BHARATHIDASAN UNIVERSITY, TIRUCHIRAPPALLI – 24
Course Structure for M.Sc. Physics (26-27)

Sem	Course	Course Title	Credits	Exams Hrs	Marks		Total
					Int.	Ext.	
I	Core Course I (CC)	Classical Mechanics	5	3	25	75	100
	Core Course II (CC)	Mathematical Physics	5	3	25	75	100
	Core Course III (CC)	Analog and Digital Electronics	5	3	25	75	100
	Core Practical I (CP)	General Physics and Electronics I	3	3	40	60	100
	Elective Course I (EC)	Physics Simulations with Python	4	3	25	75	100
	Total		**22**	-	-	-	**500**
II	Core Course IV (CC)	Quantum Mechanics	5	3	25	75	100
	Core Course V (CC)	Electromagnetic Theory	5	3	25	75	100
	Core Course VI (CC)	Advanced Mathematical Physics	5	3	25	75	100
	Core Practical II (CP)	General Physics and Electronics II	3	3	40	60	100
	Elective Course II (EC)	Microprocessor and Microcontroller	4	3	25	75	100
	Non-major Elective I		2	3	25	75	100
	Total		**24**	-	-	-	**600**

S.No.	Types of the Course	No. of Courses	No. of Credits	Marks
1.	Core Course	11	55	1100
2.	Core Practical	3	12	300
3.	Elective Courses	3	9	300
4.	Project	1	10	100
5.	Non-Major Elective Courses	2	4	200
	Total	20	90	2100

Year: I	Classical Mechanics Core Course I	Semester: I
		Credits:5

Course Objectives:

- To provide in-depth knowledge on the foundations of Classical Mechanics.
- To familiarize the laws of motion and learn about their applications in other branches of Physics.
- To build a strong base on dynamical systems.

Unit 1: Lagrange's Formulation

Mechanics of a system of particles – Constraints – Generalized coordinates – D Alembert's principle and Lagrange's equations – Simple application of the Lagrangian formulation – Hamilton's (variational) principle and derivation of Lagrange's equations – Generalized momenta and energy – Cyclic coordinates – Conservation Laws.

Unit 2: Central Force Motion and Rigid Body Dynamics

Central Force Motion: General features – The Kepler Problem: inverse square law force – Scattering in a central force field.

Rigid Body Dynamics: Moment of inertia tensor – Euler angles – Euler's equations of motion.

Unit 3: Hamilton's Formulation

Legendre transformation – Hamiltonian and Hamilton's equation of motion – Properties – Derivation of Hamilton's equations from variational principle – Canonical transformation – Applications – Poisson brackets – Hamilton's characteristic function.

Unit 4: Small Oscillations and Vibrations

Small Oscillations: Theory of small oscillations – Eigenvalue problem – Normal modes and Normal frequencies - Frequencies of free vibrations – Normal coordinates – Examples – Two coupled Pendula - Linear triatomic molecule – Forced vibrations.

Unit 5: Theory of Relativity

Inertial and non-inertial reference frames – Addition of velocities, mass, energy – Mass-Energy equivalence – Galilean and Lorentz transformations – Invariance of Maxwell's equations under Lorentz transformation.

References:

