, comparative evolution of the terrestrial planets, Jupiter, Saturn, Uranus, Neptune, Pluto and Charon
4. **Small bodies and the origin of the solar system:** Moons and rings, asteroids, comets, meteoroids and meteorites, interplanetary gas and dust, the formation of the solar system
5. **Extrasolar planets:** Detecting extrasolar planets, observations of extrasolar planets, exoplanet statistics, physics of exoplanets

List Of Recommended Reference Books

1. Astronomy: Principles and Practice, 4th edition, A. E. Roy and D. Clarke, IoP Publishing
2. Introductory Astronomy and Astrophysics, 4th edition, Michael Zeilik and Stephen Gregory, Thomson Learning.
3. Fundamental Planetary Science: Physics, Chemistry and Habitability, J. J. Lissauer and I. de Pater, Cambridge University Press
4. Astrophysical Techniques, 7th edition, C. R. Kitchin, CRC Press
5. Astronomy in India: A Historical Perspective, Thanu Padmanabhan, Springer

Additional References:

1. An Introduction to Modern Astrophysics, Second Edition, By Carroll B.W., Ostlie D.A., Pearson Addison Wesley.
2. The Physical Universe: An Introduction to Astronomy By F. H. Shu, 1982, University Science Books.

Practicals

1. Minimum four practicals in the complete semester from the following list:
    a. Circumpolar star identification and Julian date
    b. Right ascension and declination of the Sun and Moon
    c. Basic astronomical data reduction
    d. Set-up of an equatorial mount telescope
    e. Horn antenna for astronomical observations
    f. Observations of the Sun
2. Project:

    In a complete semester a student must perform one project related to the course.

Evaluation (Theory): Total marks per course - 100

I. Formative Assessment 'for' Learning (continuous internal assessment - CIA to improve learning).
   CIA - 40 marks
   CIA 1: Written test - 20 marks
   CIA 2: Field trip/ Sit-in exams/ Research article review/ Assignments/ Presentations/ MCQs - 20 marks

II. Summative Assessment 'of' Learning (focus on outcomes, quantitative data for outcomes of instruction).
   End Semester Examination – 60 marks

Evaluation (Practical): Total marks per course - 50

Project work with report – 20 marks
End Semester Practical Examination – 20 marks
Journal – 5 marks
Co-curricular activity – 5 marks

Template for the End Semester examination in Semester II for the Elective course

UNITS	KNOWLEDGE	UNDERSTANDING	APPLICATION and ANALYSES	TOTAL MARKS- Per unit
1	6	8	6	20
2	6	8	6	20
3	6	8	6	20
-TOTAL- Per objective	18	24	18	60
% WEIGHTAGE	30%	40%	30%	100%

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