CURRICULUM & SYLLABUS

Bachelor of Science (Hons.) Physics

or

Bachelor of Science (Hons.) Physics with Research/ Academic Projects

(A 4 Year Undergraduate Degree Program)

Under UGC Framework - 2022 based on NEP – 2020

(w.e.f. Academic Year 2025-26)

DEPARTMENT OF PHYSICS
FACULTY OF SCIENCE AND HUMANITIES
SRM UNIVERSITY DELHI-NCR, SONEPAT
39, Rajiv Gandhi Education City, Sonepat Haryana-131029

SRM UNIVERSITY DELHI-NCR, SONEPAT (HARYANA)

VISION

SRM University Haryana aims to emerge as a leading World Class Institution that creates and disseminates knowledge upholding the highest standards of instruction in Engineering & Technology, Science & Humanities, Commerce, Management, Hotel Management & Medicine & Health Science. Along with academic excellence, our curriculum imparts integrity and social sensitivity so that our graduates may best serve the Nation and the World.

MISSION

- To create a diverse community campus that inspires freedom and innovation.
- Strengthen Excellence in educational & skill development processes.
- Continue to build productive international alliances.
- Explore optimal development opportunities available to students and faculty.
- Cultivate an exciting and rigorous research environment.

DEPARTMENT OF PHYSICS

VISION

The Department of Physics at SRM University Delhi-NCR is a young and dynamic Department. However, it is growing rapidly in every aspect. At present, we are offering a four-year B.Sc. (Hons), four-year B.Sc. (Hons) with Research/Academic Project and a two-year M.Sc. in physics. We also offer a Ph.D. program in Physics. Further, we also offer a one semester Engineering Physics course to the first year B.Tech. students of this university. Our department strives to become a centre of excellence for higher studies in Physics focused on advanced learning, innovation and knowledge transfer from lab to industry. Our vision is to establish a research-based ecosystem that will put equal stress upon the fundamental branches of physics as well as applied areas, particularly, on topics which have interfaces with other branches of physics. The faculty members as well as the research scholars at the Department are actively engaged in cutting-edge research in different areas of Physics. Our Department envisions to build an academic ambience where 'knowledge is free' of all bounds, innovative and creative ideas are encouraged, and talents are nurtured to realize their full potential.

MISSION

- We aim to offer a balanced blending of comprehensive training in the core areas of physics along with the cutting-edge recent topics of physics.
- We tried to keep a balance between the theoretical courses and experimental courses with an emphasis on problem-solving. This will help the students to develop fundamental concepts, verify them in the lab and thereby discourage the rote-learning.
- Our motto is to prepare a student with the fundamental concepts of physics as well as the skills required to apply them so that they can go on to become a professional physicist in future.
- Overall, we intend to equip a student with the right aptitude and skills so that they can go on to become a professional Physicist in future.
- Additionally, we also intends to inculcate skills like logical thinking, quantitative argumentation, and capability of analyzing a large amount of information (or data) in the students so that even those, who are not going to build a career as a professional physicist, will benefit both professionally and also as a human being.

SCIENCE GRADUATE EMPLOYMENT ATTRIBUTES

- **Able to Apply their Knowledge and Skills in the Disciplinary Area**
- **Analytical & critical thinking and problem solving skills.**
- **Scientific Temperament Towards Research & Innovation for the Betterment of Society**
- **Efficient Communication & Presentation Skills**
- **Dependability, reliability, responsibility, and independent leadership abilities**

B. Sc. PHYSICS PROGRAM EDUCATIONAL OBJECTIVES

With the main focus of its research and teaching mission, the Physics Department works to provide its students with:

- A comprehensive, high-quality education in the physical sciences
- A flexible choice based curriculum with multiple Inter-disciplinary courses / Minor Stream Courses / Skill Enhancement Courses that allows students to tailor their education according to their specific interests.
- A scientific temperament towards the new discovery through direct participation in faculty research.
- An increased awareness of the physical processes in the surrounding world.
- The prerequisite knowledge, analytical, mathematical, computational tools with which they learn problem solving ability which helps them to pursue research in a variety of physics-related and other fields.
- To inculcate the habit of working together as a team and also develop the leadership abilities in them by introducing them to the various teaching learning techniques and coordination programmes.

B. Sc. PHYSICS PROGRAM LEARNING OUTCOMES

Graduates from the B. Sc. Physics undergraduate degree program will be able to

- Demonstrate a conceptual understanding in the core areas of physics and the supporting mathematics including the range of validity of key concepts.
- Translate physical descriptions into mathematical equations, and conversely, explain the physical meaning of mathematical results.
- Use computational techniques such as coding at a level necessary to perform statistical analysis and simulations in solving complex problems.
- Use basic laboratory equipment effectively in order to conduct measurements and analyze the results including the understanding of error limits.
- Communicate the scientific results efficiently, making use of clear and well organized writing and presentation skills, and employ equations and visualization tools as needed.

MAPPING BETWEEN THE PROGRAM EDUCATIONAL OBJECTIVES AND PROGRAM LEARNING OUTCOMES

Programme Educational Objectives (PEO’s)	Program Learning Outcomes (PLO's)				
	PLO1	PLO2	PLO3	PLO4	PLO5
PEO1					
PEO2					
PEO3					
PEO4					
PEO5					
PEO6					

Four Year B.Sc. Physics Programme Structure in alignment with NEP-2020 in the Department of Physics, SRMUH

w.e.f. Academic Year 2025-26

S. No.	Broad Category of Courses	No. of Courses	Credits	%
1	Major Course (Discipline Specific Course DSC)	24	24 × 4 = 96	53.04
2	Interdisciplinary Course (IDC) / Minor Stream Course (MSC)	7	7 × 4 = 28	15.47
3	Multi-Disciplinar Course (MDC)	3	3 × 3 = 9	4.97
4	Ability Enhancement course (AEC)	4	2 × 4 = 8	4.42
5	Skill Enhancement Course (SEC)	10	10 × 1 = 10	5.52
6	Value Added Course (VAC)	3	3 × 2 = 6	3.31
7	Project / Dissertation	4* / 3#	1 × 4 + 2 ×2 +1 × 4 = 12* 1 × 2 +1 × 4 +1 × 6 = 12#	6.63
8	Live Projects/Vocational Courses/Summer Internship	3	3 × 4 = 12	6.63
	Total	58* / 57#	181	100

* B.Sc. (H) Physics # B.Sc. (H) Physics with Research / Academic Project

Four Year B.Sc. Physics Programme Structure component-wise distribution in alignment with NEP-2020 in the Department of Physics, SRMUH w.e.f. Academic Year 2025-26.

S. No.	Broad Category of Courses	No. of Courses	Component	Course division	Credits	Total Credit	%
1	Major Course	24	Theory	24	12 × 4= 48 12 × 3= 36	96	53.04%
			Practical	11	12 × 1= 12		
2	Interdisciplinary Course (IDC) / Minor Stream Course (MSC)	7	Theory	7	4 × 4= 16 1 × 3= 03 2 × 2= 04	28	15.47%
			Practical	3	2 × 2= 04 1 × 1= 01		
3	Multi-Disciplinar Course (MDC)	3	Theory	3	3 × 3= 9	9	4.97%
4	Ability Enhancement course (AEC)	4	Theory	4	2 × 4= 8	8	4.42%
5	Skill Enhancement Course (SEC)	10	Soft SEC Practical	5	5 × 1 = 5	10	5.52%
			Techi. SEC Practical	5	5 × 1 = 5		
6	Value Added Course (VAC)	3	Theory	2	2 × 2 = 4	6	3.31%
			Practical	1	2 × 1 = 2		
7	Project / Dissertation	4*	MSC*	3*	1 × 4 = 4* 2 × 2 = 4*	12	6.63%
			Project*	1*	1 × 4 = 4*		
		3#	Theory#	1	2 × 1 = 2		
			Dissertation#	2	1 × 4 = 4 1 × 6= 6		
8	Live Projects/Vocational Courses/Summer Internship	3	Practical	3	3 × 4 = 12	12	6.63%
	Total	58* / 57#	Theory	134 = 74%		181	100%
			Practical	23 = 12.7%			
			Project	24 = 13.3 %			

*** Students pursuing Honours will do 1 MSC course of 4 Credits, 2 MSC courses of 2 Credits and 1 Minor Project of 4 Credits in lieu of a Research Project/Dissertation.**

 # Students pursuing Honours with Research would complete 2 Credits of Research Methodology, 4 credits of Minor dissertation and 6 credits of Major Dissertation.

Four Year B.Sc. Physics Programme Credit Structure Semester-wise in alignment with NEP-2020 in the Department of Physics, SRMUH

w.e.f. Academic Year 2025-26

Semester	Broad Category of Courses								Total Credits	Remarks
	Major	IDC/ MSC	MDC	AEC	SEC	VAC	RP/ Dissertation	Live Projects/ Vocational Courses/Summer Internship		
I	8	4	3	2	2	2	-	-	21	Certificate: 46 Credits
II	8	4	3	2	2	2	-	4	25	
III	12	4	3	2	2	-	-	-	23	Diploma: 95 Credits
IV	12	4	-	2	2	2	-	4	26	
V	16	4	-	-	2	-	-	-	22	Degree : 145 Credits
VI	16	8	-	-	-	-	-	4	28	
VII	12	6*	-	-	-	-	6#	-	18	Honours / Honours with Research: 181 Credits
VIII	12	6*	-	-	-	-	6#	-	18	
3 Years	**72**	**28**	**9**	**8**	**10**	**6**	**0**	**12**	**145**	
%	**49.67**	**19.31**	**6.20**	**5.52**	**6.9**	**4.14**	**0.00**	**8.28**	**100.00**	
4 Years	**96**	**28**	**9**	**8**	**10**	**6**	**12**	**12**	**181**	
%	**53.04**	**15.47**	**4.97**	**4.42**	**5.52**	**3.31**	**6.63**	**6.63**	**100.00**	

*** Students pursuing Honours will do 1 MSC courses for 4 Credits, 2 MSC courses of 2 Credits and 1 Minor Project of 4 Credits in lieu of a Research Project/Dissertation.**

 # Students pursuing Honours with Research would complete 2 Credits of Research Methodology, 4 credits of Minor dissertation and 6 credits of Major Research/Dissertation.

COURSE REVISION DETAILS

FOLLOWING MINOR STREAM COURSES ARE INTRODUCED

1. Fundamentals of Quantum Computing (25PHBS029)
2. Fundamentals of Quantum Computing Lab (25PHBS030)
3. Quantum algorithms and error correction (25PHBS031)
4. Quantum algorithms and error correction Lab (25PHBS032)
5. Classical and Quantum information processing (25PHBS033)
6. Classical and Quantum information processing Lab (25PHBS034)
7. Quantum Machine Learning (25PHBS035)
8. Quantum Machine learning lab (25PHBS036)
9. Machine Learning for Physics (25PHBS037)
10. Electric Vehicle (25PHBS038)
11. Classical field theory (25PHBS023)
12. Quantum field theory (25PHBS024)
13. MATLAB (25PHBS025)

MINOR CHANGES ARE THERE IN THE FOLLOWING MAJOR/MINOR COURSES

1. Mathematical Physics I (25PHBS101)
2. Optics (25PHBS202)
3. Optics Lab (25PHBS252)
4. Mathematical Physics III (25PHBS301)
5. Electricity & magnetism (25PHBS302)
6. Electricity & magnetism lab (25PHBS352)
7. Thermal Physics Lab (23PHBS353)
8. Analog electronics (25PHBS401)
9. Analogue electronics lab (25PHBS451)
10. Digital electronics (25PHBS501)
11. Digital electronics lab (25PHBS551)
12. Electromagnetic theory (25PHBS502)
13. Electromagnetic theory LAB (24PHBS552)

14. Condensed matter physics – I (25PHBS504)
15. Condensed matter physics lab – I (25PHBS554)
16. Condensed matter physics – II (25PHBS601)
17. Quantum mechanics – II (25PHBS603)
18. Atomic and molecular physics – I (25PHBS701)
19. Atomic and molecular physics – II (25PHBS801)
20. Astronomy & astrophysics (25PHBS008)
21. Atmospheric physics (25PHBS009)
22. Advanced Mathematical Physics II (25PHBS010)
23. Renewable energy physics (24PHBS011)
24. Nanomaterials (25PHBS012)
25. Novel & smart materials (25PHBS013)
26. Soft matter physics (25PHBS014)

B. Sc. PHYSICS - SEMESTER-I

S.No.	Course Code	Course Title	L	T	P	Credits	Course Category
1	25PHBS101/ 25PHBS151	Mathematical Physics I / Computational Physics Lab I	3	0	2	4	Major
2	25PHBS102/ 25PHBS152	Mechanics / General Properties Of Matter Lab	3	0	2	4	Major
3		IDC-1 / MSC-1	2	0	4	4	IDC/MSC
4		MDC 1	3	0	0	3	MDC
5		Functional English-1	2	0	0	2	AEC
6		Effective Communication Skills	0	0	2	1	SEC (Soft)
7		Digital Literacy & IT Skills	0	0	2	1	SEC (Tech)
8		Indian Constitution & Polity	2	0	0	2	VAC
		TOTAL	15	0	12	21	

L – Lectures, T- Tutorial, P- Practical, C- credits

B. Sc. PHYSICS - SEMESTER-II

S.No.	Course Code	Course Title	L	T	P	Credits	Course Category
1	25PHBS201/ 25PHBS251	Mathematical Physics II / Computational Physics Lab II	3	0	2	4	Major
2	25PHBS202/ 25PHBS252	Optics	3	0	2	4	Major
3		IDC 2 / MSC2	2	0	4	4	IDC/MSC
4		MDC 2	3	0	0	3	MDC
5		Functional English-2	2	0	0	2	AEC
6		Teamwork & Interpersonal Skills	0	0	2	1	SEC (Soft)
7		Advanced Excel Skills	0	0	2	1	SEC (Tech)
8		Environmental Protection & Sustainable development	2	0	0	2	VAC
9	25PHBS271	Live Projects/Vocational Courses/Summer Internship				4	SIP
		TOTAL	15	0	12	25	

L – Lectures, T- Tutorial, P- Practical, C- credits

On Exit, students shall be awarded UG Certificate (Physics) on securing the requisite 46 Credits on completion of II-Semester.

B. Sc. PHYSICS -SEMESTER-III

S.No.	Course Code	Course Title	L	T	P	Credits	Course Category
1	25PHBS301	Mathematical Physics III	3	1	0	4	Major
2	25PHBS302/ 25PHBS352	Electricity & Magnetism	3	0	2	4	Major
3	25PHBS303/ 25PHBS353	Thermal Physics	3	0	2	4	Major
4		IDC 3 / MSC 3	3	0	2	4	IDC/MSC
5		MDC 3	3	0	0	3	MDC
6		Hindi / German / French	2	0	0	2	AEC
7		Presentation Skills	0	0	2	1	SEC (Soft)
8		Statistical Analysis with SPSS	0	0	2	1	SEC (Tech)
		TOTAL	17	1	10	23	

L – Lectures, T- Tutorial, P- Practical, C- credits

B. Sc. (H) PHYSICS -SEMESTER-IV

S.No.	Course Code	Course Title	L	T	P	Credits	Course Category
1	25PHBS401/ 25PHBS451	Analog Electronics	3	0	2	4	Major
2	25PHBS402/ 25PHBS452	Modern Physics	3	0	2	4	Major
3	25PHBS403	Classical Mechanics	3	1	0	4	Major
4		IDC 4 / MSC4	3	0	2	4	IDC/MSC
5		Hindi / German / French	2	0	0	2	AEC
6		Professional Skills	0	0	2	1	SEC (Soft)
7		R language programming	0	0	2	1	SEC (Tech)
8		Sports, Yoga & Fitness	0	0	4	2	VAC
9	25PHBS471	Live Projects/Vocational Courses/Summer Internship				4	SIP
		TOTAL	14	1	14	26	

L – Lectures, T- Tutorial, P- Practical, C- credits

On Exit, students shall be awarded UG Diploma (Physics) on securing the requisite 95 Credits on completion of IV-Semester.

B. Sc. (H) PHYSICS - SEMESTER-V

S.No.	Course Code	Course Title	L	T	P	Credits	Course Category
1	25PHBS501/ 25PHBS551	Digital Electronics	3	0	2	4	Major
2	25PHBS502/ 25PHBS552	Electromagnetic Theory	3	0	2	4	Major
3	25PHBS503	Quantum Mechanics I	3	1	0	4	Major
4	25PHBS504/ 25PHBS554	Condensed Matter Physics I	3	0	2	4	Major
5		MSC 5	3	1	0	4	MSC
6		Aptitude & Reasoning	0	0	2	1	SEC (Soft)
7		Programming with MATLAB	0	0	2	1	SEC (Tech)
		TOTAL	15	2	10	22	

L – Lectures, T- Tutorial, P- Practical, C- credits

B. Sc. (H) PHYSICS - SEMESTER-VI

S.No.	Course Code	Course Title	L	T	P	Credits	Course Category
1	25PHBS601	Condensed Matter Physics II	3	1	0	4	Major
2	25PHBS602	Electrodynamics	3	1	0	4	Major
3	25PHBS603	Quantum Mechanics II	3	1	0	4	Major
4	25PHBS604	Laser and Non-linear Optics	3	1	0	4	Major
5		MSC 6	3	1	0	4	MSC
6		MSC 7	3	1	0	4	MSC
7	25PHBS671	Live Projects/Vocational Courses/Summer Internship				4	SIP
		TOTAL	18	6	0	28	

L – Lectures, T- Tutorial, P- Practical, C- credits

On Exit, students shall be awarded B.Sc. Degree (Physics) on securing the requisite 145 Credits on completion of VI-Semester.

B. Sc. (H) PHYSICS -SEMESTER-VII

S.No.	Course Code	Course Title	L	T	P	Credits	Course Category
1	25PHBS701	Atomic and Molecular Physics - I	3	1	0	4	Major
2	25PHBS702	Nuclear and Particle Physics	3	1	0	4	Major
3	25PHBS703	Statistical Mechanics I	3	1	0	4	Major
4		MSC 8 *	2*	0	0	2 *	MSC *
5		MSC 9 *	3*	1*	0	4 *	MSC *
6		Research Methodology #	2#	0	0	2 #	MSC for RP #
7	25PHBS771	Minor Project / Minor Dissertation #	-	-	-	4 #	Research Project/Dissertation for RP #
		TOTAL	11# / 14 *	3 #/ 4*	0	18	

L – Lectures, T- Tutorial, P- Practical, C- credits

*** Students pursuing Honours will do 1 MSC Course of 4 Credits and 1 MSC Course of 2 Credits in lieu of Research Project in 7th Semester**
 # Students pursuing Honours with Research will do Research Methodology of 2 Credit and Research Minor Project/ Minor Dissertation of 4 Credits.

B. Sc. (H) PHYSICS -SEMESTER-VIII

S.No.	Course Code	Course Title	L	T	P	Credits	Course Category
1	25PHBS801	Atomic and Molecular Physics - II	3	1	0	4	Major
2	25PHBS802	Semiconductor Physics	3	1	0	4	Major
3	25PHBS803	Statistical mechanics II	3	1	0	4	Major
4		MSC 8 *	2*	0	0	2 *	MSC *
5	25PHBS871	Minor Project *				4 *	Minor Research Project *
6	25PHBS872	Major Project / Major Dissertation #	-	-	-	6 #	Research Project/Dissertation for RP #
		TOTAL	9# / 11 *	3	0	18	

L – Lectures, T- Tutorial, P- Practical, C- credits

*** Students pursuing Honours will do 1 Course of 2 Credits and a Minor Project of 4 credits in lieu of Research Project in 8th Semester**
 # Students pursuing Honours with Research will do Research Project/Dissertation of 6 Credits.

On Exit, students shall be awarded B.Sc. (Physics) (Honours with Research) or (Honours) or (Honours with Research in Discipline-1 (Major) with Discipline-2 (Minor) after securing the requisite 181 Credits on completion of VIII-Semester.

List of Major Courses offered to Four Year B.Sc. Physics programme in the Department of Physics w.e.f. Academic Year 2025-26

S No	Semester	Course Code	Course Title	L	T	P	Credits	Course Category
1	I	25PHBS101	Mathematical Physics I	3	0	0	3	Major Course
2		25PHBS151	Computational Physics lab I	0	0	2	1	Major Course Lab
3		25PHBS102	Mechanics	3	0	0	3	Major Course
4		25PHBS152	General Properties Of Matter Lab	0	0	2	1	Major Course Lab
5	II	25PHBS201	Mathematical Physics II	3	0	0	3	Major Course
6		25PHBS251	Computational Physics lab II	0	0	2	1	Major Course Lab
7		25PHBS202	Optics	3	0	0	3	Major Course
8		25PHBS252	Optics Lab	0	0	2	1	Major Course Lab
9	III	25PHBS301	Mathematical Physics III	3	1	0	4	Major Course
10		25PHBS302	Electricity & Magnetism	3	0	0	3	Major Course
11		25PHBS352	Electricity & Magnetism lab	0	0	2	1	Major Course Lab
12		25PHBS303	Thermal Physics	3	0	0	3	Major Course
13		25PHBS353	Thermal Physics lab	0	0	2	1	Major Course Lab
14	IV	25PHBS401	Analog Electronics	3	0	0	3	Major Course
15		25PHBS451	Analog Electronics Lab	0	0	2	1	Major Course Lab
16		25PHBS402	Modern Physics	3	0	0	3	Major Course
17		25PHBS452	Modern Physics Lab	0	0	2	1	Major Course Lab
18		25PHBS403	Classical Mechanics	3	1	0	4	Major Course
19	V	25PHBS501	Digital Electronics	3	0	0	3	Major Course
20		25PHBS551	Digital Electronics lab	0	0	2	1	Major Course Lab
21		25PHBS502	Electromagnetic Theory	3	0	0	3	Major Course
22		25PHBS552	Electromagnetic Theory Lab	0	0	2	1	Major Course
23		25PHBS503	Quantum Mechanics I	3	1	0	4	Major Course
24		25PHBS504	Condensed Matter Physics I	3	0	0	3	Major Course
25		25PHBS554	Condensed Matter Physics I Lab	0	0	2	1	Major Course Lab
26	VI	24PHBH601	Condensed Matter Physics II	3	1	0	4	Major Course
27		25PHBS602	Electrodynamics	3	1	0	4	Major Course
28		25PHBS603	Quantum Mechanics II	3	1	0	4	Major Course
29		25PHBS604	Laser and Non linear Optics	3	1	0	4	Major Course
30	VII	25PHBS701	Atomic and Molecular Physics - I	3	1	0	4	Major Course
31		25PHBS702	Nuclear and Particle Physics	3	1	0	4	Major Course
32		25PHBS703	Statistical Mechanics I	3	1	0	4	Major Course
33	VIII	25PHBS801	Atomic and Molecular Physics - II	3	1	0	4	Major Course
34		25PHBS802	Semiconductor Physics	3	1	0	4	Major Course
35		25PHBS803	Statistical mechanics II	3	1	0	4	Major Course

List of Interdisciplinary Courses (IDC) / Minor Stream Courses (MSC) offered to Four Year B.Sc. Physics programme in the Department of Physics w.e.f. Academic Year 2025-26

S. No	Cat.	Course code	Course title	Department	L	T	P	C
1	IDC	24MABS001	Introduction to Algebra	Mathematics	3	1	0	4
2		24MABS002	Differential calculus	Mathematics	3	1	0	4
3		24MABS003	Differential Equations	Mathematics	3	1	0	4
4		24MABS004	Statistical Methods and Probability	Mathematics	3	1	0	4
5		24CYBS001	Physical Chemistry I	Chemistry	3	1	0	4
6		24CYBS002	Inorganic Chemistry	Chemistry	3	1	0	4
7		24CYBS003	Physical Chemistry II	Chemistry	3	1	0	4
8		24CYBS004	Analytical Chemistry	Chemistry	3	1	0	4
9	MSC	25PHBS001	Waves and Oscillations	Physics	2	0	0	2
10		25PHBS051	Waves and Oscillations Lab	Physics	0	0	4	2
11		25PHBS002	Biophysics	Physics	3	1	0	4
12		25PHBS003	Solid State Devices	Physics	3	0	0	3
13		25PHBS053	Solid State Devices Lab	Physics	0	0	2	1
14		25PHBS004	Radiation Physics	Physics	3	1	0	4
15		25PHBS005	Numerical Analysis	Physics	3	0	0	3
16		25PHBS055	Numerical Analysis Lab	Physics	0	0	2	1
17		25PHBS006	Statistical Analysis in Physics	Physics	2	0	0	2
18		25PHBS056	Statistical Analysis in Physics Lab	Physics	0	0	4	2
19		25PHBS007	Advanced Mathematical Physics I	Physics	3	0	0	3
20		25PHBS057	Computational Physics lab III	Physics	0	0	2	1
21		25PHBS008	Astronomy & Astrophysics	Physics	3	1	0	4
22		25PHBS009	Atmospheric Physics	Physics	3	1	0	4
23		25PHBS010	Advanced Mathematical Physics II	Physics	3	1	0	4
24		25PHBS011	Renewable Energy Physics	Physics	3	1	0	4
25		25PHBS012	Nanomaterials	Physics	3	1	0	4
26		25PHBS013	Novel & Smart Materials	Physics	3	1	0	4
27		25PHBS014	Soft Matter Physics	Physics	3	1	0	4
28		25PHBS015	Nanomagnetism and Spintronics	Physics	3	1	0	4
29		25PHBS016	Optoelectronics	Physics	3	1	0	4
30		25PHBS017	Nanophotonics	Physics	3	1	0	4
31		25PHBS018	Non-linear spectroscopy	Physics	3	1	0	4
32		25PHBS019	Fiber Optics	Physics	3	1	0	4

33	25PHBS020	Advanced Electronics	Physics	3	1	0	4
34	25PHBS021	Advanced Solid State Physics	Physics	3	1	0	4
35	25PHBS022	Advanced Solid State Physics Lab	Physics	0	0	4	2
36	25PHBS023	Classical Field Theory	Physics	3	1	0	4
37	25PHBS024	Quantum Field Theory	Physics	3	1	0	4
38	25PHBS025	MATLAB	Physics	2	0	4	4
39	25PHBS026	Plasma Physics	Physics	3	1	0	4
40	25PHBS027	Advanced Nuclear Physics	Physics	3	1	0	4
41	25PHBS028	Medical Physics	Physics	3	1	0	4
42	24RMBS710	Research Methodology	Physics	2	0	0	2
43	25PHBS029	Fundamentals of quantum computing	Physics	3	0	0	3
44	25PHBS030	Fundamentals of quantum computing	Physics	0	0	2	1
45	25PHBS031	Quantum algorithms and error correction	Physics	3	0	0	3
46	25PHBS032	Quantum algorithms and error correction lab	Physics	0	0	2	1
47	25PHBS033	Classical and quantum information processing	Physics	3	0	0	3
48	25PHBS034	Classical and quantum information processing lab	Physics	0	0	2	1
49	25PHBS035	Quantum Machine learning	Physics	3	0	0	3
50	25PHBS036	Quantum Machine learning lab	Physics	0	0	2	1
51	25PHBS037	Machine Learning for Physics	Physics	3	1	0	4
52	25PHBS038	Electric Vehicle	Physics	3	1	0	4

List of Multidisciplinary Courses (MDC) offered to

Four Year B.Sc. Physics programme in the Department of Physics

w.e.f. Academic Year 2025-26

Cat.	Code	Course Name	L	T	P	Credits
MDC I		Renewable Energy Sources	3	0	0	3
		Hybrid Electric Vehicle	3	0	0	3
		IPR in Business	3	0	0	3
		Library Information Sciences & Media Literacy	3	0	0	3
		Management Process & Organizational Behaviour	3	0	0	3
MDC II		Introduction to Bio-engineering	3	0	0	3
		Introduction to Robotics	3	0	0	3
		Psychology and Emotional Intelligence	3	0	0	3
		Indian Economy	3	0	0	3
		Creating an Entrepreneurial Mind	3	0	0	3
MDC III		Arduino based programming	3	0	0	3
		Electoral Literacy in India	3	0	0	3
		Personal Financial Planning	3	0	0	3
		Interior Design	3	0	0	3

List of Ability Enhancement Courses (AEC) offered to
Four Year B.Sc. Physics programme in the Department of Physics
w.e.f. Academic Year 2025-26

S. No.	Code	Course Name	L	T	P	Credits
1		Functional English I	2	0	0	2
2		Functional English II	2	0	0	2
3		Hindi / German / French	2	0	0	2
4		Hindi / German / French	2	0	0	2

List of Value Added Courses (VAC) offered to

Four Year B.Sc. Physics programme in the Department of Physics

w.e.f. Academic Year 2025-26

S. No.	Code	Course Name	L	T	P	Credits
1		Indian Constitution & Polity	2	0	0	2
2		Environment Protection & Sustainable Development	2	0	0	2
3		Sports, Yoga & Fitness	0	0	4	2

List of Skill Enhancement Courses (SEC) offered to Four Year B.Sc. Physics programme in the Department of Physics w.e.f. Academic Year 2025-26

Courses on Soft Skills

S. No.	Code	Course Name	L	T	P	Credits
1		Effective Communication Skills	0	0	2	1
2		Teamwork & Interpersonal Skills	0	0	2	1
3		Presentation Skills	0	0	2	1
4		Professional Skills	0	0	2	1
5		Aptitude & Reasoning	0	0	2	1

Courses on Technical Skills

S. No.	Code	Course Name	L	T	P	Credits
1		Digital Literacy & IT Skills	0	0	2	1
2		Advanced Excel Skills	0	0	2	1
3		Statistical Analysis with SPSS	0	0	2	1
4		R language programming	0	0	2	1
5		Programming with MATLAB	0	0	2	1

List of Major Courses offered to
Four Year B.Sc. Physics programme in the Department of Physics
w.e.f. Academic Year 2025-26

S No	Semester	Course Code	Course Title	L	T	P	Credits	Course Category
1	I	25PHBS101	Mathematical Physics I	3	0	0	3	Major Course
2		25PHBS151	Computational Physics lab I	0	0	2	1	Major Course Lab
3		25PHBS102	Mechanics	3	0	0	3	Major Course
4		25PHBS152	General Properties Of Matter Lab	0	0	2	1	Major Course Lab
5	II	25PHBS201	Mathematical Physics II	3	0	0	3	Major Course
6		25PHBS251	Computational Physics lab II	0	0	2	1	Major Course Lab
7		25PHBS202	Optics	3	0	0	3	Major Course
8		25PHBS252	Optics Lab	0	0	2	1	Major Course Lab
9	III	25PHBS301	Mathematical Physics III	3	1	0	4	Major Course
10		25PHBS302	Electricity & Magnetism	3	0	0	3	Major Course
11		25PHBS352	Electricity & Magnetism lab	0	0	2	1	Major Course Lab
12		25PHBS303	Thermal Physics	3	0	0	3	Major Course
13		25PHBS353	Thermal Physics lab	0	0	2	1	Major Course Lab
14	IV	25PHBS401	Analog Electronics	3	0	0	3	Major Course
15		25PHBS451	Analog Electronics Lab	0	0	2	1	Major Course Lab
16		25PHBS402	Modern Physics	3	0	0	3	Major Course
17		25PHBS452	Modern Physics Lab	0	0	2	1	Major Course Lab
18		25PHBS403	Classical Mechanics	3	1	0	4	Major Course
19	V	25PHBS501	Digital Electronics	3	0	0	3	Major Course
20		25PHBS551	Digital Electronics lab	0	0	2	1	Major Course Lab
21		25PHBS502	E. M. Theory	3	0	0	3	Major Course
22		25PHBS552	E. M. Theory Lab	0	0	2	1	Major Course
23		25PHBS503	Quantum Mechanics I	3	1	0	4	Major Course
24		25PHBS504	Condensed Matter Physics I	3	0	0	3	Major Course
25		25PHBS554	Condensed Matter Physics I Lab	0	0	2	1	Major Course Lab
26	VI	24PHBH601	Condensed Matter Physics II	3	1	0	4	Major Course
27		25PHBS602	Electrodynamics	3	1	0	4	Major Course
28		25PHBS603	Quantum Mechanics II	3	1	0	4	Major Course
29		25PHBS604	Laser and Non linear Optics	3	1	0	4	Major Course
30	VII	25PHBS701	Atomic and Molecular Physics - I	3	1	0	4	Major Course
31		25PHBS702	Nuclear and Particle Physics	3	1	0	4	Major Course
32		25PHBS703	Statistical Mechanics I	3	1	0	4	Major Course
33	VIII	25PHBS801	Atomic and Molecular Physics - II	3	1	0	4	Major Course
34		25PHBS802	Semiconductor Physics	3	1	0	4	Major Course
35		25PHBS803	Statistical mechanics II	3	1	0	4	Major Course

MATHEMATICAL PHYSICS I	
Course Code: 25PHBS101	Continuous Evaluation: ….. Marks
Credits: 3	End Semester Examination: ……Marks
L T P : 3 0 0	**Course Type: MAJOR COURSE THEORY**
Prerequisite:	

Course Objectives (CO):

1. Explain vector algebra concepts to analyse properties of vectors under various operations and transformations.
2. Apply vector differentiation and integration techniques.
3. Analyse vector calculus operators in different coordinate systems.
4. Develop basic concepts of probability and random variables.
5. Comprehend of solving differential equations and their applications in physics.

Course Learning Outcome (CLO):
The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of the course, students would:

1. Familiarity with the behaviour of vectors under rotations and scalar products.
2. Demonstrate Gauss' divergence theorem, Green's theorem, and Stokes' theorem to solve practical problems.
3. Apply coordinate transformations to vector calculus operations.
4. Analyze the basic concepts of probability and its applications in physics.
5. Able to solve differential equations and apply it in physics.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit-I: VECTOR ALGEBRA

Idea of linear independence, completeness, basis and representation of vectors. Properties of vectors under rotations. Scalar product and its invariance under coordinate rotations. Scalar product and vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields.

Unit-II: VECTOR CALCULUS

Vector Differentiation: Directional derivatives and normal derivatives. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field and their interpretation. Laplacian operators. Vector identities.
Vector Integration: Ordinary Integrals of Vectors. Multiple integrals. Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proof).

Unit-III: ORTHOGONAL CURVILINEAR COORDINATES

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

Unit-IV: PROBABILITY

Independent random variables: Sample space and Probability distribution functions; binomial, Gaussian, and Poisson, with examples. Mean and variance. Dependent events: Conditional Probability. Bayes' Theorem and the idea of hypothesis testing.

Unit-V: DIFFERENTIAL EQUATIONS

Introduction- order and degree, Variable separation, linear differential equations, reducible to linear, homogeneous, reducible to homogeneous, exact method. Applications in Physical Problems (Kirchoff's law for current in RL and RC circuits, Radioactive nuclei decay, motion of a body falling in a resisting medium).
Second order differential equations: Homogeneous equation with constant coefficients. Wronskian and general solutions. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral with operator method, method of undetermined coefficients and variation method of parameters.

TEXT BOOKS

1. George. B. Arfken, Hans J. Weber, & Frank E. Harris, Mathematical Methods for Physicists, Elsevier, 2012.
2. Murray R. Spiegel, Vector Analysis, McGraw Hill Education India, 1959.
3. P. K. Chattopadhyay, Mathematical Physics, New Age International Private Limited, 2022.
4. Mary L. Boas, Mathematical Methods in Physical Sciences, Wiley, 2006.