[1] H. Goldstein, C. P. Poole and J. Safko, *Classical Mechanics* (Pearson, New Delhi, 2011).
[2] G. Aruldhas, *Classical Mechanics* (Prentice Hall of India, New Delhi, 2015).
[3] J. C. Upadhyaya, *Classical Mechanics* (Himalaya, Bangalore, 2019).
[4] B. D. Gupta and Satya Prakash, *Classical Mechanics* (Kedar Nath Ram Nath, Meerut, 2020).
[5] S. Dutta, *Mechanics* (Pearson, New Delhi, 2012).
[6] M. Lakshmanan and S. Rajasekar, *Nonlinear Dynamics: Integrability, Chaos, and Patterns* (Springer, Chennai, 2003).
[7] T. L. Chow, *Classical Mechanics* (CRC, New York, 2013).
[8] N. Rana and P. Joag, *Classical Mechanics* (McGraw Hill, New Delhi, 2017).
[9] S. T. Thornton and J. B. Marion, *Classical Dynamics of Particles and Systems* (Cengage Learning, New Delhi, 2012).
[10] H. V. Sharma, S. L. Gupta and V. Kumar, *Classical Mechanics* (Pragati Prakashan, New Delhi, 2019).
[11] R. G. Takwale and P. S. Puranik, *Introduction to Classical Mechanics* (McGraw Hill, New Delhi, 2017).
[12] K. Prathapan, *Analytical Problems in Classical Mechanics: Complete Solutions* (Dreamtech, New Delhi, 2019).
[13] J. Awrejcewicz and Z. Koruba, *Classical Mechanics: Applied Mechanics and Mechatronics* (Springer, Heidelberg, 2012).
[14] F. C. Moon, Applied Dynamics (Wiley-VCH, New Delhi, 2008).
[15] https://ocw.mit.edu/courses/8-09-classical-mechanics-iii-fall-2014/pages/lecture-notes/
[16] https://nptel.ac.in/courses/115105098

Course Outcome:

On the successful completion of the course, students will be able to

(a) Solve problems involving Lagrangian and Hamiltonian mechanics.
(b) Attain sound knowledge of the basic formalism and geometric aspects of classical mechanics.
(c) Understand the usefulness of variational calculus in formulating the mechanical laws of motion.
(d) Find solutions to problems in the normal mode analysis and its applications.
(e) Get familiarized with the dynamical systems.

Year: I	Mathematical Physics Core Course II	Semester: I
		Credits: 5

Course Objectives:

- To give a solid mathematical foundation in vector calculus, matrices and differential equations.
- To help learn and appreciate the importance of Special functions and their applications in Physics.
- To develop mathematical skills and solve problems in various branches of Physics.

Unit 1: Vector Calculus

Vector integration – Line integral – Surface integral – Flux – Volume integral – Green's theorem – Stokes' theorem – Divergence theorem – Orthogonal curvilinear coordinates – Unit vectors in curvilinear coordinate system – Gradient, divergence, curl and Laplacian in cylindrical and spherical polar coordinates.

Unit 2: Matrices

Matrix algebra – Solution of a system of linear equations – Properties of (i) symmetric, (ii) anti-symmetric, (iii) orthogonal, (iv) Hermitian, (v) skew-Hermitian and (vi) unitary matrix – Eigenvalues and eigenvectors of a square matrix – Diagonalization – Matrix Analysis of second order linear differential equations and their solutions.

Unit 3: Ordinary Differential Equations

Methods of finding solutions of first and second order ordinary differential equations (ODEs) with constant coefficients – Initial value and boundary value problem – Methods of finding solutions – Superposition principle – Wronskian – Definition of ordinary and singular points of second order ODEs – Power series solution.

Unit 4: Special Functions

Strum-Liouville problem – Basic properties– Specific examples for Strum-Liouville equation: (i) Legendre, (ii) Hermite and (iii) Laguerre differential equations – Power series solutions – Polynomials – Generating function – Rodrigue's formula – Recursion relations – Orthogonality relations.

Unit 5: Probability

Definition – Addition rule of probability – Multiplication law of probability – Probability distribution – Binomial distribution – The first four moments of Binomial

distribution – Poisson distribution – Normal distribution – The first four moments of Poisson and Normal distribution.

References:

[1]H. K. Dass and R. Verma, *Mathematical Physics* (S. Chand, New Delhi, 2022).
[2]B. S. Rajput, *Mathematical Physics* (Pragati Prakashan, Meerut, 2019).
[3]N. Saran, S. D. Sharma and T. N. Trivedi, *Special Functions* (Pragati Prakashan, Meerut, 2021).
[4]B. D. Gupta, *Mathematical Physics* (S. Chand, New Delhi, 2009).
[5]Sathya Prakash, *Mathematical Physics with Classical Mechanics* (S. Chand, New Delhi, 2021).
[6]D. G. Zill and M. R. Cullen, *Advanced Engineering Mathematics* (Narosa, New Delhi, 2020).
[7]E. Kreysig, H. Kreysig and E. J. Norminton, *Advanced Engineering Mathematics* (John Wiley, New Delhi, 2011).
[8]G. B. Arfken, H. J. Weber and R. E. Harris, *Mathematical Method for Physicists* (Academic, Cambridge, 2011).
[9]T. L. Chow, *Mathematical Methods for Physicists: A Concise Introduction* (Cambridge University Press, Cambridge, 2014).
[10] M. P. Boas, *Mathematical Methods in the Physical Sciences* (Wiley, New York, 2018).
[11] Charlie Harper, *Introduction to Mathematical Physics* (Prentice Hall of India, New Delhi, 1998).
[12] M. P. Deisenroth, A. A. Faisal and C. S. Ong, *Mathematics for Machine Learning* (Cambridge University Press, Cambridge, 2020).
[13] C. Hurley and J. Mclean, *Wavelet Analysis and Methods* (Ed-Tech Press, London, 2018).
[14] K. F. Reily, M. P. Hobson and S. J. Bence, Mathematical Methods for Physics and Engineering (Cambridge University Press, Cambridge, 2006).
[15] https://nptel.ac.in/courses/115103036
[16] http://www.issp.ac.ru/ebooks/books/open/Mathematical%20Methods.pdf

Course Outcome:

On the successful completion of the course, students will be able to

(a) Acquire the essential mathematical skills to solve problems in various branches of physics.
(b) Understand the usefulness of vector integration theorems and their utility in solving physics problems arising in electromagnetic theory and other branches of physics.
(c) Know the usefulness of matrices and matrix operations in solving physics and engineering problems.
(d) Attain sound knowledge of classical orthogonal polynomials and their applications in quantum physics.
(e) Solve various kinds of differential equations that model a variety of natural systems.

Year: I	**Analog and Digital Electronics** Core Course III	**Semester: I**

Course Objectives:

- To introduce students to the circuit designs and provide an in-depth knowledge on Digital Electronics.
- To understand the working of advanced semiconductor devices and digital circuits and the utility of OP-AMP.
- To learn the basics of integrated circuit fabrication, applications of timer IC-555 and the building block of digital systems.

Unit 1: Semiconductor Devices

SCR - DIAC - TRIAC – Construction, operation and V-I characteristics -Tunnel diode – Gunn diode **–** V-I characteristics. Basic monolithic ICs – Epitaxial growth – Masking – Etching - Impurity diffusion – Fabricating monolithic resistors, diodes, transistors, inductors and capacitors.

Unit 2: Operational Amplifier

Wien bridge and phase-shift oscillators – Triangular, saw-tooth and square-wave generators – Schmitt trigger – Weighted resistor and binary R-2R ladder D/A converters - Counter type and successive approximation A/D converters – Solving simultaneous and differential equations.

Unit 3: 555 Timer and Phase Locked Loop

Introduction – Description and functional diagram of 555 timer – Monostable operation – Frequency divider Astable operation - PLL Basic principle – Analog phase detector – Digital phase detector – PLL applications – Frequency multiplication/division.

Unit 4 Digital Circuits-I

Digital comparator – Parity generator/checker – Data selector - BCD to decimal decoder – Seven segment decoder – Encoders – RS, JK, D, T and JK master-slave flip-flops.

Unit 5: Digital Circuits-II

Shift registers: Serial-in serial-out, Serial-in parallel-out and Parallel-in serial-out – Counters: Synchronous, asynchronous - up/down counters (using mod 10) - Multiplexers – De-multiplexers.

References:

[1] D. P. Leach and A. P. Malvino, *Digital Principles and Applications* (McGraw Hill, New Delhi, 2006).

[2] R. A. Gayakwad, *Op-Amps and Linear Integrated Circuits* (Pearson, New Delhi, 2021).

[3] L. Floyd, *Electronic Devices* (Pearson, New Delhi, 2021).