REFERENCE BOOKS

1. Applied Mathematics For Engineers And Physicists, Lauis A. Pipes and Lawrence R. Harvill, Dover Publications Inc. 3rd edition, 2014.

2. Mathematical Methods for Physics, J. Mathews and R. L. Walker, Pearson Addison-Wesley, 2nd edition, 1971.
3. Mathematical Physics, H. K. Dass, S Chand Publishing, 2018.
4. E.A. Coddington, An introduction to ordinary differential equations, PHI learning, 1989.
5. George F. Simmons, Differential Equations, McGraw Hill, 2007.
6. Donald. A. McQuarrie, Mathematical Methods for Scientists and Engineers, University
7. Science Books, US. 2003.

COMPUTATIONAL PHYSICS LAB- I	
Course Code: 25PHBS151	Continuous Evaluation: ….. Marks
Credits: 1	End Semester Examination: …. Marks
L T P : 0 0 2	**Course Type: MAJOR COURSE LAB**
Prerequisite: NIL	

Course Objectives (CO):

1. Recall the basic element of Python or C++.
2. Explain the concepts of control structures and functions in Python or C++ and their respective applications.
3. Apply the knowledge of data types, arrays, and loops to solve programming challenges.
4. Analyze and evaluate the various techniques utilized in 2D plotting with Gnuplot or Matplotlib.
5. Reproduce new programs with new methods using python or C++.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of the course, students would be

1. Identify and explain the fundamental components of Python and C++.
2. Describe the functionality and use of control structures and functions in Python or C++.
3. Utilize various data types, arrays, and looping constructs to implement solutions to programming problems.
4. Critically analyze and assess different 2D plotting techniques using Gnuplot or Matplotlib.
5. Design and implement new software programs by integrating advanced methods and features in Python or C++.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs’)	Course Learning Outcomes (CLOs’)				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS
Unit I
Section A:
Basic Elements of Python: The Python interpreter, the print statement, comments, Python as simple calculator, objects and expressions, variables (numeric, character and sequence types) and assignments, mathematical operators. Strings, Lists, Tuples and Dictionaries, type conversions, input statement, list methods. List mutability, Formatting in the print statement.

Control Structures: Conditional operations, if, if-else, if-elif-else, while and for loops, indentation, break and continue, List comprehension. Simple programs for practice like solving quadratic equations, temperature conversion etc.

Functions: Inbuilt functions, user-defined functions, local and global variables, passing functions, modules, importing modules, math module, making new modules. Writing functions to perform simple operations like finding largest of three numbers, listing prime numbers, etc., Generating pseudo random numbers.

OR
Section B:
Introduction to C++: Basic idea of Compilers. Structured programming. Idea of Headers, Data Types, Enumerated Data, Conversion and casting, constants and variables, Mathematical, Relational, Logical and Bitwise Operators. Precedence of Operators, Expressions and Statements, Scope and Visibility of Data, block, Local and Global variables, Auto, static and External variables. Input and output statements. I/O manipulations, iostream and cmath header files, using namespace.

Control Statements: The if-statement, if-else statement, Nested if Structure, If - Else if – else block, Ternary operator, Goto statement, switch statement, Unconditional and Conditional looping, While loop, Do-while loop, For loop, nested loops, break and continue statements. Simple programs for practice like solving quadratic equations, temperature conversion etc.

Functions: Inbuilt functions. User-defined functions, function declaration, function definition, function prototype, void functions and function arguments, return statement. Local and global variables. The main function. Passing parameter by value and by reference. Inline functions. Function overloading. Writing functions to perform simple operations like finding largest of three numbers, listing prime numbers etc., Generating pseudo random numbers.

Recommended List of Programs:

(a) Make a function that takes a number N as input and returns the value of factorial of N. Use this function to print the number of ways a set of m red and n blue balls can be arranged.
(b) Generate random numbers (integers and floats) in a given range and calculate area and volume of regular shapes with random dimensions.
(c) Generate data for coordinates of a projectile and plot the trajectory. Determine the range, maximum height and time of flight for a projectile motion.

Unit II

Section A:

NumPy Fundamentals: Importing Numpy, Difference between List and NumPy array, Adding, removing and sorting elements, creating arrays using ones(), zeros(), random(), arange(), linspace(). Basic array operations (sum, max, min, mean, variance), 2-d arrays, matrix operations, reshaping and transposing arrays, savetxt() and loadtxt().

Plotting with Matplotlib: matplotlib.pyplot functions, Plotting of functions given in closed form as well as in the form of discrete data and making histograms.

OR

Section B:

Arrays: Array definition, passing arrays to functions, Finding sum, maximum, minimum, mean and variance of given array. 2-d arrays, matrix operations (sum, product, transpose etc). Saving data generated by a C++ program in a file.

Gnuplot: Introduction to Gnuplot. Visualization of discrete data and plotting functions given in closed form and data for graphical visualization. Plotting data from the output file created by a C++ program, making histogram.

Recommended List of Programs

(a) To plot the displacement-time and velocity-time graph for the un-damped, under-damped critically damped and over-damped oscillator using matplotlib (or Gnuplot) using given formulae.

(b) To compute the left, right and central approximations for derivative of a function given in closed form. Plot both the function and derivative on the same graph. Plot (using matplotlib/Gnuplot) the error as a function of step size on a log-log graph, study the behaviour of the plot as step size decreases and hence discuss the effect of round off error.

(c) To generate array of N random numbers drawn from a given distribution (uniform, binomial, poisson and gaussian) and plot them using matplotlib/Gnuplot for increasing N to verify the distribution. Verify the central limit theorem.

(d) To implement the transformation of physical observables under Galilean, Lorentz and Rotation transformation

Unit III

Recommended List of Programs

(a) To find the value of π and to integrate a given function using acceptance-rejection method.

(b) To perform linear fitting of data using the inbuilt function scipy.stats.linregress in Python or using Gnuplot. Plot the data points and the fitted line on the same graph.

(c) To check if a number is i) prime number, ii) odd number, iii) even number.

(d) Sum and average of a list of numbers, largest of a given list of numbers and its location in the list,

(e) sorting of numbers in ascending descending order using Bubble sort and Sequential sort, Binary search

(f) Finding the values of trigonometric functions.

TEXT BOOK

1. John Hubbard, Schaum's Outline of Programming with C++, McGraw-Hill Education, 2000.
2. Paul J. Deitel and Harvey Deitel, C++ How to Program, Pearson, 2016.
3. Darren Walker, Computational Physics, Medtec, 2015.
4. Kendall. E. Atkinson, Elementary Numerical Analysis, John Wiley & Sons Inc, 2007.
5. Tao Pang, An Introduction to Computational Physics, Cambridge University Press, 2006.

REFERENCES

1. Documentation at the Python home page (https://docs.python.org/3/) and the tutorials there (https://docs.python.org/3/tutorial/).
2. Documentation of NumPy and Matplotlib : https://numpy.org/doc/stable/user/ and https://matplotlib.org/stable/tutorials/
3. S. S. Sastry, Introductory methods of numerical analysis, PHI Learning Pvt. Ltd, 2012.
4. Cutis F. Gerald, Applied numerical analysis, Pearson Education India, 2007.

MECHANICS

MECHANICS	
Course Code: 25PHBS102	Continuous Evaluation: …. Marks
Credits: 3	End Semester Examination: ….Marks
L T P : 3 0 0	**Course Type: MAJOR COURSE THEORY**
Prerequisite: NIL	

Course Objectives (CO):

1. Describe and explain Newton's laws of motion and their implications for inertial frames, force, and mass.
2. Analyze the dynamics of a system of particles and apply them to various scenarios.
3. Explore the concepts of central force field and gravitation.
4. Introduce the rotational dynamics of a system of particles and non-inertial system.
5. To estimate the understanding of the special theory of relativity.

Course Learning Outcome (CLO):
The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Articulate Newton's laws of motion and discuss their significance for understanding inertial frames, force, and mass.
2. Analyze and solve problems involving the dynamics of particle systems in diverse scenarios.
3. Explain and apply the principles of central force fields and gravitational interactions.
4. Apply methods to analyze the rotational dynamics of particle systems and the behavior of non-inertial reference frames.
5. Well Versed with the concepts of the special theory of relativity and apply them to relevant physical phenomena.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit-I: FUNDAMENTALS OF DYNAMICS I

Review of Newton's law of motion: concept of Inertial frame, Force & mass. Galilean transformations; Galilean invariance. Work & Kinetic energy theorem. Conservative and non-conservative forces. Stable, unstable and neutral equilibrium. Work done by non-conservative forces. Potential Energy. Energy diagram. Stable, unstable and neutral equilibrium. Force as gradient of the potential energy. Principle of conservation of Energy and momentum, Impulse. Rocket motion.

Unit-I: FUNDAMENTALS OF DYNAMICS II

Dynamics of a system of particles, Non-inertial frame and fictitious forces. Uniformly rotating frame. Centrifugal force & Coriolis force. Laws of Physics in a laboratory on the surface of the earth. Determination of Centre of Mass of discrete and continuous objects having cylindrical and spherical symmetry. Differential analysis of a static vertically hanging massive rope, Collisions: Elastic and inelastic collisions between two spherical bodies. Kinematics of $2 \rightarrow 2$ scattering in centre of mass and laboratory frames.

Unit-III: CENTRAL FORCE FIELD AND GRAVITATION

Central Force Motion: Central forces, Law of conservation of angular momentum for central forces, Two-body problem and its reduction to equivalent one-body problem and its solution. Concept of effective potential energy and stability of orbits for central potentials of the form kr^n for $n = 2$ and -1 using energy diagram, discussion on trajectories for $n=-2$. Solution of the Kepler Problem, Kepler's Laws for planetary motion, orbit for artificial satellites, Newton's law of gravitation, motion of a projectile in gravitational field, Motion in an inverse square field.

Unit-IV: ROTATIONAL DYNAMICS AND NON-INERTIAL SYSTEM

Rotational Dynamics: Angular momentum of a particle and system of particles. Torque.
Principle of conservation of angular momentum. Rotation about a fixed axis. Determination of moment of inertia of symmetric rigid bodies (rectangular, cylindrical and spherical) using parallel and perpendicular axes theorems. Kinetic energy of rotation. Motion involving both translation and rotation.
Non-Inertial Systems: Non-inertial frames and fictitious forces. Uniformly rotating frame. Centrifugal force. Coriolis force and its applications.

Unit-V: SPECIAL THEORY OF RELATIVITY

Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space, The invariant interval, light cone and world lines. Space-time diagrams. Simultaneity and order of events. Lorentz contraction. Time dilation. Length contraction, simultaneity Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Doppler effect.

TEXT BOOKS

1. R. G. Takawale, P. S. Puranik, Introduction to Classical Mechanics, Tata McGraw Hill, 2017.
2. Herbert Goldstein, Classical Mechanics, Pearson Education, 2011.

REFERENCE BOOKS

1. D. Kleppner and R. J. Kolenkow, An Introduction to Mechanics, Tata McGraw Hill, 1973.
1. D. S Mathur, Mechanics, S. Chand, 2000.

GENERAL PROPERTIES OF MATTER LAB	
Course Code: 25PHBS152	Continuous Evaluation: …. Marks
Credits: 1	End Semester Practical Examination: …. Marks
L T P : 0 0 2	**Course Type: MAJOR COURSE LAB**
Prerequisite: NIL	

COURSE OBJECTIVES (CO):

1. Explain the measurement of rigidity modulus and moment of inertia.
2. Interpret how to measure various physical parameters including coefficient of viscosity, Young's modulus, elastic constants, etc.
3. Apply and appreciate the principles involved in measuring the above-mentioned physical parameters.
4. Evaluate the estimation of errors while measuring the physical parameters.
5. Develop a setup for various properties of liquid.

Course Learning Outcome (CLO):
The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Familiarity with measurement of rigidity modulus and moment of inertia.
2. Get an insight into the principle involved in measuring the various physical parameters.
3. Understand how to measure various physical parameters including rigidity modulus, moment of inertia, coefficient of viscosity, Young's modulus, elastic constants etc.
4. Understand the error estimation.
5. Perform the experiment for various properties of the liquid.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum------of experiments)

1. To determine the modulus of rigidity of a wire by Torsional Pendulum
2. To determine the Moment of Inertia of a Flywheel.
3. To determine g and velocity for a freely falling body using Digital Timing Technique.
4. To determine Coefficient of Viscosity of water by Capillary Flow method (Poiseuille's method).
5. To determine the Young's Modulus of the material of a beam by the method of uniform bending.
6. To determine the Young's Modulus of the material of a beam by the method of Non-uniform bending.
7. To determine the elastic Constants of a wire by Searle's method.
8. To determine the value of g using Bar Pendulum.
9. Kater's pendulum: Study of a simple harmonic motion
10. Sextant: The angle of a celestial body above the horizontal line
11. Ultrasonic interferometer for liquid

TEXT BOOKS

1. Hannah Sathyaseelan, LABORATORY MANUAL IN APPLIED PHYSICS, New age International (P) Ltd., 2007.
2. Cicero H. Bernard and Chirold D. Epp., LABORATORY EXPERIMENTS IN COLLEGE PHYSICS", John Wiley and Sons Inc., 1994.

REFERENCE BOOKS

1. A.C. Melissinos, and Jim Napolitano, EXPERIMENTS IN MODERN PHYSICS, Academic Press, 1966.
2. G.L. Squires, PRACTICAL PHYSICS, Cambridge University Press, 1985.

MATHEMATICAL PHYSICS - II	
Course Code: 25PHBS201	Continuous Evaluation: …. Marks
Credits: 3	End Semester Examination: ….. Marks
L T P : 3 0 0	**Course Type: MAJOR COURSE THEORY**
Prerequisite:	

Course Objectives (CO):

1. Communicate knowledge in single variable calculus and its application in Physics.
2. Apply multi-variable calculus and its application in Physics.
3. Develop the concept of Fourier series expansion of various functions.
4. Support for solving the important second-order differential equations such as Legendre, Bessel, Hermite and Laguerre equations and their importance in physics.
5. Evaluate proficiency in evaluating special integrals using gamma and beta functions.

Course Learning Outcome (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of the course, students would be:

1. Equipped with good knowledge of basic methods of single variable calculus and the ability to apply the same in physics.
2. Well-versed with the techniques of multi-variable calculus and the ability to apply the same in physics.
3. Demonstrate the expansion of various functions according to the Fourier series.
4. Familiar with special functions such as Legendre, Bessel, Hermite and Laguerre functions and the capability to use them in physics.
5. Evaluate various forms of special integrals using gamma and beta functions.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit-I: SEQUENCES AND SERIES

Introduction-Infinite sequences and series, Convergence of power series, interval of convergence, Convergence tests of power series: D'alembert's ratio test, Cauchy's root test, Integral test, Alternating series test. Absolute and conditional convergence, Taylor series of one variable, Maclaurin series. Binomial series. Approximation errors.

Unit-II: CALCULUS OF FUNCTIONS OF SEVERAL VARIABLE

Introduction, Partial derivatives, Chain rule, homogeneous functions, Euler theorem, total derivative. Taylor's & Mauclarin's series, Maxima, minima, saddle point evaluation of two variable functions using Taylor series. Legrangeous's method for Multipliers.

Unit-III: FOURIER SERIES

Introduction, Periodic functions, Orthogonality of sine and cosine functions, Dirichlet Conditions, Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Fourier Integral theorem. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Applications of Fourier series analysis: square waves, Half wave and full wave rectifier. Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval's Identity.

Unit-IV: SPECIAL FUNCTIONS

Introduction, singular points, Validity of series solution, Frobenius method. Legendre's differential equation, Properties of Legendre Polynomials, Generating Function, Rodrigues Formula, Orthogonality, Recurrence relations. Bessel differential equations and solutions, Generating Function, recurrence relations. Orthogonality.

Hermite and Laguerre Differential Equations.

Unit-V: SPECIAL INTEGRALS

Beta and Gamma Functions. Properties of Beta and Gamma functions. Dirac delta function and properties. Error function.

TEXT BOOKS

1. George. B. Arfken, Hans J. Weber, & Frank E. Harris, Mathematical Methods for Physicists, Elsevier, 2012.
2. Murray R. Spiegel, Vector Analysis, McGraw Hill Education India, 1959.
3. P. K. Chattopadhyay, Mathematical Physics, New Age International Private Limited, 2022.
4. Mary L. Boas, Mathematical Methods in Physical Sciences, Wiley, 2006.

REFERENCE BOOKS

1. Louis Pipes, Mathematics for Physicists and Engineers, Dover Publications Inc. 2014.
2. Jon Mathews and R. L. Walker, Mathematical Methods for Physics, Addison-Wesley, 1971.
3. H. K. Dass and R. Verma, Mathematical Physics, S. Chand, 2019.
4. E.A. Coddington, An introduction to ordinary differential equations, PHI learning, 1989.
5. George F. Simmons, Differential Equations, McGraw Hill, 2007.
6. Donald. A. McQuarrie, Mathematical Methods for Scientists and Engineers, University Science Books, US. 2003.

COMPUTATIONAL PHYSICS LAB-II	
Course Code: 25PHBS251	Continuous Evaluation: …. Marks
Credits: 1	End Semester Examination: …. Marks
L T P : 0 0 2	**Course Type: MAJOR COURSE LAB**
Prerequisite:	

Course Objectives (CO):

1. Develop proficiency in programming to find the roots of mathematical equations.
2. Understand and implement fundamental numerical techniques such as root finding, interpolation, and integration.
3. Study different methods of fitting and their numerical solutions.
4. Analyze and visualize of generating and plotting of a function using series representation:.
5. Reproduce new methods to generating and plotting using series expension.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would:

1. Learn how to write code to find the roots of mathematical equations.
2. Apply numerical methods to solve physics problems that are challenging or impossible to solve analytically.
3. Implement and analyze various methods for the least square fitting.
4. Interpret and communicate findings through graphs and plots using series representation.
5. Design new methods for generating and plotting polynomials using series expansion.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit I:

Root Finding: Bisection, Newton Raphson and secant methods for solving roots of equations, Convergence analysis.

Recommended List of Programs:

(a) Determine the depth up to which a spherical homogeneous object of given radius and density will sink into a fluid of a given density.
(b) Solve transcendental equations like $\alpha = \tan(\alpha)$.
(c) To approximate n^{th} root of a number up to a given number of significant digits.

Unit II: Least Square fitting:

Algorithm for least square fitting and its relation to maximum likelihood for normally distributed data.

a) Make a function for least square fitting, use it for fitting given data (x, y) and estimate the parameters a, b as well as uncertainties in the parameters for the following cases.
    i. Linear ($y = ax + b$)
    ii. Power law ($y = ax^b$)
    iii. Exponential ($y = ae^{bx}$)
b) Weighted least square fitting of given data (x, y) with known error/uncertainty values using user-defined function.

Unit III:

Generating and plotting of a function using series representation:

a) To approximate the elementary functions (e.g. exp(x), sin(x), cos(x), ln(1+x), etc.) by a finite number of terms of Taylor's series and discuss the truncation error. To plot the function as well the n^{th} partial sum of its series for various values of n on the same graph and visualise the convergence of series.
b) Generating and plotting Legendre Polynomials using series expansion and verifying recurrence relation

TEXT BOOK

1. John Hubbard, Schaum's Outline of Programming with C++, McGraw-Hill Education, 2000.
2. Paul J. Deitel and Harvey Deitel, C++ How to Program, Pearson, 2016.
3. Darren Walker, Computational Physics, Medtec, 2015.
4. Kendall. E. Atkinson, Elementary Numerical Analysis, John Wiley & Sons Inc, 2007.
5. Tao Pang, An Introduction to Computational Physics, Cambridge University Press, 2006.

REFERENCES

1. Documentation at the Python home page (https://docs.python.org/3/) and the tutorials there (https://docs.python.org/3/tutorial/).
2. Documentation of NumPy and Matplotlib : https://numpy.org/doc/stable/user/ and https://matplotlib.org/stable/tutorials/
3. S. S. Sastry, Introductory methods of numerical analysis, PHI Learning Pvt. Ltd, 2012.
4. Cutis F. Gerald, Applied numerical analysis, Pearson Education India, 2007.

OPTICS	
Course Code: 25PHBS202	Continuous Evaluation: ….. Marks
Credits: 3	End Semester Examination: ….. Marks
L T P : 3 0 0	**Course Type: MAJOR COURSE THEORY**
Prerequisite: Knowledge on Wave & Oscillations	

Course Objectives (CO):

1. Explain the fundamental concepts of wave properties.
2. Illustrate the basics of the phenomena of interference of light.
3. Connect with the Fraunhofer diffraction phenomena.
4. Estimate the concept of Fresnel diffraction.
5. Evaluate the techniques of producing polarized light and its applications.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Get a basic understanding of the wave properties.
2. Well-versed with the interference phenomena.
3. Understanding of Fraunhofer diffraction.
4. Knowledge of Fresnel diffraction.
5. Familiarity with the concepts of polarization and its applications.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURE CONTENTS

Unit-I: FUNDAMENTAL OF OPTICAL WAVES

Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Properties of optical waves, Huygen's wave theory of wave propagation, Phase and Phase difference, Path difference, Relationship between path and phase difference. Spatial and temporal coherence, coherence sources.

Unit-II: INTERFERENCE

Interference, Superposition principle, Conditions for sustained interference, Interference by division of Wavefront - Young's double slit experiment, Fresnel's Biprism, Lloyd's mirror, Interference by division of amplitude - Interference in thin parallel and wedge-shaped films. Cosine law, reflecting and non-reflecting applications of thin film, Newton's ring. Interference by multiple reflections in plane parallel films, Interferometer - Mach-Zender, Michelson and Fabry Perot interferometer, Double interferometer.

Unit-III: FRAUNHOFER DIFFRACTION

Fraunhofer diffraction- Single slit; Double Slit. Multiple slits and Diffraction grating and its resolving power, Diffraction at Circular aperture, Rayleigh Criterion, Resolving power of microscope.

Unit-IV: FRESNEL DIFFRACTION

Fresnel Diffraction: Half-period zones. Radii and areas of half-period zones, Resultant amplitude due to whole wavefront, Zone plate: construction and theory. Fresnel Diffraction pattern by a circular aperture, straight edge, a slit and a wire using half-period zone analysis.

Unit-V: POLARIZATION

Unpolarized and polarized light, theory of plane, circularly and elliptically polarized light and its mathematical representation, difference between unpolarized and polarized light, Production of polarized light by reflection, Brewster's law, Production of polarized light by refraction, Production of polarized light by transmission, Malus Law, Polarization by double refraction and Huygen's theory, Nicol prism, wave plates (Quarter, Half & Full), Production and analysis of circularly and elliptically polarized light. Optical activity, Fresnel's theory of optical activity, Laurent's Half shade Polarimeter, Photoelasticity and Polariscope.

TEXT BOOKS

1. Ajoy Ghatak, Optics, McGraw Hill, 2020.
2. R.S. Longhurst, Geometrical and Physical Optics, Prentice Hall Press, 1967.
3. Grant R. Fowles, Introduction to Modern Optics, Dover Publications Inc., 1990.
4. N. Subrahmanyam, Brijlal and M. N. Avadhanulu, A textbook of Optics, S. Chand, 2006.

REFERENCE BOOKS

1. A. Ghatak, and K. Thyagarajan, Introduction to Fiber Optics, Cambridge University Press, 2017.
2. L.S. Grattan & B. T. Meggitt, Optical Fiber Sensor Technology: Chemical and Environmental Sensing, Chapman and Hall, 1999.
3. Bahaa E. A. Saleh and Malvin Carl Teich, Fundamentals of Photonics, Wiley-Blackwell 2007.

OPTICS LAB	
Course Code: 25PHBS252	Continuous Evaluation: ….. Marks
Credits: 1	End Semester Practical Examination: …. Marks
L T P : 0 0 2	**Course Type: MAJOR COURSE LAB**
Prerequisite: NIL	

COURSE OBJECTIVES (CO):

1. Recall and remembering the experiments and methods.
2. Extend the principles underlying optical experiments.
3. Demonstrate proficiency in setting up and using experimental apparatus for wave and optics experiments.
4. Analyze experimental results to determine relationships between variables in wave and optics experiments.
5. Reproduce new experiments with new methods.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Interpret the various methods to perform waves and optics experiments.
2. Describe a comprehensive understanding of the Physics underpinning optical experiments.
3. Illustrate the practical understanding of diverse optical principles through hands-on experimentation
4. Explain with the analysis of results of optical experiments.
5. Design new experiments or variations of existing methods.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs’)	Course Learning Outcomes (CLOs’)				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum ------of experiments)

1. Determination of angle of a prism
2. Determination of dispersive power of material of a prism.
3. Determination of refractive index of given liquid using hollow prism.
4. Determination of specific rotation of sucrose by polarimeter.
5. Determination of wavelength of light from mercury source by diffraction grating.
6. Determination of wavelength of sodium yellow line by Newton's rings with air film.
7. Determination of wavelength of sodium yellow line by Newton's rings with water film.
8. To determine diameter/thickness of a thin wire by diffraction method.
9. Determination of Resolving Power of grating.
10. Determination of wavelength by Constant deviation spectrometer.
11. Determination of refractive index of liquid using hollow prism.
12. Study of the characteristics of a laser beam.
13. Diffraction at single slit: width of the slit
14. Diffraction at double Slit: diffraction pattern.
15. Diffraction grating: wavelength of a laser.
16. Fiber optics: Numerical aperture & bending losses.
17. Cauchy's constant.
18. Michelson interferometer.
19. Fresnel's biprism.

TEXT BOOKS

1. "LABORATORY MANUAL IN APPLIED PHYSICS"-Second edition H. Sathyaseelam-New age International
2. LABORATORY EXPERIMENTS IN COLLEGE PHYSICS",C.H.Bernard and C.D.Epp.John Wiley and Sons Inc.,New York 1995

REFERENCE BOOKS

1. "EXPERIMENTS IN MODERN PHYSICS",A.C.Melisson, AcademicPress,N.Y. 1966.
2. PRACTICAL PHYSICS",G.L.Squires, Cambridge University Press,1985

MATHEMATICAL PHYSICS - III	
Course Code: 25PHBS301	Continuous Evaluation: ….. Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	**Course Type: MAJOR COURSE THEORY**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. Test the mathematical techniques of complex variables and their importance in physics problem-solving.
2. Analyze second-order differential equations using appropriate techniques and demonstrate their application in physics.
3. Demonstrate the second-order partial differential equations application in physics.
4. Evaluate the significance of the Fourier transform and Laplace transform in physics, comparing their advantages and limitations for specific applications.
5. Comprehend the significance of the Laplace transform and Laplace transform in physics, comparing their advantages and limitations for specific applications.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of the course, students would be:

1. Examine mathematical techniques involving complex variables and their importance in tackling physics problem-solving tasks.
2. Explain the methods of solving second-order differential equations using various techniques and illustrate their practical application in physics scenarios.
3. Analyse the methods of solving second-order partial differential equations for practical application in physics scenarios.
4. Interpret the significance of the Fourier transform transform in physics, and they will be able to compare their advantages and limitations for specific applications.
5. Demonstrate the significance of the Laplace transform in physics, and they will be able to compare their advantages and limitations for specific applications.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit-I: COMPLEX VARIABLES

Introduction-Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Differentiability, Cauchy-Riemann equations, Singularity and poles, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected regions. Laurent's and Taylor's expansions. Residues and Residue Theorem. Simple applications in solving Definite Integrals.

Unit-II: SECOND ORDER DIFFERENTIAL EQUATIONS

Homogeneous equation: Regular and irregular singular points; Frobenius method; Fouchs's theorem; Linear independence of solutions, Wronskian, second solution. Sturm-Liouville theory; Hermitian operators; Completeness, Solution of inhomogeneous Differential equation by Green's functions

Unit-III: SECOND ORDER PARTIAL DIFFERENTIAL EQUATIONS

Partial differential equation, classes of partial differential equations, Solution by the method of separation of variables: Laplace's equation in Cartesian, spherical polar (axially symmetric problems), and cylindrical polar (`infinite cylinder' problems) coordinate systems. Poisson's equation, heat flow equation: linear flow in an infinite bar, Two-dimensional heat flow in a circular plate, wave equation for vibrational modes of a stretched string, rectangular and circular membranes.

Unit-IV: LAPLACE TRANFORM

Introduction, Laplace Transform, Laplace Transform of Elementary functions. Properties of Laplace Transform: Change of scale Theorem, Shifting Theorem. Laplace Transform of derivatives, Laplace Transform of Integrals, Laplace Transform-Unit Step function, Periodic Functions. Convolution Theorem. Inverse Laplace Transform. Simple applications of Laplace Transforms in solving IVP and BVP.

Unit-V: FOURIER TRANSFORM

Fourier Transforms: Fourier Integral theorem (Statement only). Fourier Transform. Fourier sine and cosine transform. Fourier transform of single pulse, trigonometric, exponential and Gaussian functions. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). 1D Wave Equations.

TEXT BOOKS

1. Mathematical Methods for Physicists: Arfken and Weber.
2. Mathematical Physics: P. K. Chattopadhyay.
3. Mathematical Methods in Physical Sciences: Boas.
4. Mathematics for Physicists and Engineers: Pipes.

REFERENCE BOOKS

1. Mathematical physics, Rajput, Pragati prakashan
2. Differential Equations, George F Simmons, Tata McGraw-Hill.
3. Partial Differential Equations for Scientists & Engineers, S. J. Farlow, Dover Pub.
4. Fourier Analysis: M. R. Spiegel, Tata McGraw-Hill.

ELECTRICITY & MAGNETISM	
Course Code: 25PHBS302	Continuous Evaluation: …. Marks
Credits: 3	End Semester Examination: …. Marks
L T P : 3 0 0	**Course Type: MAJOR COURSE THEORY**
Prerequisite: NIL	

COURSE OBJECTIVES (CO):

1. Recall the fundamental principles of Coulomb interaction and electrostatics introduced in the course.
2. Comprehend the definition of dielectric materials and their significance in various electrical and electronic applications.
3. Apply the knowledge of magnetic fields and magnetostatics to solve problems and analyze simple scenarios.
4. Analyze the behavior of magnetic fields inside different types of matter, understanding their interactions and effects.
5. Develop a strong understanding of basic circuit theory and demonstrate its application in various electrical circuits and systems.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Demonstrate knowledge and understanding of Coulomb interaction and the fundamental concepts of electrostatics.
2. Explain the dielectric properties of matter and the significance of these properties in electrical and electronic applications.
3. Describe the principles of magnetic fields and magnetostatics to solve problems and analyze magnetic interactions in various scenarios.
4. Distinguish the behavior of magnetostatics and magnetic fields within different types of matter.
5. Construct a comprehensive understanding of basic circuit theory and demonstrate its application in designing and analyzing electrical circuits.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs’)	Course Learning Outcomes (CLOs’)				
	CLO 1	CLO2	CLO3	CLO 4	CLO 5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit-I: ELECTROSTATICS
Superposition principle, Coulomb's law, electric field, electric field lines, electric flux, Gauss' law with simple applications. Electrostatic potential, Laplace's and Poisson equations, electrostatic boundary conditions, electric field and potential of a dipole, force and torque on a dipole, electrostatic work and energy, electrostatic energy of system of charges, conductors in an electrostatic field, surface charge and force on a conductor.

Unit-II: DIELECTRIC PROPERTIES OF MATTER
Dielectric properties of matter, electric field in matter, polarization, polarization charges, field of a polarized object, Gauss' law in dielectrics, displacement vector D, relations between E, P and D, electrical susceptibility, permittivity. Capacitors, capacitance, dielectric constant, capacitor (parallel plate, spherical, cylindrical) filled with dielectric.

Unit-III: MAGNETOSTATICS-I
Lorentz force law, Biot-Savart's Law and its applications, force between two straight current carrying wires, curl and divergence of the magnetic field, Ampere's circuital law and its applications, magnetic vector potential, magnetostatic boundary conditions, potential and field due to a magnetic dipole, magnetic dipole moment, force and torque on a magnetic dipole, energy stored in a magnetic field.

Unit-IV: MAGNETOSTATICS-II
Magnetic fields inside matter, magnetization, field of a magnetized object, bound currents, the magnetic intensity H, linear and nonlinear media, magnetic susceptibility and permeability, relation between B, H, M, diamagnetic, paramagnetic and ferromagnetic substances, Hysteresis and B-H curve.

Unit-V: CIRCUIT THEORY
Series and parallel LCR circuit: resonance, quality factor and band width, Kirchhoff's current law and Kirchhoff's voltage law. Mesh and Node analysis. Thevenin theorem, Norton theorem, superposition theorem, reciprocity theorem, Maximum power transfer theorem.

TEXT BOOKS

1. Introduction to Electrodynamics, D. J. Griffiths, Prentice Hall.
2. Electricity and Magnetism, E. M. Purcell, and D. J. Morin, Cambridge University Press.
3. Electromagnetics, B B Laud, New Age International Publishers.

REFERENCE BOOKS

1. Electricty and Magnetism,D. Chattopadhay and P. C. Rakshit, New Central Book Agency (P) Ltd.
2. Fundamentals of Electric Circuit Theory, D. Chattopadhay and P. C. Rakshit, S. Chand.

ELECTRICITY & MAGNETISM LAB	
Course Code: 25PHBS352	Continuous Evaluation: … Marks
Credits: 1	End Semester Practical Examination: … Marks
L T P : 0 0 2	**Course Type: MAJOR COURSE LAB**
Prerequisite: NIL	

COURSE OBJECTIVES (CO):

1. Explain the principles of various circuit theorems, including Thevenin, Norton, superposition, and maximum power transfer theorem, and demonstrate their practical application in solving complex electrical circuits.
2. Apply the principles learned to measure various parameters in electrostatic experiments, and demonstrate an understanding of the experimental setup and data analysis.
3. Analyze the principals involved in measuring various parameters in magnetism.
4. Demonstrate electromagnetic induction experiments and understanding the underlying concepts and their applications in different scenarios.
5. Reproduce new experiments with new methods.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Illustrate circuit theorems and demonstrate solving complex electrical circuits.
2. Demonstrate principles to measure parameters in electrostatic experiments along with experimental setup and data analysis.
3. Deduce principles in measuring parameters in magnetism.
4. Evaluate various aspects of electromagnetic induction experiments.
5. Design new experiments or variations of existing methods.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum ------of experiments)

1. To study core losses in transformers.
2. To determine Inductance by Maxwell's bridge.
3. To verify the Thevenin theorems.
4. To verify the Norton theorems.
5. To verify the Superposition theorem.
6. To verify the Maximum power transfer theorem.
7. To determine self-inductance of a coil by Anderson's bridge.
8. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
9. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer
10. Determine a high resistance by leakage method using Ballistic Galvanometer.
11. To determine the mutual inductance of two coils by Absolute method.
12. RC circuit: High pass and low pass filter.
13. Helmholtz coil: Spatial variation of a magnetic field.
14. B-H Curve: Hysteresis loop & energy loss.
15. Anderson Bridge: Self-inductance of a coil.