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[5] V. Vjayendran, *Introduction to Integrated Electronics Digital and Analog* (S. Viswanathan Printers and Publishers, Chennai, 2014).

[6] R. L. Geiger, P. E. Allen and N. R Strader, *VLSI Design Techniques for Analog and Digital Circuits* (McGraw Hill, Singapore, 2010).

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[8] D. Chattopadhyay and P. C. Rakshit, *Electronics Fundamentals and Applications* (New Age International Publications, New Delhi, 2021).

[9] T. F. Schubert and E. M. Kim, *Active and Nonlinear Electronics* (Wiley, New York, 1996).

[10] I. J. Nagrath, *Electronics: Analong and Digital* (Prentice Hall of India, New Delhi, 2013).

[11] W. D. Stanley, *Operational Amplifiers with Linear Integrated Circuits* (Pearson, New Delhi, 2002).

[12] S. Salivahnan and S. Arivazhagan, *Digital Circuits and Design* (McGraw Hill, New Delhi, 2018).

[13] C. Durkan, *Current at the Nanoscale* (World Scientific, London, 2013).

[14] C. R. Paul, *Transmission Lines in Digital and Analog Electronic Systems* (Wiley, New York, 2010).

[15] https://www2.mvcc.edu/users/faculty/jfiore/OpAmps/OperationalAmplifiersAndLinearICs_3E.pdf

[16] https://nptel.ac.in/courses/108102112

[17] https://nptel.ac.in/courses/108105132

Course Outcome:

On the successful completion of the course, students will be able to

(a) Understand the basic principle and the underlying concepts of electronic devices.
(b) Gain a clear understanding of the operations of electronic circuits.
(c) Design and analyze electronic circuits.
(d) Learn the applications of the operational amplifier and IC 555 and demonstrate them in timer.
(e) Realize the digital circuits and communication circuits.

Year: I	**CORE PRACTICAL I** **GENERAL PHYSICS AND ELECTRONICS I**	Semester: I
	Any **Twelve** with **atleast four** experiments from each section	

Objectives: Experimental determination of certain physical constants and properties and verification of characteristics and applications of electronic components and devices

A. General Physics Experiments

1. Determination of q, n, σ by elliptical fringes method.
2. Determination of Stefan's constant.
3. Determination of bulk modulus of a liquid by ultrasonic wave propagation.
4. Determination of Rydberg's constant.
5. Study of Hall effect in a semiconductor.
6. Determination of dielectric constant at high frequency by Lecher wire.
7. Michelson interferometer - Determination of wavelength of monochromatic source.
8. Determination of wavelength of monochromatic source using biprism.
9. Charge of an electron by spectrometer.
10. Polarization of light - Verification of Malus law and Brewster angle of glass.
11. BH loop – Energy loss of a magnetic material – Anchor ring using B.G./CRO.
12. Determination of e/m of an electron by magnetron method.

B. Electronics Experiments

1. Construction of dual regulated power supply.
2. Astable and monostable multivibrators using IC555.
3. Characteristics of UJT.
4. Characteristics of SCR.
5. Design and study of Wein bridge oscillator using op-amp.
6. Design and study of square and triangular waves generators using op-amp.
8. V-I characteristics of a solar cell.
9. Operation of shift register using serial-in serial-out, serial-in parallel-out and parallel-in serial-out.
10. Digital to analog converter - R-2R and weighted method.
11. BCD to 7 segment display.
12. Study of A/D converter - Counter ramp type method.

References:

1. J. Millman and C. C. Halkias, *Electronic Devices and Circuits* (McGraw Hill, New Delhi, 1985).
2. G. Kennedy, *Electronic Communication Systems* (McGraw Hill, New Delhi, 1994).
3. D. R. Choudhury and S. Jain, *Linear Integrated circuits* (New Age International, New Delhi, 2001)
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5. K. A. Navas, *Electronics Lab Manual*, Volume I&II (Rajat Publications, New Delhi, 2015).
6. M. N. Avadhanulu, A. A. Dani and P. M. Pokley, *Experiments in Engineering Physics* (S. Chand, New Delhi, 1999).