TEXT BOOKS

1. "Laboratory Manual In Applied Physics"-Second Edition H.Sathyaseelam-New Age International
2. Laboratory Experiments In College Physics",C.H.Bernard And C.D.Epp.John Wiley And Sons Inc.,New York 1995

REFERENCE BOOKS

1. "Experiments In Modern Physics",A.C.Melisson, Academicpress, N.Y. 1966.
2. Practical Physics",G.L.Squires, Cambridge University Press,1985

THERMAL PHYSICS

Course Code: 25PHBS303	Continuous Evaluation: …. Marks
Credits: 3	End Semester Examination: …. Marks
L T P : 3 0 0	**Course Type: MAJOR COURSE THEORY**
Prerequisite: NIL	

COURSE OBJECTIVES (CO):

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

1. Explain the ideal gas behaviour by applying the kinetic theory of gases.
2. Differentiate ideal-gas behaviour from real-gas behaviour through quantitative and qualitative analyses.
3. Apply the first, second and third laws of thermodynamics to analyse energy exchanges in physical and engineering systems.
4. Analyse entropy changes and appreciate their consequences for the direction of natural processes and the concept of irreversibility.
5. Employ Maxwell relations and related thermodynamic identities to solve practical problems involving phase transitions, heat engines and refrigeration cycles.

COURSE LEARNING OUTCOMES (CLO):

On successful completion of the course, a student will be able to

1. Derive and use the Maxwell–Boltzmann speed distribution to calculate mean, RMS and most-probable speeds for a specified gas sample and estimate specific heat of monoatomic and diatomic gases.
2. Quantify deviations from ideal-gas behaviour using compressibility-factor data and Van der Waals parameters, compute the Joule–Thomson coefficient and predict the temperature of inversion for a given real gas.
3. Calculate work done, heat exchanged and internal-energy change for isothermal and adiabatic processes of an ideal gas and Compare the efficiencies of Carnot, Otto and Diesel engines.
4. Determine entropy changes and construct T–S and P–V diagrams for simple power-cycle and refrigeration-cycle analyses.
5. Apply Maxwell relations and related thermodynamic identities to solve practical problems involving phase transitions, heat engines and refrigeration cycles.

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit-I: KINETIC THEORY OF GASES
Maxwell-Boltzmann distribution Law of distribution of velocities in an ideal gas and its experimental verification, Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases; mono-atomic and diatomic gases. Collisions and Transport Phenomenon in Ideal Gases

Unit-II: REAL GAS
Behavior of Real Gases: Deviations from the Ideal Gas Equation. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule-Thomson Cooling.

Unit-III: LAWS OF THERMODYNAMIC
Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamic Processes, Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes. Compressibility and Expansion Coefficients. Second law: Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

Unit-IV: ENTROPY
Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero.

Unit-V: MAXWELL EQUATIONS
Thermodynamic functions: Internal Energy, Enthalpy, Helmholtz function, Gibb's function, Derivation of Maxwell Relations and applications: Joule-Thompson Effect, First and second order Phase Transitions with examples, Clausius-Clapeyron Equation and Ehrenfest equations, Expression for (CP and CV). T-dS equations.

TEXT BOOKS

1. Heat and Thermodynamics, R. H. Dittmanand M.W. Zemansky,7th Ed., McGraw-Hill.
2. Introduction to Statistical Physics, K Huang, CRC Press

REFERENCE BOOKS

1. Heat Thermodynamics &Statistical Physics, B. Lal, N. Subrahmanyam, and P. S. Hemme, S. Chand.
2. Thermal Physics: A B Gupta & H. P. Roy, New Central Book Agency.

THERMAL PHYSICS LAB	
Course Code: 25PHBS353	Continuous Evaluation: ….Marks
Credits: 1	End Semester Practical Examination: … Marks
L T P : 0 0 2	**Course Type: MAJOR COURSE LAB**
Prerequisite: NIL	

COURSE OBJECTIVES

1. Explain the principles of various temperature measurement techniques and their applications.
2. Apply temperature measurement techniques to accurately measure temperatures in different setups.
3. Analyze experimental data to determine thermal conductivities and other thermal properties of materials.
4. Evaluate the reliability of experimental results and identify potential sources of error.
5. Design experiments to investigate specific heat capacities of materials and validate theoretical models.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would:

1. Summarize the theory behind different heat transfer experiments.
2. Demonstrate the ability to set up and operate equipment for heat conduction experiments.
3. Examine the effects of variables like material composition and surface area on heat transfer rates.
4. Judge the significance of experimental findings in relation to real-world applications.
5. Develop setups to demonstrate thermal expansion phenomena and measure coefficients of expansion.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum ----- of experiments)

1. To determine the coefficient of thermal conductivity of copper by Searle's Apparatus.
2. Heat capacity: Specific heat of a solid
3. Measurement of Planck's constant using black body radiation.
4. To determine Stefan's Constant.
5. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
6. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.
7. To determine the temperature co-efficient of resistance by Platinum resistance thermometer.
8. To study the variation of thermo emf across two junctions of a thermocouple with temperature.
9. To record and analyze the cooling temperature of a hot object as a function of time using a thermocouple and suitable data acquisition system.
10. To calibrate Resistance Temperature Device (RTD) using Null Method/Off-Balance Bridge.
11. To study the Seebeck and Peltier effects using a thermoelectric module.
12. To determine the thermal diffusivity of a metal rod.
13. To measure the latent heat of fusion of ice using a calorimeter.
14. To measure the latent heat of vaporization of water.
15. To study Newton's Law of Cooling and verify the law experimentally.

TEXT BOOKS

1. Advanced Practical Physics for students, B.L. Flint& H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

REFERENCE BOOKS

1. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
2. A Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal, 1985, Vani Publication.

ANALOG ELECTRONICS	
Course Code: 25PHBS401	Continuous Evaluation: …. Marks
Credits: 3	End Semester Examination: …. Marks
L T P : 3 0 0	**Course Type: MAJOR COURSE THEORY**
Prerequisite: NIL	

COURSE OBJECTIVES

1. To illustrate the working and characteristics of Bipolar Junction Transistors.
2. To apprehend the application of the transistor as an amplifier.
3. To explain the working and characteristics of Field Effect Transistors.
4. To make students familiar about the principle and working of operational amplifier.
5. To develop the understanding of oscillators and wave generators.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would:

1. Explain the operation and characteristics of various electronic components.
2. Familiarize students with the applications of electronic circuits.
3. Fluent with the understanding of the Field effect transistor and its characteristics.
4. Becomes familiar with the working of operation amplifier and its application
5. Able to understand the principles behind oscillators and signal generators

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

UNITI I: BIPOLAR JUNCTION TRANSISTORS

n-p-n and p-n-p Transistors. I-V characteristics of CB and CE Configurations. Active, Cutoff and Saturation Regions. Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point.-Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. h-parameter Equivalent Circuit. Analysis of single-stage CE amplifiers using hybrid Model. Input & output Impedance. Current, Voltage and Power gains.

Unit-II: TRANSISTOR APPLICATION AS AMPLIFIER
Couple Amplifier -Two stage RC-coupled amplifier and its frequency response, Feedback in Amplifiers - Positive and Negative Feedback. Effect of negative feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise, Load lines, Classification of amplifier, class A, B (working, gain and efficiency calculation) class C and class B push pull amplifier.

Unit III: FIELD EFFECT TRANSISTORS
Junction Field Effect Transistor (JFET): Basic structure & Operation, pinch off voltage, single ended geometry of JFET, Volt Ampere characteristic, Transfer Characteristics. JFET application, MOSFET: Enhancement MOSFET, Threshold Voltage, Depletion MOSFET, comparison of p & n Channel FET, SCR, introduction to CMOS.

Unit IV: OPERATIONAL AMPLIFIER
Small-signal AC analysis, BJT amplifier frequency response, Operational Amplifiers: Block diagram, open and close loop configuration, inverting & non-inverting amplifier, Effect of feedback on closed loop voltage gain, Input resistance, output resistance, band width, output offset voltage, Measurements of Op-amp parameters. Op-amp Application, summing, scaling and Averaging amplifier, Integrator, Differentiator.

Unit V: OSCILLATORS AND WAVE GENERATORS
Oscillators: Principles, Types, frequency stability, Phase shift oscillator, Wein bridge oscillator, LC tunable oscillator, square wave, Triangular wave and pulse generator, Monostable, Bistable & Astable, Multivibrators.

TEXT BOOKS

1. Principle of Digital Electronics: Malvino and Leach.
2. Electronic Devices: T.L. Floyd.
3. Digital Principles and Applications: A.P. Malvino, D.P. Leach and Saha, 7th Ed., 2011, Tata McGraw
4. Integrated Electronics: J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill
5. Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
6. OP-Amps and Linear Integrated Circuit: R. A. Gayakwad, 4th edition, 2000, Prentice Hall
7. Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7th Ed., 2011, Tata McGraw
8. Digital Electronics, G K Kharate ,2010, Oxford University Press

REFERENCE BOOKS

1. Digital Systems: Principles &Applications, R.J. Tocci, N.S. Widmer, 2001, PHI Learning
2. Logic circuit design, Shimon P. Vingron, 2012, Springer.
3. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
4. Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill

ANALOGUE ELECTRONICS LAB	
Course Code: 25PHBS451	Continuous Evaluation: …. Marks
Credits: 1	End Semester Practical Examination: …. Marks
L T P : 0 0 2	**Course Type: MAJOR COURSE LAB**
Prerequisite: NIL	

COURSE OBJECTIVES (CO):

1. Recall the fundamental concepts of electronic components, such as resistors, capacitors, and transistors and explain the principles of circuit analysis and behavior of electronic components.
2. Apply circuit analysis techniques to design and construct basic electronic circuits.
3. Analyze the behavior of complex electronic circuits and troubleshoot common issues.
4. Evaluate the performance of electronic circuits, considering factors like gain, bandwidth, and noise.
5. Design and build advanced electronic circuits, such as audio amplifiers, filters, and timers.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would:

1. Summarize the characteristics of different amplifier configurations, filters, and oscillators.
2. Demonstrate the ability to measure voltage, current, and impedance using appropriate instruments.
3. Differentiate between different types of amplifiers and their frequency responses.
4. Critique the limitations of components and their impact on circuit functionality.
5. Develop projects that integrate multiple electronic components to achieve specific functionalities.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs’)	Course Learning Outcomes (CLOs’)				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum ----- of experiments)

1. PNP transistor: Common base characteristics.
2. NPN transistor: Common emitter characteristics.
3. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
4. To design an inverting amplifier using Op-amp (741,351) for dc voltage.
5. To design inverting amplifier using Op-amp (741,351) and study its frequency response.
6. To design non-inverting amplifier using Op-amp (741,351), study its frequency response.
7. To add two dc voltages using Op-amp in inverting and non-inverting mode.
8. To design a precision differential amplifier of given I/O specification using Op-amp.
9. To investigate the use of an op-amp as an Integrator.
10. To investigate the use of an op-amp as a Differentiator.
11. To study the frequency response of voltage-gain of a RC-coupled transistor amplifier.
12. To design a Wien bridge oscillator for given frequency using an op-amp.
13. To design a phase shift oscillator of given specifications using BJT.
14. Hartley oscillator: Low frequency.
15. To study JFET and MOSFET characteristics.
16. Build and analyze OP-AMP circuits (inverting, integrator, Schmitt trigger)
17. Study of FET/MOSFET characteristics

TEXT BOOKS

1. Chauhan and Singh , " Advanced practical physics", Revised edition, Pragati Prakashan Meerut, 1985

REFERENCE BOOKS

1. Chattopadhyay, D., Rakshit, P. C and Saha, B., "An advanced Course in Practical Physics", 2nd edition, Books & Allied Ltd, Calcutta, 1990

MODERN PHYSICS	
Course Code: 25PHBS402	Continuous Evaluation: …. Marks
Credits: 3	End Semester Practical Examination: …. Marks
L T P : 3 0 0	**Course Type: MAJOR COURSE THEORY**
Prerequisite: NIL	

COURSE OBJECTIVES

1. To state the fundamental concepts of quantum mechanics such as quantisation, wave particle duality, uncertainty principle.
2. To describe the concepts of wavefunction and Schrödinger equation.
3. To demonstrate the solutions of the Schrödinger equation for various one-body systems.
4. To construct the solution of Schrödinger equation in three dimension problem
5. To evaluate the solution of Schrödinger equation in spherical polar coordinates.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Explain the limitations of classical physics and the onset of quantum effects.
2. Construct the Schrödinger equation and able to solve it.
3. Able to apply quantum mechanical approach to solve simple 1D problem.
4. Analyse the application of Schrödinger equation in three dimension problem.
5. Evaluate the solution of Schrödinger equation in spherical polar coordinates.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURE CONTENTS

Unit-I: INTRODUCTION TO QUANTUM PHYSICS

Blackbody Radiation problem, Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle: Derivation from Wave Packets - impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle, Energy-time uncertainty principle- application to virtual particles and range of an interaction.

Unit-II: WAVE MECHANICS

Basic postulates of Quantum Mechanics. The state of a system-Probability density & Superposition principle. Time evolution of System's state, Time dependent Schröodinger equation and wave packets. Quantum to Classical Mechanics-Poisson brackets and commutators, The Ehrenfest Theorem. Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of wave-function, probabilities and normalization; Probability and probability current densities in one dimension.

Unit-III: APPLICATIONS TO SIMPLE ONE-DIMENSIONAL PROBLEMS

Bound & Unbound states, Mixed spectrum. One dimensional infinite square well - energy eigenvalues and eigenfunctions, normalization, stationary states; Quantum dot as an example. Quantum tunneling and scattering in one dimension: the finite square well potential and a step potential.The linear harmonic oscillator – energy levels, odd states and even states, comparison with classical theory, delta potential, Double-delta potential; Aharonov-Bohm effect.

Unit-IV: APPLICATION TO THREE DIMENSIONAL PROBLEM IN CARTESIAN COORDINATE

Three-Dimensional problems in cartesian coordinates - separation of variables, 3D box potential, rectangular and cubic potential box potential: concept of degeneracy. 3D isotropic harmonic oscillator (in Cartesian coordinates), 3-D spherical well and Fermi energy, free particle, 3-D harmonic oscillator.

Unit V: PROBLEMS IN SPHERICAL COORDINATE:

Central potential: separation of the Schrodinger equation in spherical polar coordinate; Radial equation; Orbital angular momentum: Eigenvalues and eigen functions - spherical harmonics, Commutation relations; Isotropic Harmonic Oscillator.

TEXT BOOKS

1. Quantum Mechanics: B. H. Bransden and C. J. Joachain.
2. Quantum Physics of Atoms, Molecules, Nuclei and Solids: R. M. Eisberg and R. Resnick.
3. Quantum Mechanics: V. Devanathan.
4. Quantum Mechanics: C. S. Chaddha.
5. Nuclear Physics: S. N. Ghoshal
6. Nuclear Physics: S. B. Patel
7. Nuclear Physics: V. K. Mittal, R. C. Verma and S. C. Gupta

REFERENCE BOOKS

1. Concepts of Modern Physics by Arthur Beiser. Tata McGraw-Hill Edition.
2. Quantum Mechanics-Concepts & Applications: N. Zettili
3. Introduction to Quantum Mechanics: David J. Griffiths
4. Principles of Quantum Mechanics: I. S. Tyagi
5. Quantum Physics: S. Gasiorowicz.

MODERN PHYSICS LAB	
Course Code: 25PHBS452	Continuous Evaluation: ….. Marks
Credits: 1	End Semester Practical Examination: …. Marks
L T P : 0 0 2	**Course Type: MAJOR COURSE LAB**
Prerequisite: NIL	

COURSE OBJECTIVES

1. To recall the insight of the exciting results and reasoning of the physical phenomena on the basis of modern physics.
2. To discuss practical knowledge on various constants including Boltzmann constant etc
3. To illustrate and appreciate the principals involved in measuring various parameters.
4. To compare the practical knowledge on the absorption lines in the rotational spectra, photoelectric effect etc.
5. To estimate the error estimation in various experiments.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would able to:

1. Relate the experimental knowledge of various modern physics concepts.
2. Compare various constants including Boltzmann constant, Planck's constant etc
3. Demonstrate the insights of the Physics involved in the experiments
4. Analyse the absorption lines in rotational spectra and photoelectric effect.
5. Assess the error estimation in various experiments

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum ----- of experiments)

1. To determine value of Boltzmann constant using V-I characteristic of PN diode.
2. To determine work function of material of filament of directly heated vacuum diode
3. To determine value of Planck's constant using LEDs of at least 4 different colors.
4. To determine the ionization potential of mercury.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the absorption lines in the rotational spectrum of Iodine vapors.
7. To study the diffraction patterns of single and double slits using laser source and measure its intensity variation using Photosensor and compare with incoherent source – Na light.
8. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light.
9. To determine the value of e/m by magnetic focusing.
10. To setup the Millikan oil drop apparatus and determine the charge of an electron.
11. Determination of wavelength of sodium D1 and D2 lines

TEXT BOOKS

1. Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

REFERENCE BOOKS

1. A Text Book of Practical Physics, Indu Prakash and R.

CLASSICAL MECHANICS	
Course Code: 25PHBS403	Continuous Evaluation: ….. Marks
Credits: 4	End Semester Examination: ….. Marks
L T P : 3 1 0	**Course Type: MAJOR COURSE THEORY**
Prerequisite: NIL	

COURSE OBJECTIVES (CO):

1. To relate the concept of constraints, Lagrangian and Hamiltonian formalism.
2. To explain the canonical transformation and Poisson's bracket.
3. To demonstrate the mechanics of rigid bodies.
4. To analyse the concepts of fluid dynamics
5. To formulate the fluid dynamics and Classical field theory concepts.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Compare the concepts of constraints, Lagrangian and Hamiltonian formulation.
2. Demonstrate the canonical transformation and Poisson's bracket.
3. Analyse the mechanics of rigid bodies.
4. Evaluate the ideas of fluid dynamics.
5. Design the Classical field theory formalism.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit-I: FORMALISMS OF CLASSICAL MECHANICS

Difficulty in Newtonian mechanics, Constraints of motion, generalized coordinates, D' Alembert's Principle and Lagrange's equation, Velocity dependent forces and the dissipation function, Simple applications including central force problem (equation of motion only). Hamilton principle, Lagrange's equation from Hamilton principle, extension to non-holonomic systems, Legendre Transformation, Hamilton's equations of motion, Hamilton's equations from variation principle, Principle of least action.

Unit-II: CANONICAL TRANSFORMATION AND POISSON'S BRACKET
Canonical transformation and its examples, Poisson's brackets, Equation of motion, Angular momentum, Poisson's Brackets relations, infinitesimal canonical transformation, Conservation Theorems and symmetry properties. Hamilton-Jacobi equation for Hamilton's principal function, Harmonic Oscillator problem.

Unit-III: RIGID BODY MOTION AND SMALL OSCILLATIONS
Idea of rigid body in terms of constraints and degrees of freedom. Combination of translation and rotation as a general motion. Rotation of rigid body about an arbitrary axis; angular momentum, angular velocity, moments of inertia, products of inertia, kinetic energy, Radius of gyration, Parallel axis theorem, Perpendicular axis theorem, Calculation of moment of inertia for rectangular, cylindrical and spherical bodies, Motion of a rigid body about a fixed axis Compound pendulum, Angular momentum and kinetic energy about a point, Moment of Inertia tensor, principle axis of inertia, Angular momentum and kinetic energy about principal axis of inertia,
Ellipsoid of Inertia, Euler's theorem, Euler angles; Inertia tensor and principal axis system; Euler's equations; Heavy symmetrical top with precession and nutation, Free vibrations, Normal coordinates, Euler angles, forced oscillations and effect of dissipative forces. Vibration of Triatomic Molecule.

Unit-IV: FLUID DYNAMICS
Kinematics of Moving Fluids: Idea of compressible and incompressible fluids, Equation of continuity; streamline and turbulent flow, Reynold's number. Euler's Equation. The special case of fluid statics F = grad P. Simple applications (e.g.: Pascal's law and Archimedes principle). Bernoulli's Theorem,

Unit-V: INTRODUCTION TO CLASSICAL FIELD THEORY
System with infinite degrees of freedom, Classical fields: Lagrangian and Hamiltonian formulations Equations of motion. Symmetries and invariance principles, Noether's theorem.

TEXT BOOKS
1. Classical Mechanics,H. Goldstein, C.Poole & J. Safko, (Pearson Education Asia, New Delhi).
2. Classical Mechanics,N.C. Rana and P.S. Joag (Tata McGraw-Hill, 1991).
3. Classical Mechanics, A Course of Lectures: A K Raychaudhuri (Oxford University Press).
4. Introduction to Classical Mechanics: R. G. Takawale, P. S. Puranik, Tata McGraw
Hill Publishing Company Ltd.

REFERENCE BOOKS
1. Classical Mechanics, A Course of Lectures: A K Raychaudhuri (Oxford University Press).
2. Principles of mechanics: J. L. Synge, B. A. Griffith, Tata McGraw Hill Publishing company Ltd.
2. An Introduction to Mechanics: D. Kleppner and R. J. Kolenkow, Tata McGraw Hill Publishing company Ltd.

DIGITAL ELECTRONICS	
Course Code: 25PHBS501	Continuous Evaluation: …. Marks
Credits: 3	End Semester Examination: …. Marks
L T P : 3 0 0	Course Type: **MAJOR COURSE THEORY**
Prerequisite: Basic knowledge about electronics	

COURSE OBJECTIVES (CO):

1. To familiarize with the different number systems, laws of Boolean algebra.
2. To familiarize with the different number systems (binary, octal and hexadecimal), laws of Boolean algebra, logic gates.
3. To familiarize with the combinational and sequential logic circuits utilised in designing counters and registers.
4. Explain the operation of the Karnaugh map.
5. Design and simulate advanced electronic circuits, such as Timers, Multivibrators.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Learn to minimise a given Boolean function using laws of Boolean algebra.
2. Develop the digital signals, positive and negative logic, Boolean variables, truth table, various number system codes and their inter-conversions.
3. Understand the working principle of arithmetic circuits, sequential logic circuits, registers, counters based on flip flops.
4. To learn the Karnaugh map to minimise the hardware requirement of digital logic circuits.
5. Develop schematics for practical implementation of electronic designs

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit-I : BOOLEAN ALGEBRA

De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map. Binary Addition. Binary Subtraction using 2's Complement Method.

Unit-II: DIGITAL CIRCUITS

Half Adders and Full Adders and Subtractors, design of a basic 2-bit ALU 4-bit binary Adder-Subtractor. Difference between Analog and Digital Circuits. Examples of linear and digital ICs, Binary Numbers. Decimal to Binary and Binary to Decimal Conversion, BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates.

Unit-III: SEQUENTIAL CIRCUITS

Sequential Circuits -SR, D, and J-K Flip-Flops, Clocked (Level and Edge Triggered) Flip-Flops, Preset and Clear operations, Race-around conditions in JK Flip-Flop, M/S JK Flip-Flop, master-slave flip-flop, Shift registers - Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in- Parallel-out Shift Registers (only up to 4 bits). Counters - Ring Counter. Asynchronous counters, Synchronous Counter.

Unit IV: COMBINATIONAL CIRCUITS

Half adder, Full adder, Karnaugh map -2, 3, 4 variable K map, Decoder, 7 segment display decoder, Data processing circuits - Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders, ring counters, Johnson counters.

Unit V: TIMERS

IC 555: Pin -out diagram, block diagram and its applications as astable multivibrator and monostable multivibrator, basis introduction to IC 556 (dual 555 timer), IC 7555 (CMOS)

TEXTBOOKS

1. Semiconductor Devices - Physics and Technology, S.M. Sze (John Wiley), 2002.
2. Solid State Electronic Devices, Ben Streetman, Sanjay Banerjee (Pearson) 7th Edition, 2016.
3. Electronic Principles, A.P. Malvino (Tata McGraw, New Delhi), 7th edition, 2009.
4. Integrated Electronics, J. Millman, C. Halkias and C.D. Parikh, Tata McGraw Hill, 2nd edition, 2015
5. Linear and Non-linear Circuits, Chua, Desoer and Kuh (Tata McGraw), 1987.
6. Circuit theory Fundamentals and Applications, Aram Budak (Prentice-Hall) 1987.
7. Integrated Electronics, Millman and Halkias (Tata McGraw Hill) 1991.

REFERENCE BOOKS

1. Electronic Devices and Circuits Theory, Boylested and Nashelsky,(Pearson Education) 10th ed. 2009.
2. OPAMPS and Linear Integrated circuits, Ramakant A Gayakwad (Prentice Hall), 1992.
3. Operational amplifiers and Linear Integrated circuits, R.F. Coughlin, and F.F. Driscoll, (Prentice Hall of India, New Delhi), 2000.
4. Principles and Applications in Electronics: A.P. Malvino, D.P. Leach, (Tata Mcgraw- Hill, N.Delhi,1993).
5. Electronic Fundamentals & Applications: John D. Ryder (Prentice Hall of India, N. Delhi)

DIGITAL ELECTRONICS LAB	
Course Code: 25PHBS551	Continuous Evaluation: ….. Marks
Credits: 1	End Semester Practical Examination:…. Marks
L T P : 0 0 2	**Course Type: MAJOR COURSE LAB**
Prerequisite: NIL	

COURSE OBJECTIVES (CO):

1. To develop practical knowledge on verification and analyzing of plane polarized light.
2. To apply the principals involved in measuring various physical parameters using polarimeter and ultrasonic grating.
3. To get practical knowledge of analyzing various optical properties of electromagnetic waves.
4. To verify various laws or radiations and determine constants.
5. To understand how to set up/handle various instruments.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would:

1. Familiarity with on measurement methods and use of specific instruments to analyze plane polarized light.
2. Get an insight into the principle involved in measuring specific rotation of solutions and wavelength and velocity of ultrasonic waves in a solution.
3. Understand how to measure various optical properties and phenomena using different methods.
4. Well-versed with the various method to determine various constants in radiation laws.
5. Evaluate data reading carefully and estimate error.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs’)	Course Learning Outcomes (CLOs’)				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

LIST OF EXPERIMENTS

Note: Students will be required to perform at least …………….. experiments in a semester. List of experiments may be amended.

1. Logic gate: AND, OR, NOT.
2. Universal Gates: NAND and NOR gates.
3. To study JFET and MOSFET characteristics
4. To study J-K flip flop: Counter, and resistor.
5. To study the characteristic of SCR and its application as a switching device.
6. To design a combinational logic system for a specified truth table.
7. To convert Boolean expression into logic circuit and design it using basic logic gate ICs.
8. To minimize a given logic circuit using K-map and design using NAND gates.
9. Designing of Half Adder and Half Subtractor using NAND gates.
10. Designing of 4-bit binary adder using adder IC.
11. To build Flip-Flop (RS, Clocked RS) circuits using NAND gates.
12. To build Flip-Flop (D-type and JK) circuits using NAND gate.
13. To build a 3-bit Counter using D-type/JK Flip-Flop ICs and study timing diagrams.
14. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
15. To design an astable multivibrator of given specifications using 555 Timer.
16. Design and test a 4-bit ripple counter (asynchronous)
17. Study of SR, JK, D, and T flip-flops using ICs
18. 4:1 MUX and 1:4 DEMUX using ICs
19. Implement a simple arithmetic logic unit (ALU) using basic gates

TEXTBOOKS

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Textbook of Practical Physics, Indu Prakash and Ramakrishna, 11th Ed., 2011, Kitab Mahal, New Delhi

REFERENCE BOOKS

Elements of Solid-State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India

ELECTROMAGNETIC THEORY	
Course Code: 25PHBS502	Continuous Evaluation: ….. Marks
Credits: 3	End Semester Examination: …. Marks
L T P : 3 0 0	**Course Type: MAJOR COURSE THEORY**
Prerequisite: NIL	

COURSE OBJECTIVES (CO):

1. To recall the concept of electromagnetic induction.
2. To discuss the basics of electromagnetic theory and Maxwell's equations.
3. To impart the knowledge of electromagnetic wave propagation in unbounded media.
4. To analyse the propagation of electromagnetic waves in bounded media.
5. To assess the understanding about the concept of polarization along with production and detection of different types of polarized EM waves.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able:

1. Explain the basics of electromagnetic induction.
2. Demonstrate fundamental laws of electromagnetic theory and Maxwell's equations.
3. Compare the EM propagations propagation in free space, dielectric and metals.
4. Formulate the reflections, refraction and polarization of EM waves.
5. Evaluate the polarization of light and various related phenomena.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit I: ELECTROMAGNETIC INDUCTION
Electromotive force, electromagnetic induction, Faraday's laws, Lenz's law, mutual-inductance and self-inductance, energy stored in an electric and magnetic field.

Unit II: MAXWELL'S EQUATION and EM WAVE
Equation of continuity, Maxwell's equations, Maxwell's modification to Ampere's law, displacement current. Total electrostatic and magnetostatic energies. Total energy stored in electromagnetic field, Poynting theorem and Poynting vector, electromagnetic (EM) waves in vacuum, wave equations for E and B, electromagnetic energy density. physical concept of electromagnetic field energy density, momentum density, intensity of electromagnetic waves.

Unit III: EM WAVE PROPAGATION IN UNBOUNDED MEDIA
Monochromatic plane EM waves, transverse nature of plane EM waves, propagation of plane EM waves through vacuum. propagation of plane EM waves and isotropic dielectric medium, refractive index and dielectric constant, wave impedance, propagation through conducting media, relaxation time and skin depth.

Unit IV: EM WAVE PROPAGATION IN BOUNDED MEDIA
Boundary conditions at a plane interface between two media, reflection and transmission of plane wave at plane interface between two dielectric media (normal and oblique incidence), laws of reflection and refraction, Fresnel's formula for perpendicular & parallel polarization cases, reflection & transmission coefficients, Brewster's law, total internal reflection.

Unit V: POLARIZATION
Description of linear, circular and elliptical polarization, propagation of EM waves in birefringent medium, uniaxial and biaxial crystals, EM wave propagation in uniaxial crystal, double refraction, polarization by double refraction, Nicol prism, ordinary and extraordinary refractive indices, phase retardation plates: quarter-wave and half-wave plates, production and analysis of polarized light. Babinet compensator and its uses.

TEXT BOOKS

1. Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
2. Optical Electronics, A.Ghatak, K. Thyagarajan, Cambridge University Press.

REFERENCE BOOKS

1. Introduction to Electrodynamics, David J. Griffiths, 3rd Edn, Prentice Hall.
2. EM Waves and Fields, P. Lorrain and O. Corson.
3. Classical Electrodynamics, J.D. Jackson, 3rd Edn., 2010, Wiley

ELECTROMAGNETIC THEORY LAB	
Course Code: 25PHBS552	Continuous Evaluation: …. Marks
Credits: 1	End Semester Practical Examination: …. Marks
L T P : 0 0 2	**Course Type: MAJOR COURSE LAB**
Prerequisite: NIL	

COURSE OBJECTIVES (CO):

1. To develop practical knowledge on verification and analyzing of plane polarized light.
2. To apply the principals involved in measuring various physical parameters using polarimeter and ultrasonic grating.
3. To get practical knowledge of analyzing various optical properties of electromagnetic waves.
4. To verify various laws or radiations and determine constants.
5. To understand how to set up/handle various instruments.

COURSE LEARNING OUTCOMES (CLO):

1. Familiarity with on measurement methods and use of specific instruments to analyze plane polarized light.
2. Get an insight into the principle involved in measuring specific rotation of solutions and wavelength and velocity of ultrasonic waves in a solution.
3. Understand how to measure various optical properties and phenomena using different methods.
4. Well-versed with the various method to determine various constants in radiation laws.
5. Understand to take data reading carefully and estimate of error.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs’)	Course Learning Outcomes (CLOs’)				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum ----- of experiments)

1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To analyze elliptically polarized Light by using a Babinet's compensator.
4. To study dependence of radiation on angle for a simple Dipole antenna.
5. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
6. To study the reflection, refraction of microwaves
7. To study Polarization and double slit interference in microwaves.
8. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.
9. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
10. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.
11. To verify Fresnel's equation.
12. To find Numerical Aperture of an optical fiber.
13. To verify Brewster's Law and to find the Brewster's angle.
14. To determine the e/m ration of a electron.

TEXT BOOKS

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
3. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Pres.
4. Engineering Practical Physics, S. Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd.

REFERENCE BOOKS

1. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
2. Electromagnetic Field and Waves, P. Lorrain and D. Corson, 2nd Ed., 2003, CBS Publisher.
3. Classical Electrodynamics, J.D. Jackson, 3rd Edn., 2010, Wiley
4. Principle of Optics, M. Born and E. Wolf, 6th Edn., 1980, Pergamon Press
5. Optics, (2017), 6th Edition, Ajoy Ghatak, McGraw-Hill Education, New Delhi.

QUANTUM MECHANICS-I	
Course Code: 25PHBS503	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: …..Marks
L T P : 3 1 0	**Course Type: MAJOR COURSE THEORY**
Prerequisite: NIL	

COURSE OBJECTIVES (CO):

1. To relate the wave functions, operators, and their properties to describe and analyse quantum systems.
2. To Explain the angular momentum algebra and its application in quantum mechanics.
3. To apply quantum mechanical models, such as the hydrogen atom, to apply theoretical concepts to real-world scenarios.
4. To formulate the external source factors such as electric and magnetic fields on the hydrogen atom problem.
5. To assess the advanced level of understanding of Schrödinger equation for identical particle system and symmetries.

COURSE LEARNING OUTCOME (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Compare the wave functions, operators, and their properties to describe and analyse quantum systems.
2. Construct the angular momentum algebra in quantum mechanics.
3. Analyse the hydrogen atom problem and compare to experimental findings.
4. Evaluate the effect of electric and magnetic fields on the solutions of the hydrogen like atoms.
5. Appraise the Schrödinger equation solution for identical particle system and its symmetries.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs’)	Course Learning Outcomes (CLOs’)				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit I: OPERATORS

Operator in quantum mechanics, Hermitian operator and Unitary operator change of basis, Eigenvalues and eigenvectors of operators, Dirac's Bra and Ket algebra, Linear harmonic oscillator, coherent states, Time development of states and operators, Heisenberg, Schrödinger and interactive pictures, annihilation & creation operators, Matrix representation of an operator, Unitary transformations.

Unit II: ANGULAR MOMENTUM

Angular momentum algebra, Commutation relations, Eigen values and eigenvectors of L^2 and L_z. Ladder operators and their matrix representations, Spin angular momentum, Eigenvalues and eigenvectors of J^2 and J_z. Representation of general angular momentum operator, Addition of angular momentum, C.G. coefficients, Wigner-Ekrat theorem.

Unit III: QUANTUM THEORY OF HYDROGEN-LIKE ATOMS

Schrodinger equation for Hydrogen-like atoms in spherical polar coordinates; Radial equation; energy levels – discrete spectrum, degeneracy, quantum numbers & spectral notations (s, p, d, shells), radial eigen functions, The hydrogenic wave functions of the bound states, shapes of the probability densities for ground & first excited states.

Unit IV: HYDROGEN-LIKE ATOMS IN ELECTRIC AND MAGNETIC FIELDS

Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman Effect: Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton. Normal and Anomalous Zeeman Effect. Paschen Backand Stark Effect (Qualitative Discussion only).

Unit V: SYMMETRY AND IDENTICAL PARTICLES

Conservation laws and degeneracy associated with symmetries, Discrete symmetries: Parity and Time- reversal symmetry, Many - Particle Systems, Interchange symmetry, Systems of Distinguishable non- interacting Particles, Identical Particles in Classical & Quantum Mechanics, Exchange degeneracy, Symmetric and Antisymmetric wave functions, Pauli's exclusion principle, connection with statistical mechanics, Systems of Identical noninteracting Particles.

TEXTBOOKS

1. Quantum Mechanics,L.I. Schiff(Tata McGraw-Hill).
2. Quantum Mechanics,B.Craseman and J.L. Powell(Narosa Publishing House).
3. Quantum Mechanics,S.Gasiorowicz (Wiley).
4. Modern Quantum Mechanics,J.J. Sakurai (Addison Wesley).
5. Quantum Mechanics,P.M. Mathews &K.Venkatesan(Tata McGraw-Hill).

REFERENCE BOOK

1. Quantum Mechanics,V.K.Thankappan(New Age International Publisher).
2. Quantum Mechanics, Concepts and Applications,N.Zettili (John Wiley & Sons Ltd.).
3. Quantum Mechanics,B.H.Bransden and C.J. Joachain (Pearson Education)

CONDENSED MATTER PHYSICS - I	
Course Code: 25PHBS504	Continuous Evaluation: …. Marks
Credits: 3	End Semester Examination: …. Marks
L T P : 3 0 0	**Course Type: MAJOR COURSE THEORY**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. To discuss the crystal structure and different structural parameters.
2. To illustrate X-ray diffraction methods.
3. To understand crystal bonding, defects and diffusion in solids.
4. To develop an advanced level of understanding of lattice vibrations, phonons and specific heat theories.
5. To make the students familiar with free electron theory and band theory of solids.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Equipped with the knowledge of crystal structure and various structural parameters
2. Familiar with X-ray diffraction methods
3. Well versed with the understanding of crystal bonding, defects and diffusion in solids.
4. Well versed with concepts of lattice vibrations and phonon modes, and theory of specific heat.
5. Familiar with free electron theory and band theory of solids.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit-I: THE CRYSTALLINE STATE

Lattice, Basis, Translational vectors, Primitive unit cell, Symmetry operations, Different types of lattices 2D and 3D (Bravais lattices), Miller indices, inter-planer distances, SC, BCC and FCC structures, Packing fraction, Crystal structures NaCl, diamond cubic, wurtzite structure, CsCl, ZnS, HCP, Concept of reciprocal lattice and its properties.

Unit-II: X-RAY DIFFRACTION
X-ray generation and classification, Interaction of X- Rays with matter, absorption of X-Rays, Elastic scattering from a perfect lattice, Crystal as a grating, Bragg's law, Reciprocal lattice and Bragg's Diffraction condition in in direct and reciprocal lattice, Ewald's construction, Brillouin zones and applications of reciprocal lattice to diffraction techniques, Experimental methods of X-ray diffraction: Laue method, Rotating Crystal method, Powder (Debye Scherer) method,

Unit-III: LATTICE VIBRATION, PHONONS AND SPECIFIC HEAT THEORIES
Lattice Modes of Vibration, Elastic Vibrations of continuous media, and Vibrations of 1D monatomic and diatomic linear lattice. Phonon Modes, Lattice vibration Spectrum, phonon momentum, Inelastic scattering by phonons. Models of 3D lattices, quantization of lattice vibrations, Einstein and Debye theories of specific heat, phono density of states.

Unit-IV: FREE ELECTRON THEORY AND BAND THEORY OF SOLIDS
Classical theory of Free electron, Wiedemann Franz relation, failures of classical free electron theory, Quantum theory of free electrons in a 3D box, Fermi gas, energy levels and density of orbitals, Fermi-Dirac distribution function, electronic specific heat of a metal. Electrons in a periodic lattice: Bloch theorem, Kronig-Penny model, band theory in metals, semiconductor, insulator, effective mass. Tight binding approximations. Fermi surface, Conduction in Semiconductors (both Intrinsic and Extrinsic), quantum Hall effect.

Unit-V: CRYSTAL BONDING, DEFECTS AND DIFFUSION IN SOLIDS:
Bond classification- types of crystal binding, Covalent, molecular and ionic crystals, London theory of van der walls bond, hydrogen bonding, cohesive and Madelung energy, Point Defects (Schottky and Frankel) and their thermodynamics, Color Centres F, M, R, V and H, Polarons and Excitons, Edge dislocation and screw dislocation, Mechanism of plastic deformation, Stress and strain fields of screw and edge dislocation, Elastic energy of dislocations, Forces between dislocations, Dislocations in fcc, hcp and bcc lattices, Frank-Read mechanism for the multiplication of dislocations, Dislocations and crystal growth.

TEXTBOOKS

1. Introduction to Solid State Physics,C. Kittel(Wiley, New York)
2. Quantum Theory of Solids,C. Kittel (Wiley, New York)
3. Principles Of the Theory of Solids,J.Ziman(Cambridge University Press, Cambridge)
4. Introduction to Solids,Azaroff& Elementary Solid-State Physics,Omar

REFERENCE BOOKS

1. Solid State Physics, Aschroft & Mermin (Reinhert & Winston, Berlin)
2. Principles of Condensed Matter Physics,Chaikil&Lubensk.
3. Solid State Physics,S. O. Pillai (New Age International Publisher) & Soild State Physics,M. A. Wohab (Narosa)

CONDENSED MATTER PHYSICS LAB - I	
Course Code: 25PHBS554	Continuous Evaluation: ….. Marks
Credits: 1	End Semester Practical Examination: ….. Marks
L T P : 0 0 2	**Course Type: MAJOR COURSE LAB**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. To impart practical knowledge on the measurement of magnetic susceptibility.
2. To learn the principals involved in measuring dielectric constant, coupling coefficient, etc.
3. To get practical knowledge on the BH curve of various magnetic and ferroelectric materials.
4. To develop understanding about to estimate parameters like resistivity and Hall coefficients of semiconductors.
5. To learn how to set up/handle various instruments.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would:

1. Get Familiar with different methods to estimate magnetic susceptibility of solids.
2. Get an insight into the practical method and principle involved in measuring the various physical parameters of dielectric materials.
3. Understand how to measure energy loos form BH curve loop.
4. Fluent with understanding of handle instruments and measure various conducting properties of semiconductors such as hall coefficient and resistivity.
5. Understand to take data reading carefully and estimate of error.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	(shaded)				
CO2		(shaded)			
CO3			(shaded)		
CO4				(shaded)	
CO5					(shaded)

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum ----- of experiments)

1. Measurement of susceptibility of paramagnetic solution (Quincke`s Tube Method).
2. To measure the magnetic susceptibility of Solids.
3. To determine the coupling coefficient of a piezoelectric crystal.
4. To measure the dielectric constant of a dielectric Materials with frequency.
5. To determine the complex dielectric constant and plasma frequency of metal using surface plasmon resonance (SPR).
6. To determine the refractive index of a dielectric layer using SPR.
7. To study the PE Hysteresis loop of a ferroelectric crystal.
8. To draw the BH curve of iron using a Solenoid and determine the energy loss from Hysteresis.
9. To measure the resistivity of a semiconductor (Ge) crystal with temperature by four probe method (from room temperature to 150 C) and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.
11. Simulation of XRD patterns using software (e.g., VESTA, Origin Pro)
12. Measurement of bandgap using electrical method (I-V, T dependence)

TEXT BOOKS

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

REFERENCE BOOKS

1. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Ed., 2011, Kitab Mahal, New Delhi

Elements of Solid-State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India

CONDENSED MATTER PHYSICS - II	
Course Code: 25PHBS601	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	**Course Type: MAJOR COURSE THEORY**
Prerequisite: CONDENSED MATTER PHYSICS I	

COURSE OBJECTIVES (CO):

1. To introduce the students with the transport properties of solids.
2. To illustrate optical properties of the materials.
3. To make students familiar with the magnetic properties
4. To discuss the superconductivity of materials.
5. To develop understanding of dielectric and ferroelectric properties of solids.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP).
After completion of course, students would be:

1. Fluent with good knowledge of transport properties of solids.
2. Get an understanding of optical properties of materials.
3. Well-versed with the magnetic properties of solids.
4. Able to gain good knowledge to students about superconductivity.
5. Familiarity with the dielectric and ferroelectric properties of solids.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENT

UNIT I: TRANSPORT PROPERTIES OF SOLIDS

Visual interpretation of band structures via E-K diagrams, Boltzmann transport equation, resistivity of metals and semiconductors, Fermi surfaces – determination, Landau levels, de Hass van Alphen effect, Quantum Hall effect- Integral quantum Hall effect and. Magnetoresistance

UNIT II: OPTICAL PROPERTIES

Optical constants and their physical significance, Reflectivity in metals, plasmonic properties of metals, determination of band gap in semiconductors: direct and indirect band gap, temperature dependence of carrier concentration, Fermi level, defect mediated optical transitions, excitons, photoluminescence, Electro-luminescence.

UNIT III: MAGNETIC MATERIALS

Langevin Diamagnetism equation, Quantum theory of atomic diamagnetism; Landau diamagnetism (qualitative discussion); Paramagnetism: classical and quantum theory of paramagnetism, Ferromagnetism: Ferromagnetic ordering, Magnon, Curie-Weiss law, temperature dependence of saturated magnetization, Magnetic hysteresis and soft/hard magnetic materials , Domain theory.

UNIT IV: SUPERCONDUCTIVITY

Basic Properties of Superconductors, Types of Superconductors, Phenomenological thermodynamics treatment, two fluid model: Magnetic behavior of superconductors, intermediate state, London's equation and penetration depth, quantized flux. electron-phonon interaction and cooper pair, brief discussion of the BCS theory, its results and experimental verification, p and d wave pairs, DC and AC Josephson effects, Brief introduction to high temperature superconductors, Superconducting magnets, SQUIDs.

UNIT V: DIELECTRIC AND FERROELECTRICS

Maxwell equations, Polarization, Macroscopic electric field, Depolarization field, Local electric field at an atom, Lorentz field, field of dipoles inside cavity, Dielectric constant and Polarizability, static dielectric constant of gases and solids; Complex dielectric constant and dielectric losses, relaxation time, Debye equations; Cases of distribution of relaxation time, Cole - Cole distribution parameter, Dielectric modulus; Structure phase transitions, ferroelectric crystals, displace transitions, soft optical phonons, Landau theory of the phase transitions, second order and first order phase transitions, Antiferroelectricity, ferroelectric domains, piezoelectricity, Pyroelectricity.

TEXTBOOKS

1. N. W. Ashcroft and N.D. Mermin Solid State Physics, Saunders College Publishing, 1976
2. D. Pines, Elementary Excitations in Solids, CRC press, 1999
3. S. Raimes, The Wave Mechanics of Electrons in Metals, North-Holland Publishing Company - Amsterdam, 1970.
4. P. Fazekas, Lecture Notes on Electron Correlation & Magnetism, World Scientific, 1999.
5. A.J. Dekker, Solid State Physics, Pan Macmillan, 2000
6. C. Kittel, Introduction to Solid State Physics, Eight Edition, Wiley, 2012.

REFERENCE BOOKS

1. M. Tinkham, Introduction to Superconductivity, Dover Publications Inc., 2004.
2. M. Marder, Condensed Matter Physics, 2nd Ed., John Wiley & Sons, 2010.
3. P.M. Chaikin and T.C. Lubensky,Principles of Condensed Matter Physics,Cambridge University Press, 1995.

ELECTRODYNAMICS	
Course Code: 25PHBS602	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	**Course Type: MAJOR COURSE THEORY**
Prerequisite: Basic knowledge about Electricity and Magnetism	

COURSE OBJECTIVES (CO):

1. To discuss the fundamental laws of electrodynamics.
2. To impart the knowledge of various potentials and fields associated with moving charged particles.
3. To make students familiar with the concept of radiations
4. To highlight compatibility between the classical electrodynamics and special theory of relativity.
5. To create knowledge of electromagnetic wave propagation.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Get an understanding of covariance laws of classical electrodynamics.
2. Well versed with the different potential and fields acting on the charged particles.
3. Fluent with the knowledge about radiation.
4. Well versed with the knowledge of relativistic electrodynamics.
5. Able to understand the propagation of EM wave in different waveguides.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit I: REVIEW OF ELECTROMAGNETIC THEORY

Maxwell's equations in free space and linear isotropic media, boundary conditions on the fields at interfaces, scalar and vector potentials. Multipole expansion of (i) scalar potential and energy due to a static charge distribution (ii) vector potential due to a steady current distribution, electrostatic and magnetostatic energy, Poynting's theorem, electromagnetic force on the charge in a volume, Maxwell's stress tensor, the momentum stored in the electromagnetic field.

Unit II: POTENTIALS AND FIELDS

Basics of scalar and vector potentials, Maxwell's equations in terms of scalar and vector potential, Gauge transformations, Coulomb gauge and Lorentz gauge, retarded potentials, Jefimenko's equations, Lienard-Wiechert potentials, the fields of a moving point charge, electric and magnetic fields of a point charge moving with constant velocity.

Unit III: RADIATIONS

Radiation from localized sources (electric and magnetic dipole) and multipole expansion in the radiation zone, radiation from an arbitrary source, point charges, power radiated by a point charge, radiation at low velocity, Larmor's formula and its relativistic generalization (Lienard's generalization), radiation when velocity (relativistic) and acceleration are parallel (bremsstrahlung), radiation when velocity and acceleration are perpendicular (synchrotron radiation), radiation reaction, Abraham-Lorentz formula for the radiation reaction force.

Unit IV: RELATIVISTIC ELECTRODYNAMICS

Magnetism as a relativistic phenomenon, Lorentz transformation for the electromagnetic fields, field invariants, covariance of Lorentz force equation and conservation laws, Electromagnetic field tensor, covariance of Maxwell's equations, relativistic Lagrangian and Hamiltonian of a charged particle in an electromagnetic field, equation of motion of a charged particle in an electromagnetic field.

Unit V: WAVE GUIDES

Wave guides, planar optical wave guides, planar dielectric wave guide, condition of continuity at interface, phase shift on total reflection, eigenvalue equations, phase and group velocity of guided waves, field energy and power transmission, TE mode, TM mode, cut off wavelength, coaxial transmission line.

TEXTBOOKS

1. David J. Griffiths, Introduction to Electrodynamics, Pearson Education India Learning Private Limited; 4th edition, 2015.
2. J.D. Jackson, Classical Electrodynamics, Wiley, 3rd edition, 2007
3. J.B. Marion and M.A. Heald, Classical Electromagnetic Radiation, Academic Press, 3rd edition, 1994.

REFERENCE BOOK

1. W. K. H. Panofsky and M. Phillips, Classical Electricity & Magnetism, Dover Publications, 2nd edition, 2012

QUANTUM MECHANICS - II	
Course Code: 25PHBS603	Continuous Evaluation: ….. Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	Course Type: MAJOR COURSE THEORY
Prerequisite: Basic knowledge of quantum well, harmonic oscillator problems	

COURSE OBJECTIVES (CO):

1. To recall the comprehensive understanding of the quantum theory and relate with the varying potentials problems.
2. To demonstrate the approximation techniques like perturbation theory and variational methods, which are used to solve complex quantum systems that cannot be solved exactly.
3. To examine the quantum mechanics solutions associated with the scattering theory.
4. To differentiate the quantum mechanics approach to analyze atomic systems with single and multiple electrons.
5. To interpret the interaction of quantum systems with radiation, gaining an understanding of concepts like spontaneous and stimulated emission and relativistic quantum mechanics, which extends the principles of quantum mechanics to accommodate relativistic effects.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Reinforce students' foundational knowledge of quantum mechanics while demonstrating its applicability in diverse physical situations.
2. delve into advanced problem-solving methods for dealing with complex quantum systems that defy exact solutions..
3. Analyse scattering experiments, calculate scattering cross-sections, and understand the quantum mechanical implications of scattering processes.
4. Justify the complexities of quantum mechanical descriptions of atoms and the challenges posed by electron correlations.
5. Evaluate the quantum phenomena in the context of both radiation and the relativistic regime, expanding their understanding of the theory's applicability..

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit I: TIME INDEPENDENT APPROXIMATION METHODS

Perturbation theory: Nondegenerate case, Degenerate case, Application to one-electron system - Relativistic mass correction, Spin-orbit coupling (L-S and j-j), Zeeman effect and Stark effect. The Variational Method, Helium atoms, Vander-Waal interactions. Exchange degeneracy; Ritz principle for excited states for Helium atom, WKB Approximation: WKB method for one-dimensional problems, Application to barrier penetration.

Unit II: TIME DEPENDENT PERTURBATION THEORY

Time-dependent perturbation theory, interaction picture, first order perturbation, harmonic perturbation, transition probability, ionization of a hydrogen atom, density of final states, ionization probability, second order perturbation, adiabatic approximation, choice of phases, connection with perturbation theory, discontinuous change in H, sudden approximation, distribution of an oscillator, Constant and harmonic perturbations, Fermi's Golden rule, Sudden and Adiabatic Approximation. Absorption and induced emission: Maxwell equation, plane electromagnetic wave, use of perturbation theory, transition probability, interpretation in terms of absorption and emission, electric dipole transitions, forbidden transitions

Unit III: SCATTERING THEORY

Basic concept of scattering, scattering cross-section, scattering amplitude, scattering by spherically symmetric potentials, partial wave analysis and phase shifts, Ramsauer-Townsend effect; Relation between sign of phase shift and attractive or repulsive nature of the potential; Scattering by a rigid sphere and square well; Coulomb scattering; Formal theory of scattering: Green's function in scattering theory; Lippman- Schwinger equation; Born approximation, applications to Yukawa potential and other simple potentials. Electron scattering by an atom.

Unit IV : MANY ELECTRONS ATOMS

Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Vector Model. Spin-orbit coupling in atoms-LS and JJ couplings. Hund's Rule. Term symbols. Spectra of Hydrogen and Alkali Atoms (Na etc.).

Unit V: RELATIVISTIC QUANTUM MECHANICS

, classical radiation field, asymptotic form, radiated energy, dipole radiation, angular momentum, dipole case, conservation from classical to quantum, Planck's distribution formula, line breadth, selection rules for a single particle, polarization of emitted radiation, Relativistic quantum mechanics: Klein – Gordon equation, Dirac equation and its plane wave solutions, concept of spin.

TEXTBOOKS

1. L.I. Schiff, Quantum Mechanics, Tata McGraw-Hill, 4th Edition, 2017.
2. S. Gasiorowicz, Quantum Physics, John Wiley& Sons Ltd.,3rd Edition, 2007.
3. B. Craseman and J.D. Powell, Quantum Mechanics, Dover Publications, 2015
4. A. Messiah, Quantum Mechanics, Dover Publications, 2014.
5. J.J. Sakurai, Modern Quantum Mechanics, Cambridge University Press, 3rd Edition, 2017.

REFERENCE BOOK

1 J.J. Sakurai, Modern Quantum Mechanics, Cambridge University Press, 3rd Edition, 2017.
2 J. D. B.Jorken and S. D. Drell, Relativistic quantum mechanics, Primis Publishing, 1st Edition, 2008.
3 P. M. Mathews & K. Venkatesan, A Textbook of Quantum Mechanics, Tata McGrawHill, 1976.
4 B. H. Bransden and C. J. Joachain, Quantum Mechanics, Pearson Prentice Hall, 2nd Edition, 2000.

LASER AND NON-LINEAR OPTICS	
Course Code: 25PHBS604	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: ….. Marks
L T P : 3 1 0	**Course Type: MAJOR COURSE THEORY**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. To develop comprehensive understanding about laser generation conditions.
2. To make students familiar with different laser arrangements.
3. To develop students' understanding about different types of laser.
4. To introduce the students with the non-linear properties.
5. To discuss laser applications in various fields.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Able to gain good knowledge about lasing action.
2. Well-versed with the construction and working of different laser systems.
3. Fluent with the principle, working, and construction of different types of laser.
4. Well equipped with the non-linear processes.
5. Able to get an understanding of laser applications in various fields

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')		Course Learning Outcomes (CLOs')			
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit-I: PRINCIPLE OF LASER

Principle and characteristics of Laser-Directionality, Coherence, Intensity. Spatial coherence and temporal coherence. Light-matter interaction, basic theory of laser (absorption, spontaneous emission and stimulated emission), rate equation, Einstein Coefficients, Requirements of Lasing action, Population Inversion, pumping methods, Gain & Threshold. Relation between Einstein Coefficients and their physical significance. Three & Four level Lasers.

Unit-II: BASIC LASING SYSTEM

Laser components, Optical resonators, various types of resonators, evaluation of beam waist of such combination, longitudinal modes and transverse modes, Gaussian beams, single mode laser and tunable lasers. Pulsed laser, Q-Switching, Mode Locking, active and passive mode locking, line broadening mechanisms, thermal broadening, Doppler broadening, collision broadening, broadening due to impurities in solids.

Unit-III: TYPES OF LASERS

Principle and Working of Ruby, Nd-YAG, Helium Neon laser, Argon Laser, Nitrogen laser, Carbon dioxide (CO2) laser, Dye laser, Excimer laser, Titanium-sapphire laser- Threshold condition for oscillations., Qualitative Description of Longitudinal and TE laser systems. Threshold condition for Oscillation in Semiconductor Laser. Bipolar and Unipolar semiconductor laser, energy band engineering, condition for Gain in bipolar semiconductor laser, Homojunction and heterojunction semiconductor lasers, GaAs quantum well, GaAs/AlGaAs hetero structure fabrication for lasing applications, Free electron laser.

UNIT IV: NOVEL APPLICATIONS OF LASER

Cooling and Trapping of Atoms, Principles of Doppler and Polarization Gradient Cooling, Qualitative Description of Ion Traps, Optical Traps and Magneto-Optical Traps, Evaporative Cooling and Bose Einstein Condensation. Optical tweezing, Health Monitoring-Endoscopy, Clinical diagnostic. Military applications, Industrial applications. Laser based optical diagnostic techniques-Raman, Laser Induced Fluorescence, Laser Induced Breakdown Spectroscopy (LIBS).

Unit-V: NON-LINEAR PROCESSES

Overview of linear and nonlinear optical processes, Classification of nonlinear optical effects and their importance, Nonlinear Susceptibilities and Polarization, Principles of Second Harmonic Generation (SHG) and its applications, Sum-frequency generation and its spectroscopic applications, Emerging Trends and Research in Nonlinear Optics

TEXT BOOKS

1. W. Demtroder, Laser Spectroscopy: Basic Concepts and Instrumentation, Springer, 3rd Edition, 2002.
2. O. Svelto, Principles of Lasers, Springer, 5th Edition, 2010.
3. Robert W. Boyd, Nonlinear Optics, Academic Press Inc, 3rd Edition, 2008.
4. J. Metcalf and P. Straten, Laser Cooling and Trapping, Springer, 1st Edition, 1999.

REFERENCE BOOKS

1. William T. Silfvast, Laser Fundamentals, Cambridge University Press, 2nd Edition, 2008.
2. B.E.A. Saleh and M.C. Teich, Fundamentals of Photonics, Wiley India Pvt Ltd, 2nd Edition, 2012.
3. S.P. Sengupta, Frontiers in Atomic, Molecular and Optical Physics, Allied Publishers, Volume 3, 2003.
4. Geoffrey New, Introduction to Nonlinear Optic, Cambridge University Press, 1st Edition, 2011.

ATOMIC AND MOLECULAR PHYSICS - I	
Course Code: 25PHBS701	Continuous Evaluation: ….. Marks
Credits: 4	End Semester Examination: ….. Marks
L T P : 3 1 0	**Course Type: MAJOR COURSE THEORY**
Prerequisite: Basic knowledge about atomic and molecular structure of atom.	

COURSE OBJECTIVES (CO):

1. To underline the foundational understanding of the principles of atomic and molecular spectroscopy
2. To discuss various spectroscopic techniques and their applications in analysing atomic and molecular systems.
3. To analyse the instrumentation and experimental setups used in different spectroscopic methods.
4. To interpret spectroscopic data and relate it to the electronic and structural properties of atoms and molecules.
5. To assess the applications of Fluorescence Spectroscopy and NMR Spectroscopy.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Explain the fundamental concepts of atomic and molecular structure, energy levels, and transitions.
2. Identify and describe the types of spectroscopic techniques used to study atomic and molecular systems.
3. Analyze and interpret electronic, vibrational, and rotational spectra to extract relevant information about energy levels and molecular properties
4. Apply selection rules and transition probabilities to predict allowed electronic and vibrational transitions.
5. Compare and contrast the advantages and limitations of various spectroscopic techniques for different types of samples and research objectives.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

UNIT I: ONE ELECTRON SYSTEMS AND PAULI PRINCIPLE

Quantum states of one electron atoms, atomic orbitals, Hydrogen spectrum, Pauli principle, spectra of alkali elements, spin orbit interaction and fine structure in alkali spectra. Spectra of two electron systems, equivalent and non-equivalent electrons.

UNIT II: TWO ELECTRON SYSTEMS

Normal and anomalous Zeeman effect, Paschen Back effect, Stark effect. Two electron systems, interaction energy in LS and jj coupling, Hyperfine structure (magnetic and electric), The Hartree-Fock equations. Spin-orbit coupling energy corrections, The spectra of alkali using quantum defect theory. Selection rules for electric and magnetic multipole radiation.

UNIT III: DIATOMIC MOLECULES AND THEIR ROTATIONAL SPECTRA

Types of molecules, Diatomic linear symmetric top, asymmetric top and spherical top molecules, Rotational spectra of diatomic molecules as a rigid rotator, energy levels and spectra of non-rigid rotor, intensity of rotational lines. Diatomic molecule as non-rigid rotator. Isotope effect in rotational spectra.

UNIT IV: VIBRATIONAL AND ROTATIONAL VIBRATION SPECTRA OF DIATOMIC MOLECULES

Vibrational energy of diatomic molecule, Diatomic molecules as a simple harmonic oscillator, Energy levels and spectrum, Morse potential energy curve, Molecules as vibrating rotator, vibration spectrum of diatomic molecules, PQR Branches, Vibrational-rotational spectra of diatomic molecules

UNIT V: SPECTROSCOPY

Fluorescence and Phosphorescence, Kasha's rule, quantum yield, nonradioactive transition, Jablonski diagram, Time resolved fluorescence and determination of excited state life-time, Raman scattering mechanism

TEXT BOOKS

1. H.E. White, Introduction to Atomic spectra, McGraw-Hill Kogakusha, LTD., 1934.
2. C.N. Banwell, Fundamental of Molecular spectroscopy, McGraw Hill Education (India) pvt LTD, 5th Edition, 2013.
3. G. Herzberg, Atomic spectra & atomic structure, Dover Publications Inc., 2nd Edition,2003.
4. Bransden and Joachain , Physics of Atoms and Molecule, Pearson, 2nd Edition, 2003.
5. J. M. Brown, Molecular spectroscopy. Oxford Chemistry Primers, 1998.
6. P.F. Bernath , Spectra of Atoms and Molecule, OUP USA, 2nd Edition, 2005

REFERENCE BOOK

1. K. Thyagrajan and A. K. Ghatak, Laser- Fundamentals and Application, Springer New York, 2nd Edition, 2011.
2. Lacowicz, Principle of Fluorescence spectroscopy, Springer, 3rd Edition, 2006.

NUCLEAR AND PARTICLE PHYSICS	
Course Code: 25PHBS702	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	**Course Type: MAJOR COURSE THEORY**
Prerequisite: Basic understanding of Quantum mechanics.	

COURSE OBJECTIVES (CO):

1. To discuss the basics of nucleus structure and its properties.
2. To develop students' understanding about Radioactivity and nuclear reactions.
3. To make students familiar with the particle accelerators and detectors
4. To illustrate the thermonuclear reactions, and working of nuclear energy reactors.
5. To introduce the students with the elementary particles, conservation laws, and symmetry groups.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be

1. Well-versed with nucleus structure and its fundamental properties.
2. Able to get an understanding of nuclear reactions, radioactive decay.
3. Equipped with construction and working of nuclear energy reactors and thermonuclear reactions.
4. Able to grasp knowledge of energy generation in nuclear fission.
5. Fluent the students with elementary particles, and symmetry groups.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')		Course Learning Outcomes (CLOs')			
	CLO1	CLO2	CLO3	CLO 4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit-I: NUCLEAR STRUCTURE

Composition, charge, size, density of nucleus, Nuclear Angular momentum, Nuclear magnetic dipole moment, Electric quadrupole moment, parity and symmetry, Mass defect and Binding energy, packing fraction, classification of nuclei, stability of nuclei (N Vs Z Curve), Nature of nuclear force, Nuclear Models: Liquid Drop model. semi-empirical mass formula and binding energy. Nuclear Shell Model. Magic numbers. Bethe-Weizsacker binding energy/mass formula, Physical concepts of the unified model (Collective Model).

Unit-II: RADIOACTIVITY AND NUCLEAR REACTIONS
Laws of radioactive decay, half-life, mean life, specific activity and its units, successive disintegration and equilibriums. (a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b) β-decay: energy kinematics for β-decay, continuous spectrum, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission from the excited state of the nucleus & kinematics, internal conversion. Types of Reactions, units of related physical quantities, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct reaction, resonance reaction, Coulomb scattering (Rutherford scattering).

Unit-III: PARTICLE ACCELERATOR AND DETECTORS
Introduction to particle Accelerators, Accelerator facility available in India, Different type of accelerators: Van-de Graaff generator, Linear accelerator, Cyclotron, Betatron, Synchrotrons, Classification of Nuclear Detectors: Gas filled Detectors (G. M. counter), Solid state detectors, scintillation counter

Unit-IV: NUCLEAR ENERGY
Fission and fusion: mass deficit, relativity and generation of energy. Fission - nature of fragments and emission of neutrons. Chain reactions, critical mass, Nuclear reactor: basic components, homogeneous and heterogeneous reactors, power reactor, fast breeders, slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions).

Unit-V: ELEMENTARY PARTICLES
Fundamental particles and their families. Fundamental particle-interactions and their basic features. Gellmann-Nishijima formula. Quark structure of hadrons. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm. concept of quark model, color quantum number and gluons. C, P, T invariance and CPT theorem, Elementary ideas of SU(2) and SU(3) symmetry groups,

TEXT BOOKS

1. S.N. Ghosal, Nuclear Physics, S. Chand Publishing, 2019
2. Irving Kaplan, Nuclear Physics, Addison-Wesley Publishing, 1956
3. S.B. Patel, Nuclear Physics, An Introduction, New Age International (P) Ltd. Publishers 1991.
4. Harald A.Enge, Introduction to Nuclear Physics, Addition Wesley co, 1966.

REFERENCE BOOKS

1. R.D.Evans, The Atomic Nucleus, Tata McGraw Hill co, 1955.
2. B.L.Cohen, Concepts of Nuclear Physics, Tata McGraw Hill Co, 1971
3. R.Gautrearu, Schaum's Outline Series Modern Physics, McGraw Hill co, 2020.
4. R. R. Roy &B. P. Nigam, Nuclear Physics, New Age International Publisher, 2014.
5. M. K. Pal Nuclear Physics, East West Press Pvt. Ltd., 1989.

STATISTICAL MECHANICS - I	
Course Code: 25PHBS703	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: … Marks
L T P : 3 1 0	**Course Type: MAJOR COURSE THEORY**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. To recall basic knowledge of statistical mechanics.
2. To discuss system of identical particle.
3. To demonstrate the Bose-Einstein statistics.
4. To create competency about the understanding of Fermi-Dirac statistics.
5. To formulate the concept of radiation and related laws.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Relate the basics of mathematical statistics.
2. Describe the understanding of statistics of system of identical particle.
3. Demonstrate various aspects of Bose-Einstein statistics.
4. Formulate the Fermi-Dirac statistics.
5. Evaluate various laws and phenomena of radiation.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit-I: CLASSICAL STATISTICAL MECHANICS

Macrostate & Microstate, Phase Space, Ergodic Hypothesis (statement only). Microcanonical ensemble, Postulate of equal a-priori probabilities. Boltzmann hypothesis: Entropy and Thermodynamic Probability. Canonical ensemble, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox. Equivalence of microcanonical and canonical ensemble. Sackur Tetrode equation, Law of Equipartition of Energy (with proof) Applications to Specific Heat and its Limitations. Thermodynamic Functions of a Two-Energy Level System. Negative Temperature. Grand canonical ensemble. Application of ideal gas using grand canonical ensemble. chemical potential.

Unit-II: SYSTEMS OF IDENTICAL PARTICLE

Collection of non-interacting identical particles. Classical approach and quantum approach: distinguishability and indistinguishability. Occupation number and MB distribution, emergence of Boltzmann factor. Composite system postulate and symmetry postulate of quantum mechanics (for a pair of particles only). Bosons and Fermions. Symmetric and Antisymmetric wave functions. state counting for bosons and fermions.

Unit-III: BOSE-EINSTEIN STATISTICS

B-E distribution law. Thermodynamic functions of a strongly degenerate Bose Gas, Bose Einstein condensation and properties of liquid He IV (qualitative description only).

Unit-IV: FERMI-DIRAC STATISTICS

Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit.

Unit-V: RADIATION

Properties of Thermal Radiation. Blackbody Radiation. Pure temperature dependence. Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure. Wien's Displacement law. Wien's Distribution Law. Saha Ionization Formula. Rayleigh-Jean's Law. Ultraviolet Catastrophe. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law.

TEXT BOOKS

1. F. Reif, Fundamentals of Statistical and Thermal Physics, Waveland Press, 2010.
2. R.K. Pathria and P. D. Beale, Statistical Mechanics, Academic Press, 3rd edition, 2011.

REFERENCE BOOKS

1. K. Huang, Statistical Mechanics, Wiley, 2nd edition, 2008.
2. B.B. Laud, Fundamental of Statistical Mechanics, New Age International Publishers, 2020.

ATOMIC AND MOLECULAR PHYSICS - II	
Course Code: 25PHBS801	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	Course Type: MAJOR COURSE THEORY
Prerequisite: Basic knowledge about atomic and molecular structure of atom.	

COURSE OBJECTIVES (CO):

1. To underline the foundational understanding of Raman spectroscopy
2. To interpret spectroscopic data and relate it to the electronic and structural properties of atoms and molecules.
3. To analyse the principle, origin and experimental setups used in X-ray spectroscopy
4. To discuss NMR spectroscopic technique and its applications
5. To assess the applications of ESR Spectroscopy.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Explain the fundamental concepts of Raman Spectroscopy.
2. Analyze and interpret electronic spectra to extract relevant information about energy levels and molecular properties.
3. Describe the origin and basics of X-ray Spectroscopy.
4. Understand the principle and technique of NMR Spectroscopy.
5. Fluent with principle, working and applications of ESR Spectroscopy.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

UNIT I: RAMAN SPECTRA

Raman effect - quantum theory - molecular polarizability pure rotational Raman spectra of diatomic molecules - vibration rotation Raman Spectrum of diatomic molecules. Intensity alternation in Raman spectra of diatomic molecules. Experimental set up for Raman spectroscopy - application of IR and Raman spectroscopy in the structure determination of simple molecules.

Unit-II: ELECTRONIC BAND SPECTRA

Salient features of electronic band spectra, Nuclear spin interaction and hyperfine splitting, Born Oppenheimer approximation, Vibrational coarse structure of electronic bands, progression and sequences, Rotational fine structure of electronic bands, The Fortrat parabola. Intensity of electronic bands: Franck Condon principle (absorption and emission), quantum mechanical treatment of Franck Condon principle,

UNIT III: X-RAYS SPECTRA

The origin of X-Rays, X-Ray emission spectra, Dependence of position of emission lines on the atomic number, X-Ray emission (Doublet) spectra, Continuous X-ray Emission, X-Ray Absorption spectra.