Outcome:

On the successful completion of the course, students will be able to

a) Understand the different moduli using elliptical fringes.
b) Gain knowledge of the Hydrogen spectrum.
c) Comprehend the principle of Hall effect.
d) Appreciate the operation of multivibrators using 555 Timer.
e) Work on analog and digital circuits.

Year: I	**Physics Simulations with Python** Elective Course I	**Semester: I**

Course Objectives:

- To introduce Python language and different Python modules.
- To give an exposure to solve and visualize the physical problems using Python.
- To develop the idea of writing programs using different numerical methods.

Unit 1: Introduction to Python Language

Input and Output methods – Variables – Operators – Expressions and statements – Strings – Lists – List Functions and methods – Sets – Set Function and methods – Tuples and Dictionaries – Conditionals, Iterations and Looping – Functions and Modules – File Input and File Output.

Unit 2: Numpy Modules – Arrays and Matrices

Creation of Arrays and Matrices (arrange, line space, zeros, ones, random, reshape, copying arrays) - Arithmetic Operations - Cross Product – Dot Product – Saving and Restoring – Matrix Inversion – Solution of Simultaneous equations.

Unit 3: Matplotlib Module – Data Visualization

Methods defined in Matplotlib – Plotting graphs – Multiple Plots – Polar plots – Pie charts – Plotting Sine, Log, Exponential, Legendre, Bessel, Gaussian and Gamma functions – Parametric Plots.

Unit 4: Numeric Methods

Inverse of a Function – Interpolation with a Cubic Spline – Zeros of Polynomials – Monte Carlo methods – Simple Integration – Integration by Importance sampling, Eigenvalues and Eigenfunctions – Shooting and Relaxation methods – Sampled Data: Sampling Theorem – Fast Fourier Transform.

Unit 5: Introduction to Computational Approach in Physics

Formulation: From Analytical methods to Numerical Methods – Oscillatory motions – Ideal Simple Harmonic Oscillator (Euler Method) – Driven LCR Circuit (R-K Method) – Circuit Analysis using Kirchoff's Law – Central Field Motion – Monte Carlo Simulations value of π – Simulation of Radioactivity – Logistic Maps.

References:

[1] S. S. Shastry, *Introductory Methods of Numerical Analysis* (Prentice Hall of India, New Delhi, 2012).

[2] B. S. Grewal, *Numerical Methods in Engineering and Science* (Khanna Publishers, New Delhi, 2013)

[3] J. B. Scarborough, *Numerical Mathematical Analysis* (Oxford & IBH Publishing., New Delhi, 2005).

[4] B. P. A. Kumar, *Python for Education* (Inter University Accelerator Centre, New Delhi, 2010).

[5] T. E. Oliphant, *Guide to Numpy* (Createspace Independent, California, 2015).

[6] S. Tosi, *Matplotlib for Python Developers* (Packt Publishing, Brimingham, 2010).

[7] D. M. Beazley, *Python Essential Reference* (Addison Wesley, New York, 2009).

[8] W. J. Chun, *Core Python Applications Programming* (Pearson, New Delhi, 2016).

[9] E. Balagurusamy, *Numerical Methods* (McGraw Hill, New Delhi, 2017).

[10] T. Veerarajan and T. Ramachandran, *Numerical Methods* (McGraw Hill, New Delhi, 2018).

[11] V. K. Mittal, R. C. Verma and S. C. *Gupta, Computational Physics* (Ane Books, New Delhi, 2021).

[12] J. Kiusalaas, *Numerical Methods in Engineering with Python* (Cambridge University Press, Cambridge, 2013).

[13] https://greenteapress.com/modsimpy/ModSimPy3.pdf

[14] https://archive.nptel.ac.in/courses/115/104/115104095/

Course Outcome:

On the successful completion of the course, students will be able to

a) Familiarize with Python language.
b) Understand the basics of Python.
c) Acquaint with different Python modules.
d) Use numerical methods to solve and visualize the physical problems.
e) Develop ideas to write a programme using python.