UNIT IV: NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY

The principle of NMR, NMR spectrometer, Types of NMR, Types of nuclei viewed from the stand point of NMR, High Resolution and Broad line NMR. Relaxation mechanisms, chemical shift; spin-spin coupling. Applications of NMR spectroscopy, Transition probability and selection rules

UNIT V: ELECTRON SPIN RESONANCE SPECTROSCOPY AND LASER

ESR spectrometer, substances which can be studied by ESR, Resonance condition. Description of ESR by Precession, Relaxation mechanisms, Features of ESR spectra (a) the g factor (b) Fine structure (c) hyperfine structure (d) ligand hyperfine structure. Applications of ESR, Three-/four-level laser schemes

TEXT BOOKS

1. H.E. White, Introduction to Atomic spectra, McGraw-Hill Kogakusha, LTD., 1934.
2. C.N. Banwell, Fundamental of Molecular spectroscopy, McGraw Hill Education (India) pvt LTD, 5th Edition, 2013.
3. G. Herzberg, Atomic spectra & atomic structure, Dover Publications Inc., 2nd Edition,2003.
4. Bransden and Joachain , Physics of Atoms and Molecule, Pearson, 2nd Edition, 2003.
5. J. M. Brown, Molecular spectroscopy. Oxford Chemistry Primers, 1998.
6. P.F. Bernath , Spectra of Atoms and Molecule, OUP USA, 2nd Edition, 2005
7. G. M. Barrow, Introduction to Molecular spectroscopy, McGraw-Hill, 1962.

REFERENCE BOOK

1. Laser- Theory and Application, K. Thyagrajan and A. K. Ghatak
2. Principle of Fluorescence spectroscopy, Lacowicz
3. Theory & Interpretation of Fluorescence and Phosphorescence, Ralp

SEMICONDUCTOR PHYSICS	
Course Code: 25PHBS802	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To impart the basic knowledge on band theory of solids and conductivity in semiconductors.
2. To develop understanding of the role Fermi level in semiconductors.
3. To develop the understanding of the various semiconductor device working.
4. To impart the knowledge on IC fabrication technology
5. To make students familiar with the concept of Lithography

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Fluent with good knowledge the conductivity in intrinsic and extrinsic semiconductors
2. Get an understanding of the concept of direct and indirect band gap semiconductors
3. Able to understand the with the conductivity at the metal semiconductor interface
4. Well-versed with the principles behind FET, MOSFET, JFET, CMOS, RAM.
5. Able to get knowledge on Lithography.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)				
	CLO1	CLO2	CLO3	CL04	CL05
CO1	■				
CO2		■			
CO3			■		
CO4				■	
CO5					■

COURE CONTENTS

UNIT I: BAND THEORY OF SOLIDS

Kronig-Penny model, Bandgaps in semiconductors - Holes and effective mass concept, Fermi distribution and energy - Density of states - Valance and conduction band density of states - intrinsic carrier concentration - intrinsic Fermi level. Extrinsic semiconductors: n and p type doping - Densities of carriers in extrinsic semiconductors and their temperature dependence - extrinsic semiconductor Fermi energy level - Degenerate and non - degenerate semiconductors - Bandgap engineering.

UNIT II: CURRENTS IN SEMICONDUCTOR

Thermal motion of carriers, Carrier motion under electric field, Drift current, Mobility and conductivity, Velocity saturation, Diffusion of carriers, General expression for currents in semiconductor, Carrier concentration and mobility, and the Van der Paw technique. drift current density – mobility effects – conductivity – carrier diffusion – diffusion current density – total current density – graded impurity distribution – induced electric field – Einstein relation – Hall Effect.

UNIT III: CARRIER DYNAMICS IN SEMICONDUCTORS

Electronic transitions in semiconductor, Radiative transition, Direct and indirect bandgap semiconductors, Roosbroeck-Shockley relationship, Radiative transition rate at non-equilibrium, Minority carrier lifetime, Localized states, Recombination center and trap, Shockley-Hall-Reed recombination, Surface recombination, Auger recombination, Derivation of continuity equation, Non-equilibrium carrier concentration, Quasi-Fermi level, Current and quasi-Fermi level, Non-uniform doping, and Non-uniform bandgap.

UNIT IV: SEMICONDUCTOR DEVICES AND IC FABRICATION TECHNOLOGY

Metal-semiconductor and Semiconductor heterojunctions – Schottky Barrier Diode – metal-semiconductor ohmic contacts – heterojunctions – bipolar transistor – Metal-Oxide semiconductor Field-Effect Transistor – Junction Field-Effect Transistor – MOSFET (n-MOS, p-MOS) and CMOS. Static and dynamic RAM, nonvolatile memories. Optical and magnetic memories Solar cell- basic characteristics – spectral response – recombination current and series resistance. MOSFET fabrication process. Substrate, dielectric, conducting and resistive layers. Lithography. Diffusion of impurities and deposition techniques.

TEXTBOOKS

1. Semiconductors, R.A. Smith (Academic Publishers).
2. Semiconductor Physics And Devices, Donald A. Neamen(Tata McGraw-Hill).
3. Fundamentals of Semiconductor Devices by Joseph Lindmayer, Charles Y. Wrigly(Litton Educational Publishing Inc.).

REFERENCE BOOKS

1. Physics of Semiconductor Devices, S.M.Sze (John Wily & Sons).
2. The Physics of Semiconductors, K. F. Brennan (Cambridge Univ.Press).
3. Fundamentals of Semiconductors, P. Y. Yu and M. Cardona, (Springer)

STATISTICAL MECHANICS - II	
Course Code: 25PHBS803	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	Course Type: MAJOR COURSE
Prerequisite: Basic knowledge about thermodynamics	

COURSE OBJECTIVES (CO):

1. To state the correlation between thermodynamic quantities and statistical parameters.
2. To explain thermodynamic behaviour of different basic systems using different ensembles and applicability of classical statistics for different particle systems.
3. To illustrate the applicability of quantum statistics for different particle systems.
4. To analyse the fluctuations and thermodynamic irreversible processes.
5. To compare the phase transition and its explanation based on different models.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able:

1. Underline various statistical terms and their relations with thermodynamic quantities.
2. Compare different ensembles and partition function.
3. Demonstrate the quantum statistics of ideal gases.
4. Comply fluctuations and thermodynamic irreversible processes.
5. Evaluate the phase transition and different models.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

UNIT-I: STATISTICAL BASIS OF THERMODYNAMICS

Objective of statistical mechanics, Central Limit Theorem, Microstates, Macrostates, Phase space and ensembles, Ensemble average and time average, Ergodic hypothesis, Postulatesof equal a-priori probability, Contact between statistics and thermodynamics: Boltzmann's postulate of entropy, Classical ideal gas, Entropy of Mixing, Gibbs paradox and its solution, Liouville’s theorem.

UNIT-II: CLASSICAL STATISTICAL MECHANICS

Theory of Microcanonical, Canonical, and Grand Canonical ensembles. Partition function Contact with thermodynamics, Helmholtz and Gibbs free energies, Applications to classical ideal gas and systems of harmonic oscillators. Equipartition and Virial Theorems. Density and energy fluctuations, Chemical equilibrium and Saha Ionization Equation.

UNIT-III: QUANTUM STATISTICS OF IDEAL GASES

Quantum states and phase space, Density matrices, Density matrix in statistical mechanics, Quantum Liouville theorem, Some simple applications (Harmonic oscillators, Free particles in a box). Statistical Mechanics of Ideal Bose and Fermi gases, Bose-Einstein Condensation, Phonon gas, Electron gas in a Metal.

UNIT IV: FLUCTUATIONS AND IRREVERSIBLE PROCESSES

Illustration of Fluctuation: molecules in two halves of a box, fluctuations in ensembles, probability of one-dimensional random walk, motion due to fluctuating force: Fokker Planck equation, Thermodynamic irreversible processes: Linear Law and ONSAGER Reciprocal Relations, Applications of Onsager relations.

UNIT V: THEORY OF PHASE TRANSITIONS

Triple Point, Van der Waal’s equation and phase transitions, Critical exponents, Ising Model, One and two-dimensional Ising model, Yang and Lee theory of phase transitions, Landau theory of phase transitions, explanation of second order phase transition in magnetic materials.

TEXTBOOKS

1. R.K. Pathria and P. D. Beale, Statistical Mechanics, Academic Press, 3rd edition, 2011.
2. F. Reif, Fundamentals of Statistical and Thermal Physics, Waveland Press, 2010.
3. K. Huang, Statistical Mechanics, Wiley, 2nd edition, 2008
4. B.B. Laud, Fundamental of Statistical Mechanics, New Age International Publishers, 2020.
5. B.K. Agarwal and M. Eisner, Statistical Mechanics, New Age International, 3rd Edition, 2020.
6. C. Kittel, Elementary Statistical Physics, Dover Publications, 2004.
7. L.D. Landau, E.M. Lifshitz, Statistical Physics, Butterworth-Heinemann Ltd., 3rd Edition, 1996.

REFERENCE BOOK

1. M. Plischke and B. Bergersen, Equilibrium Statistical Physics, World Scientific Publishing, 3rd Edition, 2006.
2. R. P. Feynman, Statistical Mechanics A set of lectures, West View Press Inc, Ist Edition, 1998.

List of Interdisciplinary Courses (IDC) / Minor Stream Courses (MSC) offered to Four Year B.Sc. Physics programme in the Department of Physics w.e.f. Academic Year 2025-26

S. No	Cat.	Course code	Course title	Department	L	T	P	C
1	IDC	24MABS001	Introduction to Algebra	Mathematics	3	1	0	4
2		24MABS002	Differential calculus	Mathematics	3	1	0	4
3		24MABS003	Differential Equations	Mathematics	3	1	0	4
4		24MABS004	Statistical Methods and Probability	Mathematics	3	1	0	4
5		24CYBS001	Physical Chemistry I	Chemistry	3	1	0	4
6		24CYBS002	Inorganic Chemistry	Chemistry	3	1	0	4
7		24CYBS003	Physical Chemistry II	Chemistry	3	1	0	4
8		24CYBS004	Analytical Chemistry	Chemistry	3	1	0	4
9	MSC	25PHBS001	Waves and Oscillations	Physics	2	0	0	2
10		25PHBS051	Waves and Oscillations Lab	Physics	0	0	4	2
11		25PHBS002	Biophysics	Physics	3	1	0	4
12		25PHBS003	Solid State Devices	Physics	3	0	0	3
13		25PHBS053	Solid State Devices Lab	Physics	0	0	2	1
14		25PHBS004	Radiation Physics	Physics	3	1	0	4
15		25PHBS005	Numerical Analysis	Physics	3	0	0	3
16		25PHBS055	Numerical Analysis Lab	Physics	0	0	2	1
17		25PHBS006	Statistical Analysis in Physics	Physics	2	0	0	2
18		25PHBS056	Statistical Analysis in Physics Lab	Physics	0	0	4	2
19		25PHBS007	Advanced Mathematical Physics I	Physics	3	0	0	3
20		25PHBS057	Computational Physics lab III	Physics	0	0	2	1
21		25PHBS008	Astronomy & Astrophysics	Physics	3	1	0	4
22		25PHBS009	Atmospheric Physics	Physics	3	1	0	4
23		25PHBS010	Advanced Mathematical Physics II	Physics	3	1	0	4
24		25PHBS011	Renewable Energy Physics	Physics	3	1	0	4
25		25PHBS012	Nanomaterials	Physics	3	1	0	4
26		25PHBS013	Novel & Smart Materials	Physics	3	1	0	4
27		25PHBS014	Soft Matter Physics	Physics	3	1	0	4
28		25PHBS015	Nanomagnetism and Spintronics	Physics	3	1	0	4
29		25PHBS016	Optoelectronics	Physics	3	1	0	4
30		25PHBS017	Nanophotonics	Physics	3	1	0	4
31		25PHBS018	Non-linear spectroscopy	Physics	3	1	0	4

32	25PHBS019	Fiber Optics	Physics	3	1	0	4
33	25PHBS020	Advanced Electronics	Physics	3	1	0	4
34	25PHBS021	Advanced Solid State Physics	Physics	3	1	0	4
35	25PHBS022	Advanced Solid State Physics Lab	Physics	0	0	4	2
36	25PHBS023	Classical Field Theory	Physics	3	1	0	4
37	25PHBS024	Quantum Field Theory	Physics	3	1	0	4
38	25PHBS025	MATLAB	Physics	2	0	4	4
39	25PHBS026	Plasma Physics	Physics	3	1	0	4
40	25PHBS027	Advanced Nuclear Physics	Physics	3	1	0	4
41	25PHBS028	Medical Physics	Physics	3	1	0	4
42	24RMBS710	Research Methodology	Physics	2	0	0	2
43	25PHBS029	Fundamentals of quantum computing	Physics	3	0	0	3
44	25PHBS030	Fundamentals of quantum computing	Physics	0	0	2	1
45	25PHBS031	Quantum algorithms and error correction	Physics	3	0	0	3
46	25PHBS032	Quantum algorithms and error correction lab	Physics	0	0	2	1
47	25PHBS033	Classical and quantum information processing	Physics	3	0	0	3
48	25PHBS034	Classical and quantum information processing lab	Physics	0	0	2	1
49	25PHBS035	Quantum Machine learning	Physics	3	0	0	3
50	25PHBS036	Quantum Machine learning lab	Physics	0	0	2	1
51	25PHBS037	Machine Learning for Physics	Physics	3	1	0	4
52	25PHBS038	Electric Vehicle	Physics	3	1	0	4

INTRODUCTION TO ALGEBRA

Course Code: 24MABS001	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	**Course Category: Interdisciplinary course**
Prerequisite:	

COURSE OBJECTIVE (CO):

1. To introduce the basics of relations and functions
2. To understand the basics of set theory and set algebra
3. To equip the students with basics of matrix and applications
4. To introduce the solutions of system of equations
5. To learn concept of vector identities

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Identify and develop concept of mapping and relations.
2. Solve the basics problems of set theory.
3. Well versed with different type of matrices.
4. Apply matrix method solving system of equations problems.
5. Solve vector identities.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURE CONTENTS

Unit-I

Types of relations: reflexive, symmetric, transitive, equivalence relations and partitions, Definition of function, One to one and onto functions.

Unit-II

The concept of set, some basic notations and definitions subsets, equality of sets, empty set, algebra of sets special sets, ordered Pairs, Cartesian products.

Unit-III

Definitions of matrix, Addition, subtraction and multiplications of matrices, Types of Matrices - Symmetric, Skew symmetric, Hermitian, Skew Hermitian, Orthogonal, Unitary and Normal matrices Elementary Properties of Matrices, Inverse of Matrices, Rank of Matrix, System of Linear Equations, Characteristic Equation, Eigenvalues and properties, Eigen vectors and properties, Cayley-Hamilton Theorem, Diagonolization.

Unit-IV

Vectors and scalars, magnitude and direction of a vector. Types of vectors (equal, unit, zero, parallel and collinear vectors), vector, addition of vectors,

Unit-V

Multiplication of a vector by a scalar, properties and application of scalar (dot) product of vectors, vector (cross) product of vectors, Divergence, Curl, Solenoidal and irrotational vectors, Vector identities.

TEXT BOOK

1. Jain R. K., Iyengar S. R. K., Advanced Engineering Mathematics, 6th edition, Narosa Publishing House, 2019.
2. Dass H. K., Advanced Engineering Mathematics,Sultan Chand Publication, Delhi, 2018.

REFERENCE BOOKS

1. Kreyszig.E, Advanced Engineering Mathematics10th edition, John Wiley &Sons, 2015.
2. Gilbert Strang and Kunze, Linear Algebra, Pearson,5th edition, 2016.

DIFFERENTIAL CALCULUS	
Course Code: 24MABS002	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: ….. Marks
L T P : 3 1 0	**Course Category: Interdisciplinary course**
Prerequisite:	

COURSE OBJECTIVE (CO):

1. To make students aware of different type function and mapping
2. To understand the limit continuity of functions
3. To equip the students with differentiability of functions
4. To introduce the topic of tangent normal and curvature
5. To learn polar coordinate and curve tracing of curve

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Identify and develop concept of mapping of functions.
2. Solve the limit continuity problems of functions.
3. Apply graphical method for test differentiability of function.
4. Well versed with tangent normal and curvature.
5. Solve problems of polar coordinate and curve tracing of curve.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURE CONTENTS

Unit-I

Different types of functions and their graphical representation viz**.** Identity function, linear function, Constant function, Polynomial function, trigonometrical functions, modulus function, signum function, greatest integer function.

Unit-II

Limit and Continuity, Types of discontinuities, continuity and discontinuities by graphs, Limit and Continuity of different type of function viz. modulus function, signum function, greatest integer function, monotonic functions.

Unit-III

Differentiability of functions, differentiability by graphs, Successive differentiation, Leibnitz's theorem, Partial differentiation, Euler's theorem on homogeneous functions.

Unit-IV

Tangents and normals, Curvature, Asymptotes.

Unit-V

Curve Tracing-Cartesion, parametric and polar curves.

TEXT BOOK

1. Shanti Narayan and P.K. Mittal, Differential Calculus, S. Chand &Company, Revised Edition, 2018.
2. Sudhir K Pundir, Bhupendra Singh and SivrajPundir, Calculus, PragtiPrakashan, 2nd Edition, 2003.

REFERENCE BOOKS

1. G.V. Thomas and R.L. Finney, Calculus, Pearson Education, 9th Edition, 2006.
2. Robert T Smith and Roland Minton, Calculus: Early Transcendental Functions, 2011.

DIFFERENTIAL EQUATIONS	
Course Code: 24MABS003	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	**Course Category: Interdisciplinary course**
Prerequisite:	

COURSE OBJECTIVE (CO):

1. To make students aware of the ordinary differential equations.
2. To understand the linear differential equations.
3. To equip the students with Cauchy-Euler equation
4. To introduce the total differential equations
5. To learn classification of second order partial differential equations

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Identify ordinary differential equations.
2. Solve the linear differential equations by various methods.
3. Well versed with Cauchy-Euler equation.
4. Apply the concept of total differential equations.
5. Identify classification of second order partial differential equations.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURE CONTENTS

Unit-I

Introduction, order and degree of differential equation, First order exact differential equations. Integrating factors, rules to find an integrating factor. First order higher degree equations solvable for x, y, p. Methods for solving higher-order differential equations.

Unit-II

Basic theory of linear differential equations, Wronskian, and its properties. Solving a differential equation by reducing its order.

Unit-III

Linear homogenous equations with constant coefficients, Cauchy-Euler equation. Solution of second order differential equation-one part of CF is known, reduction to normal form. Solution of simultaneous differential equations**.**

Unit-IV

Order and degree of partial differential equations, Concept of linear and non-linear partial differential equations, Formation of first order partial differential equations, Linear partial differential equation of first order, Lagrange's method, Charpit's method.

Unit-V

Classification of second order partial differential equations into elliptic, parabolic and hyperbolic through illustrations only. Solution of PDE by separation of variable methods.

TEXT BOOK

1. M D Raisinghania: Differential Equations, S. Chand Publishing, 2020.
2. Shepley L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, 1984.

REFERENCE BOOKS

1. Sneddon, Elements of Partial Differential Equations, McGraw-Hill, International Edition, 1967.

2. George F Simmons: Differential Equations, McGraw Hill Education. 2nd edition Edition,2017.

STATISTICAL METHODS AND PROBABILITY	
Course Code: 24MABS004	Continuous Evaluation: ….. Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	**Course Category: Interdisciplinary course**
Prerequisite:	

COURSE OBJECTIVE (CO):

1. To make students aware of the basics and importance of statistics
2. To understand the Concept of central tendency
3. To equip the students with random experiment, definition of probability
4. To introduce the Bayes theorem and its applications
5. To learn random variable and Concept of discrete random variable

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Identify and develop knowledge of basics and importance of statistics.
2. Solve the problems based on concept of central tendency.
3. Apply the concept of random experiment, definition of probability.
4. Well versed with Bayes theorem and its applications.
5. Solve problems of concept of discrete random variables.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	■				
CO2		■			
CO3			■		
CO4				■	
CO5					■

COURE CONTENTS

Unit-I
Importance of statistics, concepts of statistical population and a sample – quantitative and qualitative data – Collection of primary and secondary data. Designing a questionnaire and a schedule. Classification and tabulation of data.

Unit-II
Measurement scales –nominal, ordinal, interval and ratio. Diagrammatic and Graphical representation of data. Construction of univariate and bivariate frequency distributions. Stem and leaf plot.

Unit-III
Concept of central tendency, Partition values and dispersion, Box plot. Measures of inequality – Gini's Coefficient and Lorenz curve. Skew-ness, kurtosis and their measures based on quartiles and moments.

Unit-IV
Random experiment, definition of probability, classical and relative frequency approach to probability, axiomatic approach to probability and its properties, merits and demerits of these approaches, total and compound probability, conditional probability theorems, independence of events, Bayes theorem and its applications.

Unit-V
Random Variable: Concept of discrete random variable, probability mass function and distribution function, joint probability mass function of several discrete random variables, marginal and conditional probability mass functions. Continuous random variable: Probability density function, distribution function.

TEXT BOOK

1. S.C Gupta & V.K. Kapoor, Fundamentals of Mathematical Statistics, 11th edition, Sultan Chand& sons, reprint, 2007.

REFERENCE BOOKS

1. Mood A.M., Greybill F.A. and Bose D.C., Introduction to the Theory of Statistics, McGraw Hill, 3th Edition, 1974.
2. Goon A.M., Gupta M.K. and Das Gupta B., Fundamental of Statistics, Vol. I, World PressPrivate Ltd, 2013.
3. P. R. Vittal, Mathematical Statistics, Margham Publications, Chennai, 2013

PHYSICAL CHEMISTRY-I	
Course Code: 24CYBS001	Continuous Evaluation: ….. Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	**Course Category: Interdisciplinary course**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. To be familiar with the terminologies of thermodynamics and the concept of heat, work and internal energy.
2. To understand the concept of kinetic theory of gases, behaviour of real gases.
3. To discuss the fundamental of radioactivity, radioactive decay and radioactive measurement.
4. To be familiar with the concept of Miller indices, symmetry element, and X-ray diffraction in solids.
5. To learn X-ray diffraction techniques.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Calculate the heat flow into and work done by a system and how that is constrained by the first law of thermodynamics.
2. Explain the behaviour of ideal and real gases.
3. Describe various radioactive decay process, decay kinetics and to measure the radioactivity.
4. Demonstrate the symmetry elements and symmetry operation, lattice parameters using the X-ray diffraction pattern.
5. Apply X-ray diffraction techniques in structural characterization.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

UNIT-I: THERMODYNAMICS

Intensive and extensive variables; state and path functions; isolated, closed and open systems. Concept of heat Q, work W, internal energy U, and statement of first law; enthalpy H, relation between heat capacities, Concept of entropy; Calculation of entropy change for reversible and irreversible processes, Statement of third law.

UNIT-II: KINETIC THEORY OF GASES

Kinetic theory of gases, deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waals equation of state for real gases, Boyle's temperature, critical constants and their calculation from van der Waals equation, critical phenomenon, Andrew's isotherms of CO_2, Maxwell-Boltzmann distribution laws of molecular velocities and molecular energies and their importance, most probable, average and root mean square velocities.

UNIT-III: NUCLEAR CHEMISTRY

Fundamentals of radioactivity and decay, Radioactive decay, decay kinetics, parent daughter decay growth relationship, concepts of transient and secular equilibrium, alpha, beta and gamma decay, artificial radioactivity.

UNIT-IV: SOLID STATE CHEMISTRY:

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices;

UNIT-V: X-RAY DIFFRACTION TECHNIQUES

X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method.

TEXT BOOKS

1. Kapoor, K. L. Physical Chemistry, MacGraw Hill Publications, 2012.
2. A. R. West, Solid state chemistry and its applications, John Wiley & Sons, 1989.
3. H. J. Arnikar, Essentials of Nuclear Chemistry, New Age International Publishers, 2011.
4. N. R. Rao and J. Gopalkrishanan, New directions in solid state chemistry, Cambridge Univ. Press, 1997.

REFERENCE BOOKS

1. L. Smart and E. Moore, Solid State Chemistry, Chapman and Hall, 1992.
2. K. Cheetham and P. Day, Solid state chemistry compounds, Clarendon Press, Oxford, 1992.
3. Atkins, P. Paula, J.P. Physical Chemistry, Oxford University Press 2018.

INORGANIC CHEMISTRY	
Course Code: 24CYBS002	Continuous Evaluation: ….. Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	**Course Category: Interdisciplinary course**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. To describe the atomic structure and shape of orbitals.
2. To be familiar explain the concept of ionic bonding.
3. To be familiar explain the concept of covalent bonding.
4. To demonstrate the structure and properties of important coordination compounds.
5. To learn the structure and properties of few important compounds.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Describe the atomic structure and shape of orbitals.
2. Explain the concept of concept of ionic bonding.
3. Explain the concept of concept of covalent bonding
4. Demonstrate the structure and properties of important coordination compounds.
5. Apply the methods to get the structure of few important compounds.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURE CONTENTS

Unit-I: ATOMIC STRUCTURE

Review of Bohr's theory and its limitations, Heisenberg Uncertainty principle. Dual behaviour of matter and radiation, de-Broglie's relation. Hydrogen atom spectra. Quantum mechanics: Time independent Schrodinger equation significance of ψ and ψ^2, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydrogenic wavefunctions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers m_l and m_s. Shapes of s, p and d atomic orbitals, nodal planes. Discovery of spin, spin quantum number (s) and magnetic spin quantum number (m_s). Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals.

Unit II: IONIC BONDING

General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy (no derivation), Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

Unit III: COVALENT BONDING

VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR (H2O, NH3, PCl5, SF6, ClF3, SF4) and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds.

Unit IV:

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+

Unit V: STRUCTURE AND PROPERTIES OF FEW IMPORTANT COMPOUNDS

A study of the following compounds (including preparation, Bonding and important properties); Peroxo compounds of Cr, $K_2Cr_2O_7$, $KMnO_4$,$K_4[Fe(CN)_6]$, $K_3[Fe(CN)_6]$, sodium nitroprusside, $[Co(NH_3)_6]Cl_3$,Na_3 $[Co(NO_2)_6]$,Borazine, boranes, oxoacids of sulphur & phosphorus, pseudohalogen, phosphazene, silicates & silicones.

TEXT BOOKS

1. J. D. Lee, A New Concise Inorganic Chemistry, Blackwell Science. 2008.
2. F. A. Cotton & G. Wilkinson, Basic Inorganic Chemistry, Wiley, 1994.

REFERENCE BOOKS

1. Douglas, McDaniel and Alexader, Concepts and Models in Inorganic Chemistry, John Wiley& Sons, 1994.

PHYSICAL CHEMISTRY-II

Course Code: 24CYBS003	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	**Course Category: Interdisciplinary course**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. To be familiar with the postulates of quantum chemistry and its application to simple system.
2. To describe the concept and application of rotational spectroscopy.
3. To explain the concept application of vibrational spectroscopy.
4. To demonstrate the structure and properties of compounds using electronic spectroscopy.
5. To learn fluorescence and phosphorescences

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Apply the postulates of quantum chemistry and to simple system.
2. Describe the applications of rotational spectroscopy.
3. Explain vibrational energy and transitions in molecules.
4. Demonstrate the structure and properties of compounds using electronic spectroscopy.
5. To explain the Lambert Beer's Law and concept of Fluorescence.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit –I: QUANTUM CHEMISTRY

Postulates of quantum mechanics, Born Interpretation, quantum mechanical operators; linear and Hermitian operator, Free particle, Particleina1-Dbox (complete solution), quantization, normalization of wave functions, concept of zero-point energy, extension to particle in two-D and three-D box.

Unit –II: ROTATIONAL SPECTROSCOPY:

Schrödinger equation of a rigid rotator and brief discussion of its results (solution not required). Wave function of rigid rotator, Quantization of rotational energy levels. Microwave(pure rotational), spectra of diatomic molecules. Effect of isotopic substitution on spectra, Selection rules. Structural in formation derived from rotational spectroscopy.

Unit –III: VIBRATIONAL SPECTROSCOPY:

Schrödinger equation of a linear harmonic oscillator and brief discussion of its results (solution not required). Quantization of vibrational energy levels. Wave function of simple harmonic oscillator, Selection rules, IR spectra of diatomic molecules. Structural information derived from vibrational spectra. Normal modes of vibrations. Vibrations of polyatomic molecules. Group frequencies.

Unit –IV: ELECTRONIC SPECTROSCOPY

Electronic excited states. Selection rules, Free Electron model and its application to electronic spectra of polyenes. Energy levels in organic compounds, Colour and constitution, chromophores, auxochromes, bathochromic and hypsochromic shifts.

Unit- V:

Lambert-Beer's law. Fluorescence and phosphorescence. Quantum efficiency and reasons for high and low quantum yields.

TEXT BOOKS

1. B. R. Puri, L. R. Sharma & M.S. Pathania, Principles of Physical Chemistry, Vishal Pub. Co., 2020.
2. P.W. Atkins, Physical Chemistry, Oxford University Press, 1997.
3. A.K. Chandra, Introductory Quantum Chemistry, Tata McGraw Hill, 1994.
4. C. N. Banwell, and Elaine McCash, Fundamentals of molecular spectroscopy, McGraw Hill Education, 1994.

REFERENCE BOOKS

1. G. M. Barrow, Physical Chemistry, TataMcGraw-Hill, 2007.
2. I.M. Levine, Quantum Chemistry, Prentice Hall, 2013.
3. P.W. Atkins & R.S. Friedman, Molecular Quantum Mechanics, Oxford University Press, 1997.

ANALYTICAL CHEMISTRY

Course Code: 24CYBS004	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	**Course Category: Interdisciplinary course**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. To understand the qualitative and quantitative aspects of analysis.
2. To be familiar explain the thermal methods of analysis.
3. To understand the different electroanalytical techniques.
4. To demonstrate the use of various separation methods.
5. To learn Chromatography.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Apply the data analysis in qualitative and quantitative estimation.
2. Explain the principle and applications of thermal methods of analysis.
3. Illustrate principle and applications of different electroanalytical methods.
4. Demonstrate various techniques in separation of different compounds.
5. Learn various aspects of Chromatography

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit-I: QUALITATIVE AND QUANTITATIVE ASPECTS OF ANALYSIS

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution of indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.

Unit II: THERMAL METHODS OF ANALYSIS
Theory of thermogravimetry (TG), Techniques: TGA, DTA, DSC, their basic principle &instrumentation. Quantitative estimation of Ca and Mg from their mixture.

Unit III: ELECTROANALYTICAL METHODS
Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values.

Unit IV: SEPARATION TECHNIQUES:
Solvent extraction**:** Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions.

Unit V: CHROMATOGRAPHY:
Classification types based on interactions, stationary phase, mobile phase. Principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods.

TEXT BOOKS

1. D. A. Skoog, F.J. Holler and T. A. Nieman, Principles of Instrumental Analysis*,* Thomson Asia Pvt. Ltd. Singapore, 1998.
2. O. Mikes, and R. A. Chalmers, Ed. Laboratory Hand Book of Chromatographic and Allied
3. Methods, Elles Horwood Ltd. London, 1979.
4. R. V. Dilts Analytical Chemistry – Methods of separation, Van Nostrand Reinhold Company, 1974.

REFERENCE BOOKS

1. Vogel, I. Arthur: A Textbook of Quantitative Inorganic Analysis, The English Language Book Society of Longman, 1989.
2. Willard, H. Hobart: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing
3. Company, Belmont, California, USA, 2001.
4. Gary D. Christian, Analytical Chemistry, John Wiley & Sons, New York, 2007.
5. Daniel C. Harris, Exploring Chemical Analysis, W.H. Freeman & Co Ltd. 2012.
6. S. M. Khopkar, Basic Concepts of Analytical Chemistry, New Age International Publisher, 2008.

WAVES AND OSCILLATIONS	
Course Code: 25PHBS001	Continuous Evaluation: …. Marks
Credits: 2	End Semester Examination: … Marks
L T P : 2 0 0	**Course Category: Minor Stream Course theory**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. To make students familiar with the basic of simple harmonic motion and superposition of harmonic oscillations.
2. Demonstrate the damped oscillations.
3. Explain the motion of an oscillator under the effect of different forces
4. Illustrate the concept of coupled oscillations.
5. Solving the wave equations for the waves on stretched strings.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Get better understanding of SHM and superposition of waves.
2. Can observe the damped oscillations and differentiate different type of damped oscillations.
3. Solve the problems related to forced oscillator
4. Can calculate the energy transfer and energy relations for coupled oscillators.
5. Solve the wave equations for waves on stretched strings.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	■				
CO2		■			
CO3			■		
CO4				■	
CO5					■

COURSE CONTENTS

Unit I: Simple Harmonic Motion

Differential equation of simple harmonic oscillator, its solution and characteristics, energy in simple harmonic motion, linearity and superposition principle, rotating vector representation of simple harmonic oscillation, motion of simple and compound pendulum (Bar and Kater's pendulum), loaded spring. Superposition of N collinear harmonic oscillations with (1) equal phase differences and (2) equal frequency differences, Beats Superposition of two perpendicular harmonic oscillations: Graphical and Analytical Methods. Lissajous Figures with equal and unequal frequencies, effect of variation of phase

Unit II: DAMPED OSCILLATIONS

Damped Oscillations: Equation of motion, dead beat motion, critically damped system, lightly damped system: relaxation time, logarithmic decrement, quality factor

Unit III: FORCED OSCILLATIONS

Forced Oscillations: Equation of motion, complete solution, steady state solution, resonance, sharpness of resonance, power dissipation, quality factor

Unit IV: COUPLED OSCILLATIONS

Coupled oscillators, normal coordinates and normal modes, energy relation and energy transfer, di-atomic molecules, representation of a general solution as a linear sum of normal modes, normal modes of N coupled oscillators.

Unit V: WAVE MOTION

One dimensional plane wave, classical wave equation, standing wave on a stretched string (both ends fixed), normal modes. Travelling wave solution

TEXTBOOKS

1. A. P. French, Vibrations and Waves, CBS Pub. and Dist., 1987
2. N.K. Bajaj , The Physics of Waves and Oscillations, Tata McGraw-Hill, 1988
3. K. Uno Ingard, Fundamentals of Waves and Oscillations, Cambridge University Press, 1988.
4. Daniel Kleppner, Robert J. Kolenkow , An Introduction to Mechanics, McGraw-Hill, 1973.
5. Franks Crawford, Waves: BERKELEY PHYSICS COURSE, Tata McGrawHill, 2007.
6. Peter Dourmashkin Classical Mechanics by, John Wiley and Sons

REFERENCE BOOKS

1. https://phys.libretexts.org/Bookshelves/Classical_Mechanics/classical_Mechanics_(Dou r mashkin) Suggestive Readings:
2. Fundamentals of Physics, Wiley, 2013.
3. R. P. Feynman, R. B. Leighton, M. Sands, 2008, Feynman Lectures, Vol. 1, Pearson Education.
4. H. D. Young, R. A. Freedman, University Physics, Pearson Education.
   2015,

WAVES AND OSCILLATIONS LAB	
Course Code: 25PHBS051	Continuous Evaluation: …. Marks
Credits: 2	End Semester Examination: …. Marks
L T P : 0 0 4	**Course Category: Minor Stream Course lab**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. To provide students with a comprehensive understanding of the fundamental principles of waves and oscillations through hands-on experiments and practical applications.
2. To bridge the gap between theoretical concepts and real-world phenomena, enabling students to develop critical thinking, experimental skills, and a deeper appreciation for the role of waves and oscillations in various physical systems.
3. Designing, conducting, and analysing experiments related to wave propagation, harmonic motion, resonance, and other oscillatory phenomena.
4. Understand the applications of CRO.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Demonstrate a solid understanding of the basic principles of waves and oscillations, including wave properties, harmonic motion, and resonance.
2. Design and conduct experiments to investigate various wave and oscillatory phenomena. This includes selecting appropriate equipment, setting up experiments correctly, and ensuring accurate data collection.
3. Analyse experimental data using appropriate techniques and tools. Interpret the results to draw meaningful conclusions about the behaviour of waves and oscillations.
4. Recognize and appreciate the relevance and application of waves and oscillation principles in various real-world contexts, such as engineering, medicine, and environmental science.
5. Can use CRO in different practical applications.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					.

COURSE CONTENTS

1) Experiments using bar pendulum:
   a) Estimate limits on angular displacement for SHM by measuring the time period at different angular displacements and compare it with the expected value of time period for SHM.
   b) Determine the value of g using bar pendulum.
   c) To study damped oscillations using bar pendulum
   d) Study the effect of area of the damper on damped oscillations. Plot amplitude as a function of time and determine the damping coefficient and Q factor for different dampers.
2) To determine the value of acceleration due to gravity using Kater's pendulum for both the cases (a) $T_1 \approx T_2$ and (b) $T_1 \neq T_2$ and discuss the relative merits of both cases by estimation of error in the two cases.
3) Understand the applications of CRO by measuring voltage and time period of a periodic waveform using CRO. And study the superposition of two perpendicular simple harmonic oscillations using CRO (Lissajous figures)
4) Experiments with spring and mass system
   a) To calculate g, spring constant and mass of a spring using static and dynamic methods.
   b) To calculate spring constant of series and parallel combination of two springs.
5) To study normal modes and beats in coupled pendulums or coupled springs.
6) To determine the frequency of an electrically maintained tuning fork by Melde's experiment and to verify $\lambda 2$ – T Law.
7) To determine the current amplitude and phase response of a driven series LCR circuit with driving frequency and resistance. Draw resonance curves and find quality factor for low and high damping.

TEXTBOOKS

1. B. L. Flint and H. T. Worsnop ,Advanced Practical Physics for students, Asia Publishing House, 1971.
2. S. Panigrahi and B. Mallick , Engineering Practical Physics, Cengage Learning India Pvt. Ltd., , 2015.
3. G. L. Squires, Practical Physics, Cambridge University Press, 2015.

REFERENCE BOOKS

1. Prakash and Ramakrishna, A Text Book of Practical Physics, Vol I and II, Kitab Mahal, 2011
2. J. R. Taylor ,An Introduction to Error Analysis: The study of uncertainties in Physical Measurements, University Science Books List of experiments, 1997.

BIOPHYSICS	
Course Code: 25PHBS002	Continuous Evaluation: ….. Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	**Course Category: Minor Stream Course Theory**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. Explain the basic principles of biophysics, including the physical principles underlying biological processes.
2. Apply physical principles to analyze and model molecular interactions in biological macromolecules.
3. Analyze data related to biophysical techniques, such as spectroscopy and microscopy.
4. Evaluate the impact of biophysical forces and mechanisms on cellular functions and processes.
5. Build strategies to investigate specific biophysical properties of biomolecules or cellular structures.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would:

1. Outline key terms and concepts related to molecular biophysics, cellular mechanics, and bioenergetics.
2. Demonstrate the ability to calculate forces and energies in biophysical systems using appropriate equations.
3. Differentiate between different biophysical methods and their applications in studying biological systems.
4. Review the limitations and potential artifacts of biophysical techniques and propose solutions for improving accuracy.
5. Develop innovative approaches to address biological questions using biophysical methods.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs’)	Course Learning Outcomes (CLOs’)				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit-I: INTRODUCTION OF BIOPHYSICS
Physical properties applied to biology- Surface tension, Viscosity, adsorption, diffusion, osmosis, dialysis and colloids Genetic code- symmetry, Introduction to amino acids, DNA structure.

Unit-II: BIOPOTENTIALS
Bioelectric signals: structure of neuron, resting potential, action Potential, Nernst equation Compound action potentials of the human body ECG, EEG, ERG, EOG (in brief) Transducers: Definition, types- resistive, capacitive and inductive transducers, LVDT, photo diode

Unit-III: BIOINSTRUMENTS
Basic principle, Construction and working of colorimeters, spectrophotometer, ECG machine, PH meter, Centrifuge measurement.

Unit-IV: RADIATION BIOPHYSICS
Definition, Units of Radioactivity and radiation doses, X-Ray Crystallography as a method for a structure determination of biomolecules, Nuclear Magnetic Resonance (NMR). Nuclear detector (G M Counter)

Unit-V: BIOMETRY AND ELECTRON MICROSCOPY
Biostatistics and Biometry, Definition and concept in brief.Electron microscope: Scanning Electron Microscope (SEM), Transmission Electron Microscopy (TEM)

TEXT BOOKS
1. P. Narayanan, Introduction to Biophysics, New Age P.
2. Khandpur , Medical Instrumentation, TMH
3. P.B. Vidyasagar, Laboratory Manuals of Biophysics Instruments.

REFERENCE BOOKS
1. Vatsala Piramal ,Biophysics, Dominant Publisher and Distributors, New Delhi-110002
2. R.N. Roy, Biophysics
3. Hall and Rao, Photosynthesis.

SOLID STATE DEVICES	
Course Code: 25PHBS003	Continuous Evaluation: …. Marks
Credits: 3	End Semester Examination: ….. Marks
L T P : 3 0 0	**Course Category: Minor Stream Course Theory**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. To recall the fundamental principles of semiconductor physics.
2. To develop the ability to analyse the electrical properties of semiconductors.
3. To demonstrate with the principles of rectifiers and its applications in various devices.
4. To discuss the behaviour of electrons and holes in semiconductors and their role in electronic devices.
5. To assess the importance of semiconductors in modern technology and its impact on various industries.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Explain the concept of energy bands and bandgap in semiconductors and describe their significance in electronic behaviour.
2. Explain the characteristics and applications of various electronic components.
3. Analyse the concept of diode in both half and full rectifier.
4. Differentiate between intrinsic and extrinsic semiconductors and explain the role of dopants in controlling carrier concentrations.
5. Appraise the importance of semiconductors in modern technology, including integrated circuits, communication devices, and renewable energy systems.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)				
	CLO1	CLO2	CLO3	CL04	CL05
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

UNIT I: BAND THEORY OF SOLIDS

Band theory of solids -Fermi distribution and energy - Density of states - Valence and conduction band density of states - intrinsic carrier concentration - intrinsic Fermi level. Extrinsic semiconductors: n and p type doping - Densities of carriers in extrinsic semiconductors and their temperature dependence - extrinsic semiconductor Fermi energy level.

UNIT II: SEMICONDUCTOR DIODES

P and N type semiconductors. Energy Level Diagram, Conductivity and Mobility, Concept of Drift velocity. Barrier Formation in PN Junction Diode. Derivation for Barrier Potential, Barrier Width and Current for abrupt Junction. Equation of continuity, Current Flow Mechanism in Forward and Reverse Biased Diode, Static and Dynamic Resistance.

UNIT III: RECTIFIERS

Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency,

UNIT IV: CURRENTS AND CARRIER IN SEMICONDUCTOR

Carrier motion under electric field, Drift current, Diffusion of carriers, General expression for currents in semiconductor, Electronic transitions in semiconductor, Radiative transition, Roosbroeck-Shockley relationship, Recombination center and trap, Shockley-Hall-Reed recombination, Surface recombination, Auger recombination.

UNIT V: SEMICONDUCTOR DEVICES

Direct and Indirect bandgap semiconductor, Zener Diode and Voltage Regulation, Tunnel diode, LDR, LED, Photodiode, Photovoltaic effect, Solar cell, Hall effect.

TEXTBOOKS

1. R.A. Smith, Semiconductors, Academic Publishers.
2. Donald A. Neamen, Semiconductor Physics And Devices, Tata McGraw-Hill.
3. Joseph Lindmayer, Charles Y. Wrigly, Fundamentals of Semiconductor Devices, Litton Educational Publishing Inc..
4. D.A. Neamen, Semiconductor Physics and Devices 3rd Ed., Tata McGraw-Hill.

REFERENCE BOOKS

1. S.M. Sze, Physics of Semiconductor Devices, John Wily & Sons.
2. K. F. Brennan, The Physics of Semiconductors, Cambridge Univ. Press.
3. P. Y. Yu and M. Cardona, Fundamentals of Semiconductors, Springer.
4. C. Kittel, Introduction to Solid State Physics- 6th Ed., Willey.

SOLID STATE DEVICES LAB	
Course Code: 25PHBS053	Continuous Evaluation: …. Marks
Credits: 1	End Semester Examination: … Marks
L T P : 0 0 2	**Course Category: Minor Stream Course Lab**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. Recall the fundamental concepts of electronic components, such as resistors, capacitors, and transistors and explain the principles of circuit analysis and behavior of electronic components.
2. Apply circuit analysis techniques to design and construct basic electronic circuits.
3. Analyze the behavior of complex electronic circuits and troubleshoot common issues.
4. Evaluate the performance of electronic circuits, considering factors like gain, bandwidth, and noise.
5. Design and build advanced electronic circuits, such as audio amplifiers, filters, and timers.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would:

1. Summarize the characteristics of different amplifier configurations, filters, and oscillators.
2. Demonstrate the ability to measure voltage, current, and impedance using appropriate instruments.
3. Differentiate between different types of amplifiers and their frequency responses.
4. Critique the limitations of components and their impact on circuit functionality.
5. Develop projects that integrate multiple electronic components to achieve specific functionalities.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)				
	CLO1	CLO2	CLO3	CL04	CL05
CO1					
CO2					
CO3					
CO4					
CO5					

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum ----- of experiments)

1. Measurement of energy band gap of Si using a p-n junction diode
2. To study charging and discharging of capacitor and determination of RC time constant
3. To study V-I characteristics of PN junction diode, and Light emitting diode
4. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
5. Study of V-I & power curves of solar cells and find maximum power & efficiency.
6. Glow an LED via USB port of PC.
7. Sense the input voltage at a pin of USB port and subsequently glow the LED connected with another pin of USB port.
8. To study the characteristics of half wave with and without filter and calculate the ripple factor, rectification efficiency and % regulation.
9. To study the characteristics of full wave with and without filter and calculate the ripple factor, rectification efficiency and % regulation.
10. To study the characteristics of bridge wave rectifier with and without filter and calculate the ripple factor, rectification efficiency and % regulation.

TEXTBOOKS

1. Chauhan and Singh , Advanced practical physics, Revised edition, Pragati Prakashan Meerut, 1985

REFERENCE BOOKS

1. Chattopadhyay, D., Rakshit, P. C and Saha, B., An advanced Course in Practical Physics, 2nd edition, Books & Allied Ltd, Calcutta, 1990

RADIATION PHYSICS	
Course Code: 25PHBS004	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	**Course Category: Minor Stream Course Theory**
Prerequisite: NIL	

COURSE OBJECTIVES (CO):

1. Explain the principles of radiation interaction with matter, including the processes of absorption, scattering, and attenuation.
2. Apply mathematical equations to calculate radiation dose, exposure, and shielding requirements.
3. Analyze the factors affecting radiation dose distribution in different materials and tissues.
4. Evaluate the risks and benefits of radiation-based medical imaging techniques, such as X-rays and CT scans.
5. Design shielding strategies for radiation protection in medical, industrial, and research environments.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would:

1. Infer the biological effects of radiation exposure and the factors influencing dose distribution.
2. Display the ability to use dosimetry techniques to measure and assess radiation levels.
3. Differentiate between different types of radiation detectors and dosimeters and their applications.
4. Examine the safety protocols and regulations for handling radiation sources in various settings.
5. Develop protocols for radiation safety and emergency response procedures.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs’)		Course Learning Outcomes (CLOs’)			
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit-I: LOW AND HIGH ENERGY RADIATION

Introduction to Microwave and Radio waves covering spectrum, power levels and detection methods. Laboratory sources of infrared, visible and ultra- violet radiation with details of energy spectrum. Introduction to Cosmic radiation types of particles and their energies in cosmic rays. Basic laboratory sources of electrons and ions up to 50 keV

Unit-II: X-RAY RADIOGRAPHY

Principle and methods of generation of characteristics X-Rays. Interaction of X-Rays with matter, attenuation coefficient. Methods for recording X-Ray radiograph using photographic plate. Modern digital methods for recording X-ray radiograph. Medical applications of X-rays

Unit-III: RADIATION DETECTORS AND DOSIMETRY

Working principle of ionization chamber and Scintillator detector, Units for radiation exposure, absorbed dose, Relative biological effective dose and dose equivalent. FrickeDosimeter.Personal dosimeters, Film badge dosimeters, thermo-luminescent dosimeter

Unit-IV: RADIATION PROTECTION

Interaction of MeV energy electrons, ions and gamma-rays with matter. Materials for radiation shielding. Radiation Protection and Safety rules as per the regulatory guidelines of the Government of India, Safety codes for handling radioactive sources.

Unit-V: RADIOACTIVE ISOTOPES AND APPLICATIONS

Naturally occurring radioactive isotopes. Production of radioactive nuclides in nuclear reactors and by charged particle beams from accelerators. Measurement of radioactivity and lifetime of radioactive sources. Radioactive nuclei used in diagnostic applications. Applications of gamma rays in sterilization of medical instruments, Medication items and preservation of food.

TEXT BOOKS

1. Nuclear and Radiation Physics in Medicine.
2. Tony Key, World Scientific.2014
3. Radiation Protection and Health Science.

REFERENCE BOOKS

1. Marilyn E. Noz. World Scientific, 2007.
2. Grupen C, Introduction to radiation Protection, Springer, 2008

NUMERICAL ANALYSIS	
Course Code: 25PHBS005	Continuous Evaluation: …. Marks
Credits: 3	End Semester Examination: …. Marks
L T P : 3 0 0	**Course Category: Minor Stream Course Theory**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. Understanding of the theoretical underpinnings of numerical methods, as well as their practical implementation using computational tools.
2. Familiarize with the linear system of equations.
3. Acquaintance with the different interpolation techniques
4. Application of numerical integration methods on the various problems related to problems in physics.
5. Understanding the initial and boundary value problems.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of the course, students would be:

1. able to apply Computational techniques to solve the numerical problems
2. able to understand the fundamental principles and methods to solve the mathematical problems related to linear systems
3. analyse the different interpolation techniques and their applications.
4. Validating the numerical integration methods on the various problems related to problems in physics.
5. Adapt the initial and boundary value conditions to solve different problems.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs’)	Course Learning Outcomes (CLOs’)				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit – I: APPROXIMATION AND ERRORS IN COMPUTING

Introduction to numerical computation, Taylor's expansion and mean value theorem. Floating Point Computation, overflow and underflow. Single and double precision arithmetic. Rounding and truncation error, absolute and relative error, error propagation.

Unit – II: LINEAR SYSTEMS

Solution of linear systems by Gaussian elimination method, partial and complete pivoting, LU decomposition, norms and errors, condition numbers, Gauss-Seidel method, diagonally dominant matrix and convergence of iteration methods. Solution of Tridiagonal systems; Eigenvalue Problem: Power method, inverse power method.

Unit – III: INTERPOLATION

Lagrange and Newton's methods (divided difference) for polynomial interpolation, theoretical error of interpolation. Inverse Interpolation. Optimal points for interpolation and Chebyshev Polynomials. Minimax Theorem (Statement only)

Unit – IV: NUMERICAL INTEGRATION

Newton Cotes quadrature methods. Derivation of Trapezoidal and Simpson (1/3 and 3/8) rules from Lagrange interpolating polynomial. Error and degree of precision of a quadrature formula. Composite formulae for Trapezoidal and Simpson methods. Gauss Quadrature methods. Legendre, Lagaurre and Hermite quadrature methods.

Unit – V: INITIAL AND BOUNDARY VALUE PROBLEMS

Solution of initial value problems by Euler, modified Euler and Runge Kutta (RK) methods of second and fourth orders. Local and global errors, comparison of errors in the Euler and RK methods Finite difference and shooting method for solving two-point linear boundary value problems.

TEXT BOOKS

1. Cutis F. Gerald and P. O. Wheatley, Applied numerical analysis, Pearson Education, India, 2007
2. Erwin Kreyszig Advanced Engineering Mathematics, Wiley India, 2008
3. S. S. Sastry, Introduction to Numerical Analysis- 5th Edition, PHI Learning Pvt. Ltd, 2012
4. K. E. Atkinson, Elementary Numerical Analysis-3rd Edition, Wiley India Edition, 2007

REFERENCE BOOKS

1. Saul A. Teukolsky and William Vetterling, Numerical Recipes: The art of scientific computing, William H. Press, Cambridge University Press; 3rd Edition, 2007

2. M. K. Jain, S. R. K. Iyenger, Numerical methods for scientific and engineering computation, New Age Publishers, 2012.

NUMERICAL ANALYSIS LAB

Course Code: 25PHBS055	Continuous Evaluation: …. Marks
Credits: 1	End Semester Examination: …. Marks
L T P : 0 0 2	**Course Category: Minor Stream Course LAB**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. Explain the concept of approximation and errors.
2. Familiarize with the linear system of equations.
3. Analyze the interpolation methods and divided difference.
4. Evaluate the integrals by different methods.
5. Create competency and deep understanding of IVP and BVP by different methods.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of the course, students would be:

1. Analyse the concept of approximation and error.
2. Derive numerical solutions of linear equations.
3. Analyse and evaluate the accuracy of the numerical methods learned.
4. Apply the numerical methods for evaluating the integrals.
5. Demonstrate the numerical solutions of IVP and BVP.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')		Course Learning Outcomes (CLOs')			
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

List of experiments:

1. Solve a system of linear equations using Gauss Elimination method with pivoting (application to electric networks).
2. Solve a system of linear equations using Gauss-Seidel method and study the convergence (application to spring mass system).
3. Determine the inverse of a square matrix using Gauss-Jordan method.
4. Solve a tri-diagonal system of linear equations.
5. Study an example of ill-conditioned systematic
6. Find the LU equivalent of a matrix.

7. Determine the largest and smallest eigenvalues using Power and inverse power methods. Consider a case where power method fails.
8. Given a dataset (x, y) with equidistant x values, prepare the Newton's forward difference, backward difference and divided difference tables.
9. Given a dataset (x, y) corresponding to a physics problem, use Lagrange and Newton's forms of interpolating polynomials and compare. Determine the value of y at an intermediate value of x not included in the data set. This may be done with equally spaced and non-equally spaced x-values.
10. Given a tabulated data for an elementary function, approximate it by a polynomial and compare with the true function.
11. Compare the interpolating polynomial for a given dataset (following a known form e.g. exponential) with the approximation obtained by least square fitting.
12. Compare the interpolating polynomial approximating a given function in a given range obtained with uniformly spaced points and by Chebyshev points.
13. Compare the Chebyshev and Maclaurin series expansions of an exponential or sinusoidal function
14. Use integral definition of error function to compute and plot erf(x) in a given range. Use Trapezoidal, Simpson and Gauss Legendre methods and compare the results for small and large values of x.
15. Use the definition of erf(x) and numerically take the limit x going to infinity to get the value of Gaussian integral using Simpson method. Compare the result with the value obtained by Gauss Hermite and Gauss Lagaurre methods.
16. Verify the degree of precision of each quadrature rule. d) Use Simpson methods to compute a double integral over a rectangular region.
17. Compare the errors in Euler, RK2 and RK4 by solving a first order IVP with known solution. Reduce the step size to a point where the round off errors takes over.
18. Solve a system of n first order differential equations by Euler and RK methods. Use it to solve an nth order IVP. Solve a damped free and forced harmonic oscillator problem using this.
19. Solve a physics problem like free fall with air drag or parachte problem using RK method.
20. Solve a compound spring system (3 springs) by solving a system of differential equations using Euler and RK for a given set of i1nitial conditions.
21. Obtain the current flowing in a series LCR circuit with constant voltage for a given set of initial conditions

TEXT BOOKS

1. Darren Walker, Computational Physics-1st Edition, Scientific International Pvt. Ltd, 2015
2. T. Pang, An Introduction to Computational Physics, Cambridge University Press, 2010.
3. R. H. Landau and M. J. Páez, Computational Problems for Physics, CRC Press, 2018

REFERENCE

1. Documentation at the Python home page (https://docs.python.org/3/) and the tutorials there (https://docs.python.org/3/tutorial/).
2. Documentation of NumPy and Matplotlib: https://numpy.org/doc/stable/user/ and https://matplotlib.org/stable/tutorials/

STATISTICAL ANALYSIS IN PHYSICS	
Course Code: 25PHBS006	Continuous Evaluation: …. Marks
Credits: 2	End Semester Examination: ….. Marks
L T P : 2 0 0	**Course Type: Minor Stream Course Theory**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. Understand Random Variables and Probability Distributions:
2. Apply Classical Inference Techniques.
3. Define in a Bayesian context, the likelihood, prior and posterior distributions and their role in Bayesian inference and hypothesis testing.
4. Conduct Bayesian Parameter Estimation and Model Evaluation
5. Implement Bayesian Regression Models.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Compute statistical measures such as mean, variance, and covariance for random vectors.
2. Interpret and use cumulative distribution functions and quantiles, apply the Central Limit Theorem.
3. Apply Bayesian Thinking to Real-World Problems.
4. Estimate parameters using Bayesian methods for common distributions (Normal, Poisson, Binomial) and employ Bayes factors for model comparison and selection
5. Perform multi-linear and logistic regression analysis for a given data and understand the concept of gradient descent and use it for the regression analysis

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)				
	CLO1	CLO2	CLO3	CL04	CL05
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit I:

Random variables, Discrete and Continuous Probability Distributions. Bivariate and multivariate random variables, Joint Distribution Functions (with examples from Binomial, Poisson and

Normal). Mean, variance and moments of a random vector, covariance and correlation matrix, eigen decomposition of the covariance matrix (bivariate problem).

Unit II:

Cumulative Distribution Function and Quantiles. Point Estimation, Interval estimation, Central Limit Theorem (statement, consequences and limitations).

Unit III: BAYESIAN STATISTICS I

Conditional probability and Bayes Theorem, Prior and Posterior, probability distributions, examples of Bayes theorem in everyday life.

Unit IV: BAYESIAN STATISTICS II

Bayesian parameter estimation. Normal, Poisson and Binomial distributions, their conjugate priors and properties. Bayes factors and model selection.

Unit V: BAYESIAN REGRESSION

Introduction to Bayesian Linear Regression. Bayesian logistic regression and its applications. Bayesian parameter estimation for regression models. Posterior distribution of model parameters and the posterior predictive distributions.

TEXTBOOKS

1. Schaum's Outline Series of Probability and Statistics, M. R. Spiegel, J. J. Schiler and R. A. Srinivasan, 2012, McGraw Hill Education
2. Schaum's Outline Series of Theory and Problems of Probability, Random Variables, and Random Processes, H. Hsu, 2019, McGraw Hill Education
3. Bayesian Logical Data Analysis for the Physical Sciences: A Comparative Approach with Mathematica Support, P. Gregory, 2010, Cambridge University Press
4. Linear Regression: An Introduction to Statistical Models, P. Martin, 2021, Sage Publications Ltd.
5. Data Analysis: A Bayesian Tutorial, D. S. Sivia and J. Skilling, 2006, Oxford University Press
6. Data Reduction and Error analysis for the Physical Sciences, P. R. Bevington and D. K. Robinson, 2002, McGraw-Hill Education

REFERENCE BOOKS

1. A Guide to the Use of Statistical Methods in the Physical Sciences, R. J. Barlow, 1993, Wiley Publication
2. An Introduction to Error Analysis, J. R. Taylor, 1996, Univ. Sci. Books
3. Applied Multivariate Data Analysis, Volume I: Regression and Experimental Design, J. D. Jobson, 2012, Springer-Verlag
4. Statistical Rethinking A Bayesian Course with Examples in R and STAN, Richard McElreath, 2020, CRC Press
5. Introduction to Bayesian Statistics, W. Bolstad, 2007, John Wiley

STATISTICAL ANALYSIS IN PHYSICS LAB	
Course Code: 25PHBS056	Continuous Evaluation: ….. Marks
Credits: 2	End Semester Examination: …. Marks
L T P : 0 0 2	**Course Type: Minor Stream Course Lab**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. Generate and visualize random samples from Binomial, Poisson, Normal, and Cauchy distributions.
2. Apply Hypothesis Testing and Bayesian Inference.
3. Perform Regression Analysis and Optimization.
4. Model and Simulate Markov Chains.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Simulate and Analyze Probability Distribution.
2. Use likelihood-based methods to estimate unknown parameters and compare Bayesian priors and posteriors through plotting.
3. Derive linear regression parameters using least squares, including cases with measurement uncertainty and Implement gradient descent to optimize regression cost functions.
4. Simulate Markov chains and construct transition matrices for multi-step state changes and Analyze stochastic processes like Markovian Brownian motion and interpret their statistical behavior.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CL04
CO1	■			
CO2		■		
CO3			■	
CO4				■

COURSE CONTENTS

Unit I: PROBABILITY DISTRIBUTIONS

1. Generate sequences of N random numbers M (at least 10000) number of times from different distributions (e.g. Binomial, Poisson, Normal). Use the arithmetic mean of each random vector (of size N) and plot the distribution of the arithmetic means. Verify the Central Limit Theorem (CLT) for each distribution. Show that CLT is violated for the Cauchy-Lorentz distribution.
2. Given a data for two independent variables (xi, yi). Write a code to compute the joint probability in a given sample space. Verify the same for the data generated by random number

generator based on a given probability distribution of pair of independent variables (both discrete and continuous).

Unit II:

1) Hypothesis testing Make a random number generator to simulate the tossing of a coin n times with the probability for the head being q. Write a code for a Binomial test with the Null hypothesis H0 ($q = 0.5$) against the alternative hypothesis H1 ($q \neq 0.5$).
2) Bayesian Inference a) In an experiment of flipping a coin N times, M heads showed up (fraction of heads $f = M/N$). Write a code to determine the posterior probability, given the following prior for the probability of f: i. Beta Distribution B(a, b) with given values of a and b . ii. Gaussian Distribution with a given mean and variance. b) Using the Likelihood of Binomial distribution, determine the value of f (fraction of heads) that maximizes the probability of the data. c) Plot the Likelihood (normalised), Prior and Posterior Distributions.

Unit III: REGRESSION ANALYSIS AND GRADIENT DESCENT

1) Given a dataset (Xi, Yi). Write a code to obtain the parameters of linear regression equation using the method of least squares with both constant and variable errors in the dependent variable (Y). The data obtained in a physics lab may be used for this purpose. Also obtain the correlation coefficient and the 90% confidence interval for the regression line. Make a scatter plot along with error bars. Also, overlay the regression line and show the confidence interval.
2) Write a code to minimize the cost function (mean squared error) in the linear regression using gradient descent (an iterative optimization algorithm, which finds the minimum of a differentiable function) with at least two independent variables. Determine the correlation matrix for the regression parameters.
3) Write a code to map a random variable X that can take a wide range of values to another variable Y with values lying in limited interval say [0, 1] using a sigmoid function (logistic function). Considering the Log Loss as the cost function of logistic regression, compute its minimum with gradient descent method and estimate the parameters.

Unit IV: MARKOV CHAIN

1) Write a code to generate a Markov chain by defining (a finite number of) M (say 2) states. Encode states using a number and assign their probabilities for changing from state i to state j. Compute the transition matrix for 1, 2,…, N steps. Following the rule, write a code for Markovian Brownian motion of a particle.
2) Given that a particle may exist in one of the given energy states (Ei, i = 1, … 4) and the transition probability matrix T, so that Tij gives the probability for the particle to make transition from energy state Ei to state Ej. Determine the long-term probability of a particle to be in state in the state Ef if the particle was initially in state Ei.

TEXTBOOKS

1) Data Science from Scratch – First Principles with Python, J. Grus, O’Reilly, 2019, Media Inc.
2) Bayes’ Rule with Python: A tutorial introduction to Bayesian Analysis, J. V. Stone, 2016, Sebtel Press

3) Practical Bayesian Inference, B. Jones, 2017, Cambridge University Press.

REFERENCE BOOKS

1) Modeling and Simulation in Scilab/Scicos with Scicos Lab 4.4, S. L. Campbell, Jean-P. Chancelier and R. Nikoukhah, Springer.
2) Scilab Textbook Companion for Probability And Statistics For Engineers And Scientists, S. M. Ross, 2005, Elsevier Numerical Recipes:
3) The art of scientific computing, W. H. Press, S. A. Teukolsky and W. Vetterling, 2007, Cambridge University Press.

ADVANCED MATHEMATICAL PHYSICS - I	
Course Code: 25PHBS007	Continuous Evaluation: …. Marks
Credits: 3	End Semester Examination: …. Marks
L T P : 3 0 0	**Course Type: Minor Stream Course Theory**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. Illustrate the concept of vector space and its significance in physics.
2. Understand the concept of dual spaces and inner product spaces.
3. Analyse linear transformations as matrices and understand the basic properties of matrices.
4. Identify the properties of matrices and their relevance in physics.
5. Comprehend the eigenvalues and eigenvectors of matrices and diagonalise the matrices.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of the course, students would be:

1. Understand algebraic structures in n-dimension and basic properties of the linear vector spaces.
2. Understand the concept of dual spaces and inner product spaces.
3. Represent linear transformations as matrices and understand basic properties of matrices.
4. Describe the properties of matrices and understand their relevance in various physics applications.
5. Determine the eigenvalues and eigenvectors of matrices and diagonalise the matrices.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit – I: VECTOR SPACES AS ALGEBRAIC STRUCTURES

Definition and examples of groups, rings, fields and vector spaces. Real and Complex fields, Subspaces, Linear combination of vectors, Linear dependence and independence of vectors, span of a subset of vectors, Bases and dimension of vector space, direct sum of spaces, representation of vectors as column vectors with Rn as example.

Unit – II: INNER PRODUCT SPACES

Inner product of vectors ($< \alpha|\beta >$) and norm of a vector, Euclidean spaces and unitary spaces. Cauchy-Schwartz inequality, concept of length and distance, metric spaces. Hilbert Space (definition only). Linear functional, dual space, dual basis ($< \alpha\alpha|$ notation); Orthogonality of vectors, orthonormal basis, Gram-Schmidt procedure to construct an orthonormal basis.

Unit – III: LINEAR TRANSFORMATION

Linear Mappings and Examples, Homomorphism and Isomorphism of vector space, rank and nullity of a linear mapping, Range space and Kernel (null space) of a linear mapping, non-singular transformations, Nilpotent and Idempotent Transformations.

Unit – IV: MATRICES AS REPRESENTATIONS

Matrix Representation of a Linear transformations, composition of linear transformations and matrix multiplication, linear algebra. Algebra of matrices, determinant and trace of matrix and their properties. Non-singular matrices. Rank of a matrix and invertibility of matrices. Direct sum and direct product of matrices. Change of basis transformation, similar matrices, trace and determinant as invariants of basis change. Transpose and adjoint of a linear transformation, self-adjoint operators. Symmetric & Skew-symmetric matrices, complex matrix, Hermitian & Skew-Hermitian matrices. Preservation of norms by orthogonal and unitary transformations.

Unit – V: EIGENVALUES AND EIGENVECTORS

Characteristic equations, eigenvalues and eigen vectors of a transformation and corresponding matrix representation. Cayley- Hamilton Theorem (Statement only) and its applications (inverse and powers of a matrix). Diagonalization of matrices. Normal matrices. Simultaneous diagonalizability of two matrices. Use of Matrices in Solving Coupled Linear first order ordinary differential equations with constant coefficients. Minimal Polynomial, Functions of a Matrix.

TEXT BOOKS

1. Mathematical Methods for Physicists, G. Arfken, H. Weber and F. E. Harris, 7th edition, 2012, Elsevier
2. Introduction to Matrices and Linear Transformations, D. T. Finkbeiner, 2011, Dover Publications
3. Schaum's Outline of Theory and Problems of Linear Algebra, S. Lipschutz and M. Lipson, 2017, McGraw Hill Education
4. Linear Algebra, S. H. Friedberg, A. J. Insel, and L. E. Spence, 2022, Pearson Education
   5) Linear Algebra and Applications, D. C. Lay, 2002, Pearson Education India.

REFERENCE BOOKS

1. Elementary Linear Algebra with Supplemental Applications, H. Anton and C. Rorres, 2016, Wiley Student Edition
2. A Physicist's Introduction to Algebraic Structures: Vector Spaces, Groups, Topological Spaces and More, P. B. Pal, 2019, Cambridge University Press
3. Matrices and Tensors in Physics: A.W. Joshi, 2017, New Age International Pvt. Ltd.
4. An Introduction to Linear Algebra and Tensors, M. A. Akivis, V. V. Goldberg, Richard and Silverman, 2012, Dover Publications
5. Vector Spaces and Matrices in Physics, M. C. Jain, 2000, Narosa
6. Mathematical Methods for Physics and Engineering, K. F. Riley and M. P. Hobson, 2018, Cambridge University Press.

COMPUTATIONAL PHYSICS LAB-III	
Course Code: 25PHBS057	Continuous Evaluation: …. Marks
Credits: 1	End Semester Examination: …. Marks
L T P : 0 0 2	**Course Type: Minor Stream Course Lab**
Prerequisite:	

Course Objectives (CO):

1. Develop proficiency in a programming language commonly used in scientific computing
2. Understand and implement fundamental numerical techniques such as root finding, interpolation, and integration.
3. Study different types of ordinary differential equations (ODEs) and their numerical solutions.
4. Analyze and visualize simulation results using appropriate tools and libraries.
5. Reproduce new experiments with new methods.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would:

1. Learn how to write, debug, and optimize code for numerical simulations.
2. Apply numerical methods to solve physics problems that are challenging or impossible to solve analytically.
3. Implement and analyze various ODE solvers, including Euler, Runge-Kutta, and adaptive methods.
4. Interpret and communicate findings through graphs, plots, and visual representations.
5. Design new experiments or variations of existing methods.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit I:

Interpolation: Concept of Interpolation, Lagrange form of interpolating polynomial, Error estimation, optimal points for interpolation.

Recommended List of Programs

(a) Write program to determine the unique polynomial of a degree *n* that agrees with a given set of (n+1) data points (x_i, y_i) and use this polynomial to find the value of *y* at a value of *x* not included in the data.

(b) Generate tabulated data containing a given number of values (x_i, $f(x_i)$) of a function $f(x)$ and use it to interpolate at a value of *x* not used in table.

Unit II:

Numerical Integration: Newton Cotes Integration methods (Trapezoidal and Simpson rules) for definite integrals, derivation of composite formulae for these methods and discussion of error estimation.

Recommended List of Programs

(a) Given acceleration at equidistant time values, calculate position and velocity and plot them.

(b) Use integral definition of ln(x) to compute and plot ln(x) in a given range. Use trapezoidal, Simpson and Gauss quadrature methods and compare the results.

(c) Verify the rate of convergence of the composite Trapezoidal and Simpson methods by approximating the value of a given definite integral.

(d) Verify the Orthogonality of Legendre Polynomials.

(e) To evaluate the Fourier coefficients of a given periodic function (e.g. square wave, triangle wave, half wave and full wave rectifier etc.). To plot the function as well the nth partial sum of its series for various values of n on the same graph and visualise the convergence of series. Study of Gibbs phenomenon.

(f) Verify the properties of Dirac Delta function using its representation as a sequence of functions.

Unit III: Numerical Solutions of Ordinary Differential Equations:

Euler, modified Euler, and Runge-Kutta (RK) second and fourth order methods for solving first order initial value problems (IVP) and system of first order differential equations,

Recommended List of Programs

(a) Solve given first-order differential equation (Initial value problems) numerically using Euler RK2 and RK4 methods and apply to the following physics problems:

i. Radioactive decay
ii. Current in RC and LR circuits with DC source
iii. Newton's law of cooling

(b) Write a code to compare the errors in various numerical methods learnt by solving a first order IVP with known solution.
(c) Solve a system of first-order IVP numerically using Euler and Runge-Kutta methods. Application to physical problems.

TEXT BOOK

1) Elementary Numerical Analysis, K. E. Atkinson, 3rd Edn., 2007, Wiley India Edition.
2) An Introduction to Computational Physics, T. Pang, Cambridge University Press (2010).
3) Introduction to Numerical Analysis, S. S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
4) Applied numerical analysis, Cutis F. Gerald and P. O. Wheatley, Pearson Education, India (2007).
5) Numerical Recipes: The art of scientific computing, William H. Press, Saul A.

REFERENCES

1) Documentation at the Python home page (https://docs.python.org/3/) and the tutorials there (https://docs.python.org/3/tutorial/).
2) Documentation of NumPy and Matplotlib: https://numpy.org/doc/stable/user/ and https://matplotlib.org/stable/tutorials/
3) Computational Physics, Darren Walker, 1st Edn., Scientific International Pvt. Ltd (2015).
4) Teukolsky and William Vetterling, Cambridge University Press; 3rd edition (2007)
5) Computational Problems for Physics, R. H. Landau and M. J. Páez, 2018, CRC Press.

ASTRONOMY & ASTROPHYSICS	
Course Code: 25PHBS008	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	**Course Category: Minor Stream Course Theory**
Prerequisite: Basic knowledge of astronomy and astrophysics	

COURSE OBJECTIVES (CO):

1. Remember and describe the fundamental concepts of astronomy and astrophysics.
2. Understand and explain the processes of star formation and evaluation.
3. Demonstrate a clear understanding of the Sun's and the solar system.
4. Recognize and identify various types of galaxies within the Universe.
5. Critically analyze and interpret concepts of cosmology and the universe.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Demonstrate a thorough comprehension of key fundamental concepts in astronomy and astrophysics.
2. Possess detailed knowledge of the processes involved in star formation and evaluation.
3. Illustrate an understanding of the Sun's characteristics and its various dynamic activities.
4. Describe and analyze the structure, types, formation, and evolutionary pathways of galaxies.
5. Compare and contrast various theories of the universe's origin and evolution, demonstrating a comprehensive understanding.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	■				
CO2		■			
CO3			■		
CO4				■	
CO5					■

COURSE CONTENTS

UNIT-I: FUNDAMENTALS OF ASTRONOMY AND ASTROPHYSICS

Astronomical scales: Mass, length, time, Brightness, Radiant flux and luminosity, and magnitude scales (apparent and absolute), distance modulus. **Astronomical measurements:** Kepler's Laws, distances, stellar radii, masses of stars, stellar temperatures. **Positional astronomy:** celestial sphere and coordinates, geometry of a sphere, astronomical coordinate systems, geographical coordinate systems, equatorial system. **Astronomical spectroscopy:** Electromagnetic radiation and spectrum, radiation from heated objects, emission and absorption spectrum, radiation curves, doppler shift, black body radiation, Wien's Law. **Astronomical observational tools:** Atmospheric windows, optical telescopes (refracting and reflecting telescopes), telescope mountings, plate scale, light gathering power, magnification, resolution, diffraction limit.

Unit-II: STAR FORMATION AND EVOLUTION

Spectral types and their temperature dependence, staller classification (spectral and luminosity), H-R diagram. Basic equations of stellar structure, hydrostatic equilibrium and the virial theorem, nuclear energy production inside the stars. **Staller formation and evolution:** nebulae, star life cycle, pre-main-sequence stage, main sequence stage, late evaluation phase of stars, evolution of high-mass and low-mass stars (core and shell hydrogen burning, helium ignition). End stages of stars white dwarfs (electron-degeneracy pressure, mass-radius relation), neutron stars (mass limit of neutron stars, Chandrasekhar limit, neutron stars observable as pulsars), black holes as end point of stellar evolution, supernovae.

Unit-III: THE SUN AND SOLAR SYSTEM

The sun: Solar structure, solar interior, core, radiative zone, convective zone, the photosphere, solar atmosphere, chromosphere, corona. **Surface features of the Sun:** Active regions, sunspot, magnetic field of the Sun. Basics of Solar Magneto-hydrodynamics. **Solar Activity:** solar cycle, butterfly diagram, solar flares, filament eruptions and coronal mass ejections. Basic idea of Helioseismology. **The Solar System:** overall composition and structure of solar system, planets, asteroids, meteors, comets. **Origin of the Solar System:** The Nebular Model.

Unit-IV: GALAXIES IN THE UNIVERSE

Basics of galaxies: Galaxies, type of galaxies, classification of galaxies, composition, mass. **The Milky Way galaxy (our home galaxy):** components, structure, formation, kinematics of the Milky way, the galactic center, spiral arms. **Types of galaxies:** quiet and active galaxies, types of active galaxies, Active Galactic Nuclei (AGN) and Quasars, accretion by supermassive black holes.

Unit-V: COSMOLOGY

Cosmology theories: Steady state theory, Oscillating Universe theory, expending universe theory. **Big bang theory:** Cosmological redshift, dark matter, dark energy and the accelerating universe, Hubble's law and the expanding Universe, age of the universe, scale factor and comoving coordinate, big bang theory. Observational evidences of big bang theory (cosmic microwave background, bark matter and bark energy).

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TEXT BOOKS

1. An Invitation to Astrophysics, T. Padmanabhan, World Scientic Publishing Co.
2. An Introduction to Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.
3. Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th Edition, Saunders College Publishing.
4. Astrophysics in a Nutshell (Basic Astrophysics), Dan Maoz, Princeton University Press.
5. Foundations of Astrophysics, Barbara Ryden and Bradley M. Peterson, Addison Wesley.
6. Astrophysics for Physicists, Arnab Rai Choudhuri, Cambridge University Press.

REFERENCE BOOKS

1. Astronomy and Astrophysics, A. B. Bhattacharya, S. Joardar, R. Bhattacharya, Overseas Press (India) Pvt.Ltd.
2. Theoretical Astrophysics, Volume III: Galaxies and Cosmology, T. Padmanabhan, Cambridge University Press.
3. K.S. Krishnasamy, 'Astro Physics a modern perspective,' Reprint, New AgeInternational (p) Ltd, New Delhi,2002.
4. BaidyanathBasu, 'An introduction to Astro physics', Second printing, Prentice - Hall of India Private limited, New Delhi,2001.
5. Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.

ATMOSPHERIC PHYSICS	
Course Code: 25PHBS009	Continuous Evaluation: ….. Marks
Credits: 4	End Semester Examination: … Marks
L T P : 3 1 0	**Course Category: Minor Stream Course Theory**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. Explain the fundamental concepts of atmospheric science.
2. Demonstrate an understanding of various atmospheric instruments used for measurements and analysis.
3. Describe the principles and phenomena related to atmospheric optics.
4. Interpret the various concept of atmospheric circulation and energy budget.
5. Recognize and describe the concept of remote sensing and applications.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Illustrate the fundamental of atmospheric science and its various applications.
2. Develop a detailed understanding various atmospheric instruments used for measurements and analysis.
3. Identify and describe principles and phenomena related to atmospheric optics.
4. Analyse the concept of atmospheric circulation and energy dudget.
5. Evaluate the concept of remote sensing and its application the context of Earth's atmospheric.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit-I: PROPERTIES OF ATMOSPHERE

Structure and composition of atmosphere. Different layers of atmosphere, properties of atmosphere, temperature, pressure, wind, humidity, radiation, variation of various parameters with height, atmospheric thermodynamics: characteristics of gases, ideal gas laws, hydrostatic Equation, .

Unit-II: OBSERVING THE ATMOSPHERE

Instrumentation- Temperature, Pressure and Humidity of atmosphere, Measurement of Temperature, Pressure and Humidity of atmosphere; Wind- measurement, Clouds and Precipitation: – Cloud types, Precipitation types, Measurement of precipitation; Cloud microphysics – cloud formation, Warm clouds, cold clouds and Rain making, lightning and cloud chemistry.

Unit-III: ATMOSPHERIC OPTICS AND RADIATION

Visibility - attenuation of light, turbidity, physic behind optical phenomena – rainbows – haloes – corona – glory – mirage – blue of the sky – colours at sunrise and sunset – atmospheric refraction, Radiation in the atmosphere – The spectrum, black body radiation, black body radiation laws, scattering.

Unit-IV: ATMOSPHERIC EFFECTS AND ENERGY

The atmosphere as a heat Engine – Solar energy – The earth's Heat balance - Distribution of heat energy over the earth – temperature lag, General atmospheric circulation, monsoons, weather disturbances in tropics, weather maps. Greenhouse effect and its impact, Global warming.

Unit-V: REMOTE SENSING

Remote Sensing– general principles, different components of remote sensing, passive and active remote sensing and sensors, Radar and GPS (elementary ideas), application of remote sensing.

TEXT BOOKS

1. Meteorology, Albert Miller Merril Physical Science Series
2. Atmospheric Science, An introductory survey, J M Wallace and P V Hobbs
3. Meteorology, Albert Miller Merril Physical Science Series

REFERENCE BOOKS

1. Meteorology, William Donn, McGraw Hill Book Company.
2. Introduction to the Atmosphere, H. Reihl, McGraw Hill Book Company.
3. Introduction to Meteorology, Franklyn W Cole, John Wiley & Sons, INC, New York, U.SA

ADVANCED MATHEMATICAL PHYSICS - II	
Course Code: 25PHBS010	Continuous Evaluation: … Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	**Course Type: Minor Stream Course Theory**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. Illustrate the concepts of tensor analysis and tensor calculus.
2. Demonstrate the concepts of tensors in anisotropic media with examples of moment of inertia tensor, elasticity tensor and polarizability tensor.
3. Apply Lorentz Transformation in four-vector notation.
4. Develop abstract thinking skills by understanding and proving theorems in group theory.
5. Develop competency in the basic concepts of error analysis.

COURSE LEARNING OUTCOMES(CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of the course, students would:

1. Have a knowledge and understanding of tensor analysis and tensor calculus
2. Be able to apply the concepts of tensors in anisotropic media with examples of moment of inertia tensor, elasticity tensor and polarizability tensor.
3. Be able to write down the Lorentz Transformation in four-vector notation.
4. Utilize group theory concepts creatively to solve complex problems.
5. Acquire an understanding of error analysis within a dataset.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit – I: CARTESIAN TENSORS

Transformation of co-ordinates under rotation of axes. Einstein's Summation Convention. Relation between direction cosines. Transformation Law for a tensor of rank n. Sum, inner product and outer product of tensors, contraction of tensors, Quotient Law of tensors, symmetric and anti-symmetric tensors. Invariant tensors (Kronecker and Alternating Tensor). Association of anti-symmetric tensor of rank two with vectors. Vector algebra and calculus in tensor notation. Differentiation, gradient, divergence and curl of Tensor Fields. Vector Identities in tensor notation, Applications of Cartesian Tensors

Unit – II: GENERAL TENSORS

Transformation of co-ordinates and contravariant and covariant vectors. Transformation law for contravariant, covariant and mixed tensors. Kronecker Delta and permutation tensors. Algebra of general tensors. Quotient Law general tensors. Symmetric and anti-symmetric tensors. Metric Tensor. Reciprocal Tensors. Associated Tensors.

Unit – III: TENSORS

Christoffel Symbols of first and second kind and their transformation laws. Covariant derivative, gradient, divergence and curl of tensor fields. Minkowski Space, Four Vectors (four-displacement, four-velocity, four-momentum, fourvector potential, four- current density,). Tensorial form of Lorentz Transformation.

Unit-IV: GROUP THEORY

Definitions; Multiplication table; Rearrangement theorem; Isomorphism and homomorphism; Illustrations with point symmetry groups including symmetry of an equilateral triangle, square and a regular hexagon, symmetry of a cubic crystal; Group representations: faithful and unfaithful representations, reducible and irreducible representations; Lie groups and Lie algebra, SU(2), SU(3), SO(2), SO(3) algebra.

Unit-V: ERROR ANALYSIS

Importance of error analysis in scientific research, Types of errors: systematic, random, and instrumental, Accuracy and precision in measurements, instrumental error analysis, Mean, median, and mode, Variance, standard deviation, and standard error, Normal distribution and other probability distributions, Rules for propagating uncertainties in arithmetic operations, Linear regression and uncertainty in slope and intercept, Standard and probable error. Least square fit, variables Error in difference, chi-test, t-test, z-test, Statistical Analysis and Confidence Intervals: Confidence intervals and significance testing, Hypothesis testing and p-values, Chi-square analysis for goodness of fit

TEXT BOOK

1. Vector Analysis and Cartesian Tensors, 3rd edition, D. E. Bourne, P. C. Kendall, 1992
2. Cartesian Tensors, H. Jeffreys, 1931, Cambridge University Press.
3. Mathematical Methods for Physicists, H. J. Weber and G. B. Arfken, 2010, Elsevier.
4. A Brief on Tensor Analysis, J. G. Simmonds, 1997, Springer.
5. Schaum's Outline Series on Tensor Calculus, D. Kay, Revised 1st edition, 2011.

6. An Introduction to Tensor Calculus and Relativity, D. F. Lawden, 2013, Literary Licensing

REFERENCE BOOKS

1. Matrices and tensors in physics by A. W. Joshi, 1995, New Age International Publications.
2. A Student's Guide to Vectors and Tensors, D. A. Fleisch, 2011, Cambridge Univ. Press.
3. The Feynman Lectures on Physics, Volume II, Feynman, Leighton and Sands, 2008, Narosa Publishing House.
4. Classical Electrodynamics, J. D. Jackson, 3rd edition, 2009, Wiley Publication.
5. A Primer in Tensor Analysis and Relativity, I. L. Shapiro, 1st edition, 2019, Springer.
6. Gravity-An introduction to Einstein's General Relativity, J. B. Hartle, 2009, Pearson Education.
7. A first course in general relativity, B. F. Schutz, 2004, Cambridge University Press.

RENEWABLE ENERGY PHYSICS	
Course Code: 25PHBS011	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	**Course Category: Minor Stream Course Theory**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. Explain the basic principles of renewable energy sources and their role in sustainable energy production and the underlying physics of renewable energy conversion processes, such as photovoltaic and wind turbine operation.
2. Apply mathematical equations to calculate energy output, efficiency, and feasibility of renewable energy systems.
3. Analyze the factors influencing the efficiency of various renewable energy technologies, including geographic and meteorological considerations.
4. Evaluate the challenges and limitations of integrating renewable energy sources into existing energy grids.
5. Design renewable energy systems for specific applications, considering factors such as location, energy demand, and technology selection.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would

1. Elucidate the environmental and economic benefits of utilizing renewable energy sources.
2. Demonstrate the ability to analyze data and predict energy generation from renewable sources.
3. Differentiate between different types of solar cells, wind turbine designs, and hydropower systems based on their operational principles.
4. Judge the potential environmental impacts and solutions associated with large-scale renewable energy installations.
5. Formulate innovative approaches to optimize the performance and reliability of renewable energy systems.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs’)	Course Learning Outcomes (CLOs’)				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURE CONTENTS

UNIT I: FUNDAMENTALS OF RENEWABLE ENERGY SYSTEMS

Conventional and non-conventional energy sources. Current energy scenario. Introduction to renewable energy: significance, applications, advantages and disadvantages. Renewable energy Technology. Different sources of renewable energy: solar, biomass, hydrogen, wind, thermoelectric, geothermal, hydropower and ocean. Energy management criteria. Impact on environment, social and economic development. Renewable energy access and security. Challenges in renewable energy technology. Role of bulk and nanomaterials for renewable energy application. Efficiency comparisons across photovoltaic generations.

UNIT II: SOLAR ENERGY AND APPLICATION

Solar energy: definition and current scenario. Active and passive solar energy. Working principles, applications, advantages and limitations. Basic components of solar power. Photovoltaic and photothermal effect. Different solar cells, their working principles, efficiency, advantages and limitations: silicon solar cell, organic solar cell, cadmium telluride solar cell, solid-state solar cell, perovskite solar cell, thin-film solar cell and others. Numerical problems. Future and latest developments

UNIT III: BIOMASS ENERGY

Introduction, Bio -mass conversion technologies, Bio-gas generation Factors affecting bio-digestion (list of factors), Working of biogas plant, Advantages and disadvantage of floating and fixed dome type plant, Bio-gas from plant wastes, Methods for obtaining energy from biomass, Thermal gasification of biomass, Working of downdraft gasifier, Advantages and disadvantages of biological conversion of solar energy, Thermochemical conversion for biomass.

UNIT IV: NUCLEAR ENERGY

Nuclear power and working principles of nuclear energy. Nuclear fusion vs fission. Nuclear energy as green and clean energy. Renewability vs sustainability. Challenges and limitations. Future prospects.

UNIT V: OTHER RENEWABLE ENERGY SYSTEMS

Definition, working principles, efficiency, applications, advantages, limitations, future and latest developments of wind, thermoelectric, geothermal, hydropower and ocean energy. Choosing of materials for different renewable energy applications. Current developments and future prospects of magneto-electric, magneto-mechanical, piezoelectric and piezomagnetic energy conversions, India-specific RE policies (e.g., National Solar Mission)

TEXTBOOKS

1. Renewable energy: power for a sustainable future by Godfrey Boyle.
2. Renewable: the world-changing power of alternative energy by Jeremy Shere.
3. Renewable energy: a first course by Robert Ehrlich.
4. Renewable Energy: sustainable energy concepts for the energy change by Roland Wengenmayr.

REFERENCE BOOKS

1. Non-conventional Energy sources, G. D. RAI (4th edition), Khanna Publishers, Delhi.
2. Solar Energy, S.P. Sukhatme (second edition), Tata McGraw Hill Ltd, New Delhi.
3. Solar Energy Utilisation, G. D. RAI (5th edition), Khanna Publishers, Delhi.

NANO MATERIALS	
Course Code: 25PHBS012	Continuous Evaluation: ….. Marks
Credits: 4	End Semester Examination: ….. Marks
L T P : 3 1 0	**Course Category: Minor Stream Course Theory**
Prerequisite:	

COURSE OBJECTIVES

1. To discuss general concepts of material properties at nano dimensions.
2. To highlight characterization of nanomaterials
3. To develop understanding about the thin film growth and vacuum systems.
4. To make students familiar with thin film deposition and characterization of thin films.
5.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion ofcourse, students would be:

1. Fluent with good knowledge on the properties of material at nanoscale.
2. Get an understanding of characterization of nanomaterials
3. Able to understand the growth of thin film and vacuum systems.
4. Well-versed with the techniques of thin film deposition and its characterization.
5.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENT

Unit - I: PHYSICS OF NANOMATERIALS

Background to nanoscience and nanotechnology - scientific revolutions - nanosized effects, surface to volume ratio- – atomic structure – molecules & phases – energy at the nanoscale molecular and atomic size -quantum effects. Definition of a nano system - classification of nanocrystals - dimensionality and size dependent phenomena; Quantum dots, Nanowires and Nanotubes, 2D films.

Unit - II: SYNTHESIS OF NANOMATERIALS AND THIN FILM

Top down and bottom up Approach, **Mechanical methods:** Grinding – high energy ball milling; **Chemical Methods:** Sol-gel technique – co-precipitation method; **Physical Methods:** Principle of different vacuum pumps; (vacuum pumps: rotary pump, diffusion pump, turbo molecular pump, cryogenic-pump, ion pump, Ti-sublimation pump), Measurement of Pressure, Concept of different gauges; Pirani, Penning and pressure control. Vapor deposition: electron beam-thermal evaporation and different types of epitaxial growth techniques - pulsed laser deposition, Magnetron sputtering – Deposition progress and Micro lithography – RF/DC magnetron sputtering, Green synthesis using plant extracts and bio-wastes.

Unit - III: CHARACTERIZATION OF NANOMATERIALS

X- ray diffraction- Quantitative determination of phases; Structure analysis - crystallite size analysis using Debye-Scherrer's formula, Rutherford backscattering, AFM, TEM, SEM, STM, Surface Profilometer, EDAX. Raman spectroscopy, XPS, XAS and EXAFS. Basic principles and applications of UV-Vis Spectroscopy, Photoluminescence, BET.

Unit - IV: BASICS OF THIN FILMS

Thin film growth modes: Vapor condensation & adsorption, surface diffusion, sticking coefficient, formation of thermodynamically stable cluster, theory of nucleation, Growth modes: Island growth, Volmer weber, Layer growth. Epitaxy, Evolution of stresses and strain in thin films.

Unit - V: PROPERTIES OF NANOMATERIALS

Importance of the nanoscale materials and their devices, Electronic, magnetic, dielectric, optical and mechanical properties at nanoscale, Applications of nanomaterials in various fields, Nanotoxicology, bio-nanomaterials

TEXTBOOKS

1. The Physics of Low Dimensional Semiconductors, John H. Davies (Cambridge University Press)
2. Nanotechnology- An Introduction, J.J. Ramsden, William Andrew Elsevier
3. Nano-optoelectronics Sensors & Devices, Ning Xi, King w. Chiu Lai, and William AndrewElsevier

4. Quantum Heterostructures- Microelectronics & Optoelectronics,(V.V. Mitin, V.A. Kochetp&
   M.A. Stroscio, Cambridge University Press
5. Nanostructures & Nanomaterials, Synthesis, Properties & Applications, G. Cao (Imperial CollegePress)

REFERENCE BOOKS

1. Introduction to Nanotechnology, C.P.Poole Jr. & F.J. Owens (John Wiley & Sons)
2. Nanotechnology, M. Wilson, K. Kannangara, G. Smith, M. Simmons & B. Raguse (OverseasPress)
3. Thin Film Phenomenon L. Chopra, McGraw-Hill
4. Methods of Experimental Physics (Vol 14), G. L. Weissler and R.W. Carlson
5. A User's Guide to vacuum Technology, J. F. O'Hanlon, John Wiley, and Sons
6. Evaporation: Nucleation and Growth Kinetics", J.P. Hirth and G. M. Pound, Pergamon Press
7. Nanostructured Materials and Nanotechnology, H. S. Nalwa (Ed.) (Academic Press, 2002)

NOVEL & SMART MATERIALS	
Course Code: 25PHBS013	Continuous Evaluation: … Marks
Credits: 4	End Semester Examination: ….. Marks
L T P : 3 1 0	**Course Category: Minor Stream Course Theory**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. To demonstrate a comprehensive understanding about the Electronic, Nano and Magnetic Materials
2. To illustrate the physical mechanism in electronic materials
3. To learn about Integrated Circuit Fabrication.
4. To impart the properties and application of magnetic material.
5. To assess the concept of magnetic bubbles and transducers & optic sensors.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Fluent with good knowledge about the Physics of Electronic, Nano and Magnetic Materials
2. Able to understand the physical mechanism in electronic materials
3. Get an understanding of Integrated Circuit (IC) Technology and their Fabrication
4. Able to understand the properties and applications of magnetic materials
5. Get an understanding about magnetic bubbles and transducers and optic sensors.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit I: PHYSICAL MECHANISM IN ELECTRONIC MATERIALS

Crystal Structures of Electronic materials (Elemental, III-IV and VI semiconductors), Energy band consideration in solids in relation to semiconductors, Direct and Indirect bands in Semiconductor, Electron/Hole concentration and Fermi energy in Intrinsic/Extrinsic semiconductor, continuity equation, Carrier mobility in Semiconductors, Carrier Trapping and recombination/generation in semiconductors, Shockley theory of recombination, Defect related electronics states characterization by C-V characteristics of electronic junction devices, NiTi alloy working mechanism and stress-strain curves.

Unit II: INTEGRATED CIRCUIT FABRICATION

Introduction to IC technology, Basic monolithic integrated circuit epitaxial growth, diffusion of impurities, masking and etching, Fabrication of monolithic ICs, Active and Passive components, advantages of IC s, MSI, LSI, Application of IC and Clean Room Specification, Simple quantitative model for piezoelectricity

Unit III: NANOMATERIALS

Introduction to Nanomaterial, comparison of properties of nano-and bulk materials, top-down and bottom up approach, methods used for synthesis of nano-materials. Nano-thin films: development and applications, Carbon Nano-tubes: synthesis and properties. Applications of nano-materials.

Unit IV: ENGINEERING MAGNETIC MATERIALS

Hard and soft Magnetic materials, ferrites, Types of Ferrites, Rare earth compounds and bonded magnets. Materials for antenna, inductor and transformer cores. Magnetic recording fundamentals. Particulate and thin film recording media. Recording heads: ferrite heads, metal in gap heads, thin film heads and magneto resistive heads. Fundamentals opto magneto opto recording. Magneto optic recording media and heads. Introduction to magnetic bubbles.

Unit-V: TRANSDUCERS & SENSORS

Characteristics of Transducers. Transducers as electrical element and their signal conditioning. Linear Position transducer: Strain gauge, Piezoelectric. Spectroscopy based fiber optic sensors, Smart coatings and MEMS/NEMS

TEXTBOOKS

1. Physics of Semiconductor Devices, S.M. Sze
2. Solid State Electron Devices Ben G Streetman, Sanjay Kumar Banerjee
3. Semiconductor Devices Basic Principles, Jasprit Singh
4. Quantum Theory Of Magnetism Magnetic Properties Of Materials, Rober M. White
5. Metal/Semiconductor Schottky Barrier Junction and their Applications, B.L. Sharma.

REFERENCE BOOKS

1. Encyclopedia of Applied Physics, G.L. Trig Vol. 9, G.L. Trigg (V.CH Publishers).
2. Linear Integrated Circuits, D. Roy Choudhury and SahilB. Jain, (New Age Int. Pub).
3. Integrated Electronics,Millman and Halkias (Tata McGraw-Hill).
4. Transducers and Instrumentation, D.V.S. Murty.

SOFT MATTER PHYSICS	
Course Code: 25PHBS014	Continuous Evaluation: ….. Marks
Credits: 4	End Semester Examination: ….. Marks
L T P : 3 1 0	**Course Category: Minor Stream Course Theory**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. To impart the knowledge of basic materials in soft matter physics.
2. To illustrate the properties of polymers.
3. To impart the Elastic properties of soft materials and fluid dynamics.
4. To discuss the various interactions involved in soft matter physics.
5. To assess the concepts of different special nanomaterials.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion ofcourse, students would be:

1. Fluent with good knowledge about materials viz. liquid crystals, colloids, polymers etc.
2. Able to understand the different statics involved in polymer materials
3. Get an understanding of the elastic properties of soft materials and fluid dynamics.
4. Well-versed with the various interactions involved in soft matter physics
5. Able to have an understanding about the special nanomaterials.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	■				■
CO2	■	■			
CO3		■	■		
CO4				■	
CO5					■

COURSE CONTENTS

Unit I: SOFT MATERIALS
Amorphous materials, Brownian motion, Diffusion, Connection between Diffusion and random walks, Langevin equation. Order parameters in liquids, Long-and short-range order, Liquid crystals, Liquid crystal order parameter, Polymers, Colloids, Quasi-crystals, Granular Materials, Amphiphilic molecules and self-assembly

Unit II: POLYMERS
Polymer statistics: Single chain statistics; Chain under external action; Flory theory; Polymer solutions: Dilute, Semi-dilute and melts; Osmotic pressure; Scaling laws; Segregation in polymer mixtures; Polymers near the interfaces: Adsorption; Depletion layer; Steric repulsion; Dynamics of a polymer chain: Rouse model; Normal modes; Motion of monomers; Hydrodynamic interactions.

Unit III: ELASTICITY AND FLUID MECHANICS
Elasticity, Nonlinear elasticity, Rubber elasticity, Larger extensions of rubber, Linear elasticity, Solids of cubic symmetry, Isotropic solids. Newtonian fluids, Euler's equation, Navier-stokes equation, Polymeric solutions, Plasticity, Super-fluid 4He, Two-fluid hydrodynamics, Second sound, Origin of super-fluidity, Non-DLVO interactions (e.g., depletion, steric).

Unit IV: INTERFACIAL INTERACTIONS
Van der Waals interaction; non-retarded interaction; interactions of many molecules; Electrostatic interaction; screening; Colloidal dispersions; Interfacial tension; Laplace pressure; Surface-active agents; interface free energy; thermal fluctuations of interfaces; fluctuations of fluid membranes; persistence length; steric repulsion; micelles; critical micelles concentration; vesicles; micro- emulsions, Real viscoelastic materials: blood and slime.

Unit-V: SPECIAL NANO-MATERIALS
Carbon nano-tubes (CNTs)-Single and Multiwalled, Graphene, Quantum dots-Emission wavelength dependency of QD size,Brus Equation, Nanocrystalline ZnO and TiO_2, Soft robotics and hydrogels in biomedical devices.

TEXTBOOKS
1. Statistical thermodynamics of Surfaces, Interfaces, and Membranes", Samuel A. Safran, CRCPress.
2. Scaling Concepts in Polymer Physics, Pierre-Gilles de Gennes , Cornell University Press
3. The Theory of Polymer Dynamics, M. Doi, S. F. Edwards, Oxford Science Publication.

REFERENCE BOOKS
1. Theory of Polymer Dynamics, W.J. Briels.
2. Condensed Matter Physics, 2nd Edition, Michael P. Marder, Wiley
3. Oxford Master Series in Condensed Matter Physics, Richard A.L. Jones.
4. Introduction to nanotechnology, C. P. Poole Jr. and F. J. Ownes, Willey Publications.
5. Origin and development of nanotechnology, P. K. Sharma, Vista International Publishing house.
6. Nanostructure and nanomaterials synthesis, Properties and applications, G. Cao, Imperials College Press, London.

NANOMAGNETISM AND SPINTRONICS	
Course Code: 25PHBS019	Continuous Evaluation: … Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	**Course Category: Minor Stream Course**
Prerequisite:	

COURSE OBJECTIVE (CO):

1. To recall the basic concepts of magnetism and to introduce nano-magnetism.
2. To discuss general concepts of magnetism in metals.
3. To develop understanding of different magnetic interactions.
4. To illustrate understanding of spin dependent transport processes in spintronics devices.
5. To apply then knowledge in recent advances in spintronic materials, technology and futuristic materials.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Explain the concepts of magnetism and to nano-magnetism.
2. Fluent with good knowledge on the concepts of magnetism in metals
3. Get an understanding of different magnetic interactions.
4. Able to understand the spin dependent transport processes in spintronics devices.
5. Well-versed with the advances in spintronic materials, technology.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)				
	CLO1	CLO2	CLO3	CL04	CL05
CO1					
CO2					
CO3					
CO4					
CO5					

COURE CONTENTS

Unit I - BASICS OF MAGNETISM & INTRODUCTION TO NANOMAGNETISM

Magnetic fields and magnetic materials, Units in Magnetism, The various types of magnetic energy (magnetostatic energy, magnetocrystalline energy, magnetostrictive energy), domain walls, demagnetizing field, magnetization process. the Bloch domain wall. Why magnetism at nanoscale? The origin of Nanomagnetic behavior. Dimensionality and Density of Electronic states.

UNIT II - MAGNETISM IN METALS Free electron model, Pauli paramagnetism, Spontaneously spin-split bands, Landau levels, Landau diamagnetism, Magnetism of the electron gas, Excitations in the electron gas, Spin density waves, Kondo effect. Magnetic anisotropy: Shape anisotropy, Magnetocrystalline anisotropy and its origin, Induced anisotropy

Unit III - COMPETING INTERACTIONS AND LOW DIMENSIONALITY Magnetic frustration, Spin glasses, Superparamagnetism, One and two-dimensional magnets, Spin chain, Spin-Peierl's transition, Spin ladders. Galvenomagnetic Effetcs in Ferromagnetic Materials: Spin-orbit interaction, Anomalous Hall Effect, Anisotropic Magnetoresistance, Mechanism of AMR, Magnetic multilayers, Giant Magnetoresistance, Mechanism of GMR, Colossal Magnetoresistance, Spin flip scattering

Unit IV - SPIN TUNNELING AND MAGNETORESISTANCE Spin tunneling, Tunnel Magnetoresistance (TMR), Effects of Fermi surface, Effect of interfacial states, diffusive tunneling, Spin flip tunneling, Bias voltage dependence of TMR, Magnetic tunnel Junctions (MTJ), Tunnel Junctions with Half Metals.

Unit V - SPIN INJECTION & ADVANCES IN SPINTRONIC MATERIALS, TECHNOLOGY AND DEVICES Spin polarization, Spin Injection, Spin accumulation, Spin-transfer torque, Spin torque effects in magnetic systems, Spin injection magnetization switching, High frequency phenomena - Spin transfer oscillation, Spin Hall effect and Inverse Spin Hall effect. Materials for spin electronics, Nanostructures for spin electronics, Magnetic Memories: GMR technology, MRAM, Read Heads, MRAMS, Field Sensors, Spintronic Biosensors, Quantum Computing with spins.

TEXT BOOKS:

1. Principles of Nanomagnetism, Alberto P. Guimaraes, Springer, 2009.
2. Nanomagnetism and spintronics, edited by Teruya Shinjo, Elsevier, 2013.
3. Magnetism and Magnetic Materials, J. M. D. Coey, Cambridge University Press, 2009.
4. Introduction to Spintronics, SupriyoBandyopadhyay and Marc Cahay, CRC press, 2008.
5. S. Blundell, Magnetism in Condensed Matter, 1st edition, Oxford University Press, 2001.
6. R. C. O'Handley, Modern Magnetic Materials, John Wiley & Sons, Inc., 2000.
7. T. Shinjo (Ed.) Nanomagnetism and Spintronics,1st edition, Elsevier, 2009.
8. E. Y. Tsymbal and I Zutic, Handbook of Spin Transport and Magnetism, CRC Press, 2012.

REFERENCE BOOKS:

1. Spin Waves: Theory and Applications, Daniel D. Stancil, Anil Prabhakar Springer Science, 2009.
2. Relaxation Processes in Micromagnetics, Harry Suhl, Oxford University Press, 2007.
3. Spin Electronics, D. Awschalom, Robert A. Buhrman, James M. Daughton, Stephan von Molnár, Michael L. Roukes (Editors), Springer, 2004.
4. J.M.D. Coey, Magnetism and Magnetic Materials, Cambridge University Press (2010).

OPTOELECTRONICS	
Course Code: 25PHBS016	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	**Course Category: Minor Stream Course Theory**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. Recall the fundamental concepts of optoelectronics, including the interaction between light and electronic devices and explain the principles of light propagation in different materials and the behavior of photons.
2. Apply semiconductor physics principles to analyze the operation of optoelectronic devices.
3. Interpret the factors affecting the performance of optoelectronic components, such as modulation bandwidth and quantum efficiency.
4. Evaluate the advantages and limitations of different modulation techniques used in optoelectronic communication systems.
5. Design optoelectronic systems for specific applications, considering factors such as wavelength, power, and efficiency.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would

1. Describe the characteristics of optoelectronic devices, such as LEDs, lasers, and photovoltaic cells.
2. Demonstrate the ability to design and analyze simple optical waveguides and resonators.
3. Differentiate between various types of lasers and photodetectors based on their operational principles.
4. Judge the challenges and solutions for integrating optoelectronic components into modern technologies.
5. Develop innovative approaches to improve the performance and functionality of optoelectronic devices.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)				
	CLO1	CLO2	CLO3	CL04	CL05
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

UNIT I: OPTICAL WAVEGUIDES

Planar slab waveguide and circular waveguide (optical fibre); modes, numerical aperture; attenuation and dispersion in waveguides; fabrication and characterization of waveguides; coupling between optical sources and waveguides, Basic semiconductor and device physics, optical properties of semiconductors, p-n junctions, optical absorption, amplification, semiconductor lasers, photo-detectors and noises, quantum well devices

UNIT II: DIELECTRIC WAVEGUIDES AND OPTICAL FIBERS

Symmetric planar dielectric slab waves, modal and waveguide dispersion in planar waveguides, step index optical fibre, step index optical fibre, Numerical Aperture, dispersion in single mode fibres, dispersion modified fibre and compensation, Bit rate, dispersion and electrical and optical bandwidth, the Graded index optical fibre, attenuation in optical fibres

UNIT III: OPTOELECTROINCS EFFECTS AND PHOTO DETECTORS

Polarization, light propagation in anisotropic medium, Birefringent optical devices, optical activity and circular birefringence, Liquid crystal displays, Electro-optic effect, Pockel's effect, Kerr effect, Integrated optical modulators, acousto-optic modulators, Faraday Rotation and optical isolator, Principle of the p-n unction photodiode, Shockley Ramo theorem and external photocurrent, Quantum efficiency and responsively, the pin photodiode, avalanche photodiode, heterojunction photodiodes, Schottky junction photo detectors, phototransistors, basic photodiode circuits, noise in photo detectors, image sensors.

UNIT IV: STIMULATED EMISSION DEVICES: OPTICAL AMPLIFIER AND LASERS I

Stimulated emission, photon amplification and laser, stimulated emission rate and emission cross section, Erbium doped fibre amplifier, broadening of the optical gain curve and line width, principle of laser diode, heterostructure laser diodes,

UNIT V: STIMULATED EMISSION DEVICES: OPTICAL AMPLIFIER AND LASERS II

Quantum well devices, elementary laser diode characteristics, steady state semiconductor rate equations, single frequency semiconductor lasers, vertical cavity surface emitting lasers, semiconductor optical amplifier, direct modulation of laser diodes, holography

TEXTBOOKS

1. Introduction to fiber optics, A. Ghatak and K. Thyagarajan (Cambridge University Press, Cambridge, UK 1998)
2. Fundamentals of photonics, B.A. Saleh and M.C. Teich (Wiley Interscience, NJ, USA 2007)
3. Fundamentals of optoelectronics, C.R. Pollock (Irwin Inc., USA 1995)

REFERENCE BOOKS

1. Quantum electronics / Optical electronics, A. Yariv
2. Optoelectronics, Wilson and Hawkes
3. Optoelectronics and Photonics, Kasap & Fiber optic communications, Palais

NANOPHOTONICS	
Course Code: 25PHBS017	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	**Course Category: Minor Stream Course Theory**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. To illustrate the photonics operative at a nano scale
2. To discuss the concepts of near field and their application in microscopy.
3. To highlight the plasmonics and elementary concept of photonic crystals.
4. To analyse the non-linear behaviour of the photonic crystals
5. To impart the knowledge on the application of photonic materials in biotechnology.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion ofcourse, students would be:

1. Fluent with good knowledge of the field of nanophotonics.
2. Get an understanding of near field interaction and their application in microscopy.
3. Able to understand the Plasmonics and photonic crystals.
4. Formulate non-linear behaviour of the photonic crystals
5. Well-versed with the application of photonic materials in biotechnology.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs’)	Course Learning Outcomes (CLOs’)				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENT

UNIT I: INTRODUCTION
Overview of Nanophotonics, Confinement of Photons and electrons, Bandgap-Tunneling, Localization under periodic potential, Quantum Confinement Effects-Quantum wells/wire/dots, Nanoscopic interaction dynamics, Dielectrics confinement effects, Superlattices.

UNIT II: NEAR-FIELD INTERACTION & MICROSCOPY
Near-Field Optics, Near-Field Microscopy, Example of Near-Field Studies-Single Molecule Spectroscopy & Nonlinear Optical Processes. Nano-scale enhancement of optical interactions-Surface Enhanced RamanScattering Spectroscopy. Time and Space-Resolved studies of Nanoscale Dynamics.

UNIT III: PLASMONICS& PHOTONIC CRYSTALS I
Metallic Nanoparticles-Spherical, Nano rods and Nano shells, Local Field Enhancement, Subwavelength AperturePlasmonics, Nanostructure and excited states.

UNIT IV: PLASMONICS& PHOTONIC CRYSTALS II
Basic concepts of Photonic crystals, Nonlinear Photonic crystals, Photonic crystal sensors, Nanocomposites as photonic media.

UNIT V: MATERIALS & APPLICATIONS IN BIOTECHNOLOGY
Nanocomposites, Bioderived Materials, Biotemplates, Bacteria as Bio-synthesizers, Near-Field Bioimaging, Optical Diagnostics, Nanoclinics for Targeted Therapy and Gene delivery. Photodynamic Therapy for killing cancer cells, Nanomedicine.

TEXTBOOKS
1. Biophotonics, P. N Prasad
2. Introduction to Nanophotonics, S. V. Gaponenko

REFERENCE BOOKS
1. Principles of Nano-optics, Lukas Novotny
2. Diffractive Optics &Nanophotonics, V. A. Soifer

NONLINEAR SPECTROSCOPY	
Course Code: 25PHBS018	Continuous Evaluation: … Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	**Course Category: Minor Stream Course Theory**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. Review and explain the fundamental principles of nonlinear spectroscopy and the underlying mechanisms of nonlinear interactions with light.
2. Apply the theory of nonlinear spectroscopy to predict and analyze spectral features and responses.
3. Analyze experimental data from nonlinear spectroscopy techniques to extract information about molecular and material properties.
4. Evaluate the advantages and limitations of various nonlinear spectroscopy methods for different sample types and experimental conditions.
5. Design experiments to investigate specific molecular and material properties using nonlinear spectroscopy techniques.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would:

1. Describe the differences between linear and nonlinear spectroscopy and their significance.
2. Demonstrate the ability to calculate nonlinear susceptibility and predict signal intensities in various nonlinear spectroscopy processes.
3. Differentiate between different types of nonlinear spectroscopy techniques based on their underlying principles and applications.
4. Critique the potential sources of error in nonlinear spectroscopy measurements and propose strategies for improving data quality.
5. Develop innovative applications of nonlinear spectroscopy in interdisciplinary research fields.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

UNIT I: INTRODUCTION
Prologue: Linear Spectroscopy, Brief introduction to tunable laser sources and linear spectroscopy, The Density Matrix for a Two-Level System, the Interactions and the Hamiltonian, Relaxation, the Master Equation and the Vector Model, the Nonlinear Polarization Density and Nonlinear Susceptibility, physical principles underlying various spectroscopic techniques and line broadening phenomena, Inhomogeneous Broadening, Effective Operators for Multi-quantum Transitions.

UNIT II: SATURATION SPECTROSCOPY
Burning and Detecting Holes in a Doppler-Broadened Two-Level System, Crossover Resonances and Polarization Spectroscopy, Coupled Doppler-Broadened Transitions, Experimental Methods of Saturation Spectroscopy in Gases, Ramsey Fringes in Saturation Spectroscopy, The Line-Shape Problem in Saturation Spectroscopy, Experimental Results in Saturation Spectroscopy of Gases, Multiphoton and Double Resonance Saturation Techniques, Saturation Techniques for Condensed Phases, Applications of Saturation Techniques

UNIT III: COHERENT RAMAN SPECTROSCOPY
Introduction, Driving and Detecting a Raman Mode, Symmetry Considerations, Relationship between χR and the Spontaneous Cross Section, Wave-Vector Matching, Coherent Anti-Stokes Raman Spectroscopy, Raman-Induced Kerr Effect Spectroscopy, Stimulated Raman Gain and Loss Spectroscopy, Four-Wave Mixing, Applications.

UNIT IV: MULTIPHOTON ABSORPTION AND NON-LINEAR SPECTROSCOPY I
Introduction, Doppler-Free Two- and Three-Photon Absorption, Multi-quantum Ionization, Nonlinear Mixing, Applications, Optical Coherent Transients, The Optical Free-Induction Decay, Optical Nutation, The Photon Echo, the Stimulated Echo, Ramsey Fringes, Second Harmonic generation, Third- and Higher-Order Sum and Harmonic generation

UNIT V: MULTIPHOTON ABSORPTION AND NON-LINEAR SPECTROSCOPY II
Raman Shifting, Spontaneous Anti-Stokes, Infrared Spectro-photography, multiphoton ionization methods; life time measurements, Quantum beat spectroscopy, Henle effect; Pico second and femto-second spectroscopic techniques for probing ultrafast dynamics, four wave mixing for determining dephasing times using intense
incoherent light.

TEXTBOOKS
1. Introduction to Nonlinear Spectroscopy, M. D. Levenson
2. Nonlinear Laser Spectroscopy, V. S. Letokhov& V. P. Chebotayev

REFERENCE BOOKS
1. Laser Induced Dynamic Gratings, H. J. Eicher, P. Gunter & D. W. Pohl.

FIBER OPTICS	
Course Code: 25PHBS019	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: ….. Marks
L T P : 3 1 0	**Course Category: Minor Stream Course Theory**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. To understand basic knowledge on optical fibers structure and principle of wave guiding.
2. To highlight the dispersion phenomenon in fiber optics signals.
3. To develop the students understanding about the optical fiber sensor applications.
4. To illustrate the application of the fiber sensors
5. To acquire knowledge on health-based applications of fiber sensors

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Equipped with knowledge of the wave guide characteristics and basic structures of optical fibres.
2. Able to understand the principle behind the signal dispersion of the guided mode of optical fiber
3. Well-versed with the principles behind spectroscopic application of optical fibers.
4. Fluent with good knowledge of the optical fiber application
5. Well versed with health-based applications of fiber sensors

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit-I: BASIC OPTICS: Introduction: The fiber optics revolution. Plane, circularly and elliptically polarized wave. Reflection at a plane interface-Brewster angle and Total internal reflection. Two beam interference-Fiber optic Mach-Zehnder interferometer. Concept of coherence. Diffraction of Gaussian beam.

Unit-II: FUNDAMENTALS OF OPTICAL FIBER

Optical Fiber: Principles-Physical structure, Wave guide parameter (V-Number), Optical Fiber Types: Multi mode and single mode optical fibers. Optical Fiber Profiles-Step Index & Parabolic Index, Concept of optical modes-Field Patterns of some low order guided modes, TE modes of a symmetric step index planar waveguide.

Unit-III: DISPERSION IN OPTICAL FIBER

Pulse Dispersion in Multimode Optical fiber-Ray & Material Dispersion in Step Index fiber, Pulse Dispersion in Singlemode Optical fiber-Intramodal Dispersion, Waveguide dispersion, Optical Fibers for dispersion compensation, Polarization mode Dispersion, Fiber Amplifiers.

Unit-IV: PROPAGATION CHARACTERISTICS OF OPTICAL FIBER

Propagation characteristics of a Step index fiber: Modal analysis for a step index fiber. Fractional modal power in the core. Single mode fibers- Gaussian approximation, splice loss. Propagation characteristics of a Graded index fiber: Modal analysis of a parabolic index fiber. The LP_{lm} modes. Photonic crystal fiber.

Unit-V: FIBER OPTICS COMMUNICATION & SENSORS

Communication requirements, Elementary ideas on semiconductor laser, diode laser. Principle of optical detection. Intrinsic & Extrinsic Sensors, Basic Optical Fiber Sensor Components-Isolators, Couplers, Modulators. Optical Fiber Sensor (OFS) based on principles: Fiber Braggs Grating, Evanescent Wave, Raman Spectroscopy.

TEXT BOOKS

1. Fiber Optic Sensors, Principles and Applications: B. D. Gupta
2. Introduction to Fiber Optics, A. Ghatak and K.Thyagrajan, Cambridge University Press.
3. Fiber Optic Essentials, A. Ghatak and K.Thyagrajan.

REFERENCE BOOKS

1. Optical Fiber Sensors, Advanced Techniques and Applications, G. Rajan
2. Fiber Optics, Physics and Technology,F.Mitschke

ADVANCED ELECTRONICS	
Course Code: 25PHBS020	Continuous Evaluation: ….. Marks
Credits: 4	End Semester Examination: ….. Marks
L T P : 3 1 0	**Course Category: Minor Stream Course Theory**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. To acquire basic knowledge on microwave electronics.
2. To demonstrate a comprehensive understanding of the signal communication in computer and network system.
3. To develop understanding of the analog signal transmission.
4. To create competency and deep understanding of INTEL 8085 microprocessor architecture.
5. To make familiar with the principle involved in optical fiber communication

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Good understanding of the microwave characteristics and its detection techniques.
2. Ability to understand the working, and principle behind LAN, WAN, MAN and topology.
3. Get an understanding of the signal transmission by Amplitude and phase modulations.
4. Able to grasp the knowledge about the working and applications of INTEL 8085 microprocessor architecture.
5. Familiarity with the working and application of LED and diode LASERS.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

UNIT I: MICROWAVE ELECTRONICS

Microwave characteristic features & applications, Wave guide and cavity resonators, Tw o cavities Klystron, Reflex Klystron, Gunn diode characteristics, microwave antenna, Detection of microwave, Dielectric constant measurement, Isolator and circulator, PIN diode modulator.

UNIT II: DIGITAL SIGNAL (DATA) TRANSMISSION

Introduction, Optimum Receiver for Binary Digital Modulation Schemes, Binary ASK, Binary FSK, Binary PSK and Differential PSK Signaling Schemes, Serial Data Communication in Computers USART 8251, Basics Communication Networks (LAN, WAN, MAN) And Its Topology.

UNIT III: ANALOG SIGNAL TRANSMISSION

Introduction, Amplitude, Frequency & phase modulation; AM, FM modulating and e modulating circuits; AM, FM Receivers functioning (Block Diagram) and characteristic features; Pulse modulation; Sampling Processes, PAM, PWM and PPM modulation and demodulation, Quantization noise.

Unit-IV: INTEL 8085 MICROPROCESSOR ARCHITECTURE

Main features of 8085. Block diagram. Components. Pin-out diagram. Buses. Registers. ALU. Memory. Stack memory. Timing and Control circuitry. Timing states. Instruction cycle, Timing diagram of MOV and MVI.

UNIT V: FIBRE OPTIC COMMUNICATION

Basic Optical Communication System, Wave Propagation in Optical Fiber Media, Step and Graded Index Fiber, Material Dispersion and Mode Propagation, Losses in Fiber, Optical Fiber Sources (LEDs and LASERs) And Detectors (PIN Photodiode, APD Photodiode), Optical Joints and Couplers.

TEXTBOOKS

1. M.Kulkarni, Microwave and Radar Engineering, Umesh Publications, 4th Edition, 2003.
2. A.P. Malvino, D.P.Leach and Saha,Digital Principles and Applications, Tata McGraw, 7th Edition, 2011.
3. A. Kumar, Fundamentals of Digital Circuits, PHI Learning Pvt. Ltd, 2nd Edition, 2009.
4. Venugopal, Digital Circuits and systems,Tata McGraw Hill, 2011.
5. Roddy and Coolen, Electronic Communication, Pearson, 4th Edition, 2008.

REFERENCE BOOKS

1. K. San Shanmugam, Digital and Analog Communication systems, Wiley, 2019.
2. Pratt and Bosterin, Satellite Communication, Wiley, 2nd Edition, 2006.
3. S.K. Mandal, Digital Electronics, McGraw Hill, 1st Edition, 2010.
4. R.S. Goankar, Microprocessor Architecture Programming & applications with 8085, Prentice Hall, 2002.

ADVANCED SOLID STATE PHYSICS	
Course Code: 25PHBS021	Continuous Evaluation: ….. Marks
Credits: 4	End Semester Examination: ….. Marks
L T P : 3 1 0	**Course Type: Minor Stream Course Theory**
Prerequisite: Condensed Matter Physics	

COURSE OBJECTIVES (CO):

1. To illustrate the properties and applications of glasses and polymers.
2. To discuss general concepts of liquid crystals.
3. To highlight the phase transitions in solid state materials.
4. To make students familiar with surface physics.
5. To make familiar with the theory of quantum Hall effect

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Fluent with good knowledge on the glasses and polymers.
2. Get an understanding of structure of liquid crystals.
3. Able to understand the phase transitions in solid state materials.
4. Well-versed with the knowledge of surface physics.
5. Able to understand the theory of quantum Hall effect

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO 2	CLO 3	CLO 4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURE CONTENTS

Unit - I: GLASSES AND POLYMERS

Glass formation, types of glasses and glass transition, radial distribution function and amorphous semiconductors, electronic structure of amorphous solids, localized and extended states, mobility edges, Density of states and their determination, transport in extended and localized states, Optical properties of amorphous, semiconductors. Structure of polymers, polymerization mechanism, characterization, techniques, optical, electrical, thermal and dielectric properties of polymers.

Unit - II: LIQUID CRYSTALS

Liquid Crystals. Structural peculiarities and applications, Thermotropic, liquid crystals; Classification, Phases and phase transitions; anisotropic materials; symmetry aspects; optics; electro-optics of liquid crystals; ferro-, and antiferroelectric liquid crystals; examples of LCs in nanoscience, photonics and microwave electronics, display devices.

CARBON BASED MATERIALS: Fullerenes, C60, C80 and C240 Nanostructures; Properties and Applications (mechanical, optical and electrical). CNT-single walled and multiwalled, grapheme.

Unit - III: PHASE TRANSITIONS IN SOLIDS

Landau's theory, Critical exponents. Ginzburg Criterion. Critical dimensionality, first order and second order transition, order parameter and critical exponents, examples of phase transition: Solid-liquid, liquid-gas, magnetic transitions, ferroelectric-paraelectric, ferromagnetic – paramagnetic, superconducting transition, liquid crystals, glass transitions

Kadonoff's scaling hypothesis. The renormalization group, renormalization group for the Ising chain. Fixed points. Calculation of fixed point for the 2D Ising model on the triangular lattice

Unit - IV: INTRODUCTION TO SURFACE PHYSICS

Reconstruction and relaxation, surface electronic structure; Heterostructures; Self-assembled monolayers, Electrified interfaces, Charge transfer at the liquid-solid interfaces.

Unit – V: SPECIAL TOPICS

Integral and fractional quantum Hall effect: electron in a strongmagnetic field, Landau levels and their degeneracy, simple explanation of IQHE; Metal-Insulator transitions: Mott- Hubbard and impurity induced; Landau theory of Fermi liquid, Mott variable range hopping, Bose- Einstein condensation

TEXTBOOKS

1. Neil, W. Aschroft& N. David Mermin , Solid State Physics, Cengage Learning, Ist Edition, 2003.
2. Gerald Burns, Solid State Physics, Academic Press, 1985.
3. Wlater A. Harrison, Solid State Physics, Dover Publications, 1980.
4. Harald Ibach, Solid State Physics : An introduction to Principles of Materials Science, Springer; 4th Edition. 2009.
5. R. Zallen, Physics of Amorphous Solids, John Wiley and sons, 1983.
6. Ulrich Eisele and Stephen D. Pask, Introduction to Polymer Physics, Springer, 1990.
7. Pierre-Gilles de Gennes, The physics of liquid crystals, Oxford University Press, 2nd Edition, 2003.

REFERENCE BOOKS

1. Peter J. Wojtowicz, E. Priestly, Ping Sheng, Introduction to Liquid Crystals, Plenum press, 1975.
2. Michael J. O'Connell, Carbon Nanotubes: Properties and Applications, CRC press, 2006.
3. P. Papon, J. Leblond, and Paul H. E. Meijer, The Physics of Phase Transitions - Concepts and Applications, Springer, 2nd Edition, 2006)
4. P. E. J. Flewitt, R. K. Wild, Physical Methods for Materials Characterization, CRC Press, 2nd Edition, 2015.
5. R. C. Brundle, Encyclopedia of materials characterization: surfaces, interfaces, thin films, Butterworth-Heinemann, 1992.

ADVANCED SOLID STATE PHYSICS LAB	
Course Code: 25PHBS022	Continuous Evaluation: ….. Marks
Credits: 2	End Semester Examination: ….. Marks
L T P : 0 0 4	**Course Type: Minor Stream Course Lab**
Prerequisite: Advanced Solid State Physics	

COURSE OBJECTIVES (CO):

1. To discuss general structural detections of solids.
2. To illustrate the optical and electrical properties of solids.
3. To highlight thermo-gravimetric analysis of materials
4. To make students familiar with theoretical and experimental topics in solid state physics.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Fluent with good knowledge structural detection of solid state materials.
2. Get an understanding of experimental techniques for finding the optical and electrical properties of materials.
3. Able to understand the thermo-gravimetric analysis of materials.
4. Well-versed with the extent of error involved in the experimental techniques.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')			
	CLO1	CLO2	CLO3	CLO4
CO1	■			
CO2		■		
CO3			■	
CO4				■

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum ___ of experiments)

1. Measurement of lattice parameter and indexing of powder photograph.
2. Identification of unknown sample using powder diffraction method.
3. To study the ferroelectric transitions in TGS crystal and measurement of Curie temperature.
4. To measure the superconductivity transition temperature and transition width of a high temperature superconductor.
5. Band gap measurement of oxide film using UV spectroscopy
6. To study the heat capacity of solids.
7. To study electric properties of thin films of metals & oxides.
8. To determine magneto resistance of a Bismuth crystal as a function of magnetic field.
9. To find the 'g' factor of DPPH using electron spin resonance.
10. To determine Hall Voltage, concentration of charge carrier and the type of semiconductor in the Hall effect experiment.
11. Study of crystalline properties of materials using XRD
12. B-H Curve of magnetic material.
13. To calculate the resistivity by Four Probe method.
14. To investigate the lattice dynamics of monoatomic and diatomic molecules.
15. To calculate the forbidden energy gap for Si, Ge and LED.
16. To perform the Fourier analysis of square wave and triangular wave.
17. To determine the dielectric constant.
18. To determine the magnetic susceptibility of a paramagnetic solution by Quinck's tube method.

TEXTBOOKS

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology, Wiley India Pvt. Ltd., 1st edition 2003.
2. S.K. Kulkarni, Nanotechnology: Principles & Practices, Capital Publishing Company 2nd edition, 2011.

REFERENCE BOOKS

1. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology, PHI Learning Private Limited, 2009.
2. Supriyo Datta, Electronic transport in mesoscopic systems, Cambridge University Press, 1997.

CLASSICAL FIELD THEORY	
Course Code:25PHBS023	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: ….. Marks
L T P : 3 1 0	**Course Type: Minor Stream Course Theory**
Prerequisite: NIL	

COURSE OBJECTIVES

1. To develop a foundational understanding of field theory through the Lagrangian and Hamiltonian formalisms.
2. To explore the role of symmetry and conservation laws in classical field dynamics via Noether's theorem.
3. To analyze classical electromagnetic field theory using covariant notation and gauge principles.
4. To introduce the concept of spontaneous symmetry breaking and its consequences in field theory.
5. To examine applications of classical fields in physical systems and set the groundwork for quantum field theory.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Formulate and solve the Euler-Lagrange equations for classical fields including scalar and vector fields.
2. Derive and interpret conservation laws using Noether's theorem in classical field contexts.
3. Analyze electromagnetic fields in a covariant framework and understand the importance of gauge invariance.
4. Explain the mechanism of spontaneous symmetry breaking and the emergence of massless Goldstone bosons.
5. Identify real-world applications of classical field theory such as MOT systems, solitons, and the Higgs mechanism, and relate them to quantum field theory.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENT

UNIT I: INTRODUCTION TO CLASSICAL FIELD THEORY

Review of classical particle mechanics, Lagrangian formulation for fields, Euler-Lagrange equations for fields, Examples: Scalar fields and vector fields, Symmetries and conservation laws

UNIT II: HAMILTONIAN FORMALISM AND NOETHER'S THEOREM

Hamiltonian density and conjugate momenta, Canonical equations of motion for fields, Noether's theorem and conserved currents, Energy-momentum tensor, Examples from scalar and electromagnetic fields

UNIT III: CLASSICAL ELECTROMAGNETIC FIELD THEORY

Classical Maxwell's equations in covariant form, Lagrangian for the electromagnetic field, Field strength tensor and gauge invariance, Stress-energy tensor of EM fields, Dual field tensor and magnetic monopoles (introductory idea)

UNIT IV: SYMMETRIES AND SPONTANEOUS SYMMETRY BREAKING

Internal and spacetime symmetries, Continuous vs discrete symmetries, Spontaneous symmetry breaking, Goldstone's theorem and massless modes, Examples of Nambu-Goldstone bosons

UNIT V: CLASSICAL FIELD THEORY APPLICATIONS

Laser cooling and trapping (MOT: Magneto-Optical Traps), Higgs mechanism (qualitative introduction), Classical solutions: Solitons and topological defects (overview), Pathway from classical to quantum field theory, Review and conceptual bridge to QFT

TEXT BOOKS

1. **L. H. Ryder** – *Quantum Field Theory* (Chapters 1–4 focus on classical field theory foundations) Publisher: Cambridge University Press
2. **Mark Srednicki** – *Quantum Field Theory* (Early chapters cover classical field theory in detail) Publisher: Cambridge University Press
3. Amitabha Lahari, Palash B. Pal, A first book of Quantum Field Theory, Narosa publications, 2nd Edition, 2007.
4. Michael E. Peskin and Daniel V. Schroeder, An introduction to Quantum Field Theory, Westview Press Inc, 1st Edition, 1995.
5. Thomas Banks, Modern Quantum Field Theory, Cambridge University Press, 2008

REFERENCE BOOKS

1. Steven Weinberg, The Quantum Theory of Fields: foundations, volume 1, Cambridge University Press, 2005.

2. V. B. Berestetskii, E.M Lifshitz and L.P. Pitaevskii, Quantum Electrodynamics, Butterworth-Heinemann, 2nd Edition 1982
3. M. Maggiore, A modern introduction to Quantum Field Theory, Oxford University Press, 2005
4. David Tong – *Lecture Notes on Classical Field Theory*, https://www.damtp.cam.ac.uk/user/tong/.
5. N. M. J. Woodhouse – *Introduction to Analytical Dynamics*, Publisher: Clarendon Press
6. A. Zee – *Quantum Field Theory in a Nutshell*, Publisher: Princeton University Press
7. T.-P. Cheng & L.-F. Li – *Gauge Theory of Elementary Particle Physics*, Publisher: Oxford University Press

QUANTUM FIELD THEORY	
Course Code:25PHBS024	Continuous Evaluation: ….. Marks
Credits: 4	End Semester Examination: ….. Marks
L T P : 3 1 0	**Course Type: Minor Stream Course Theory**
Prerequisite: NIL	

COURSE OBJECTIVES

1. To introduce students to the canonical quantization of scalar and spinor fields, leading to a quantum description of particles.
2. To enable students to compute scattering amplitudes and decay rates using Feynman diagrams and quantum interaction theory.
3. To develop a foundational understanding of quantum electrodynamics (QED), including photon quantization and lowest-order processes.
4. To provide a conceptual and technical understanding of divergences and renormalization techniques in QED.
5. To explore advanced applications of QFT such as loop corrections, the Higgs mechanism, and connections to the Standard Model.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Quantize scalar and Dirac fields using canonical formalism and interpret the role of normal ordering and Fock space.
2. Apply Feynman rules to calculate transition amplitudes, decay rates, and scattering cross-sections.
3. Analyze physical processes in QED including electron scattering and photon interactions with matter.
4. Explain the need for renormalization, use Ward-Takahashi identity, and identify divergent diagrams.
5. Discuss the significance of form factors, loop corrections, symmetry principles, and the Higgs mechanism in modern quantum field theory.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENT

UNIT I: CANONICAL QUANTIZATION OF FIELDS
Canonical quantization of scalar fields, Fourier decomposition, normal ordering, Fock space and particle interpretation, Complex scalar field and propagator, Quantization of Dirac fields, Dirac equation, Plane wave solutions, projection operators

UNIT II: INTERACTIONS, FEYNMAN DIAGRAMS AND CROSS SECTIONS
Yukawa interaction, Decay processes: scalar particle decay, Matrix elements and transition amplitudes, Feynman diagrams and Feynman rules, Virtual particles, decay rate, scattering cross sections, Mandelstam variables and 2-to-2 scattering.

UNIT III: QUANTUM ELECTRODYNAMICS (QED)
Quantization of the electromagnetic field, Problems and gauge fixing, Physical photon states and propagators, Local gauge invariance in QED, Lowest order QED processes:
$e^-e^- \rightarrow e^-e^-$, $e^+e^- \rightarrow \mu^+\mu^-$, Compton scattering, Bremsstrahlung.

UNIT IV: RENORMALIZATION IN QED
Divergences and regularization, Degree of divergence in diagrams, Electromagnetic vertex function and form factors, Anomalous magnetic moment of the electron, Ward-Takahashi identity, Renormalization procedure (outline).

UNIT V: ADVANCED TOPICS AND APPLICATIONS
Charge form factor and electron-proton scattering, Overview of loop corrections, Higgs mechanism (in context of QFT), Role of symmetry in renormalization, Modern extensions and outlook (Standard Model connection)
.

TEXT BOOKS

1. Amitabha Lahari, Palash B. Pal, A first book of Quantum Field Theory, Narosa publications, 2nd Edition, 2007.
2. Michael E. Peskin and Daniel V. Schroeder, An introduction to Quantum Field Theory, Westview Press Inc, 1st Edition, 1995.
3. Thomas Banks, Modern Quantum Field Theory, Cambridge University Press, 2008
4. Michael E. Peskin & Daniel V. Schroeder – *An Introduction to Quantum Field Theory*, Publisher: Addison-Wesley
5. Mark Srednicki – *Quantum Field Theory*, Publisher: Cambridge University Press

REFERENCE BOOKS

1. Steven Weinberg, The Quantum Theory of Fields: foundations, volume 1, Cambridge University Press, 2005.
2. V. B. Berestetskii, E.M Lifshitz and L.P. Pitaevskii, Quantum Electrodynamics, Butterworth-Heinemann, 2nd Edition 1982
3. M. Maggiore, A modern introduction to Quantum Field Theory, Oxford University Press, 2005.

4. Lewis H. Ryder – *Quantum Field Theory*, Publisher: Cambridge University Press
5. Franz Mandl & Graham Shaw – *Quantum Field Theory* (2nd Ed.), Publisher: Wiley
6. Ta-Pei Cheng & Ling-Fong Li – *Gauge Theory of Elementary Particle Physics,* Oxford University Press
7. Steven Weinberg – *The Quantum Theory of Fields* (Vol. I & II), Cambridge University Press

MATLAB	
Course Code: 25PHBS025	Continuous Evaluation: ….. Marks
Credits: 2	End Semester Examination: ….. Marks
L T P : 2 0 0	**Course Type: Minor Stream Course Theory**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. To introduce students to the MATLAB programming environment, including variables, arrays, and mathematical operations.
2. To enable learners to perform matrix operations and create 2D and 3D plots for data visualization and analysis.
3. To develop proficiency in writing MATLAB scripts and function files for structured and modular programming.
4. To teach logical reasoning and algorithm development using control structures and conditional logic in MATLAB.
5. To familiarize students with practical applications of MATLAB in numerical analysis, curve fitting, file handling, and toolbox utilities.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Navigate and utilize the MATLAB interface to create and manipulate variables, arrays, and matrices effectively.
2. Generate and format 2D and 3D plots, and apply data visualization techniques for interpreting scientific data.
3. Develop MATLAB scripts and user-defined functions to automate computational tasks and workflows.
4. Apply conditional statements, loops, and logical operations to implement algorithms and solve problems programmatically.
5. Use MATLAB for practical engineering/scientific tasks such as polynomial fitting, interpolation, solving equations, numerical integration, and exploring built-in toolboxes.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')		Course Learning Outcomes (CLOs')			
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit I: MATLAB basics

The MATLAB environment, scalar Variables and constants: useful commands for managing variables, 1D and 2D arrays: creating arrays, simple mathematical operations with arrays, operators/functions and simple calculations, Built-in functions for creating matrices, Handling arrays/matrices: adding, deleting elements and rows/columns.

Unit II: Matrices and plotting in MATLAB

Matrix and linear algebra/Matrix operations and functions in MATLAB, Strings: creating and handling strings (catenation, num2str etc commands), 2D Plots: plot and fplot commands, plotting multiple graphs in the same plot (plot, hold on and hold off, line commands), formatting a plot (labelling axes, titling, legends, linewidths, line colour, types etc), putting multiple plots on the same page. 3D plots: line plots, mesh and surface plots.

Unit III: Script and function files

MATLAB scripts and functions: creating, saving and accessing of these functions, Simple sequential algorithms; input and output commands: display, fprintf etc, importing and exporting data: load, save xlsread and xlswrite etc commands.

Unit IV: Programming in MATLAB

Relational and logical operators, Control structures: conditional statements, loops, nested loops, break and continue commands.

Unit V: Applications of MATLAB programming

File handling: file creation or loading, reading and writing data; Polynomial, curve fitting and interpolation; Numerical Analysis: Solving an equation (linear and nonlinear) with one variable, numerical integration; MATLAB Toolbox: Introduction to MATLAB Toolbox and its access, different toolboxes and their important functions.

TEXTBOOKS

1. MATLAB: An Introduction with Applications, Amos Gilat (Wiley).
2. MATLAB for Engineers, Holly Moore (Pearson).

REFERENCE BOOKS

1. Matlab: A Practical Introduction to Programming and Problem SolvingStormy Attaway (Butterworth-Heinemann)
2. Matlab for Beginners:A gentle Approach, Create space Independent Publishing Platform, Peter I. Kattan

PLASMA PHYSICS	
Course Code: 25PHBS026	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	**Course Category: Minor Stream Course Theory**
Prerequisite: Basic knowledge about classical mechanics and electrodynamics	

COURSE OBJECTIVES (CO):

1. To discuss the introduction to plasma and its applications
2. To illustrate the motion of a charged particle.
3. To make students familiar with general knowledge of waves in cold, warm and hot isotropic plasma.
4. To develop students' understanding about the waves in hot magnetized plasmas, stability and equilibrium.
5. To understand the transport processes in plasmas.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Well-versed with basics of plasma and its applications.
2. Equipped with the motion of a charged particle.
3. Able to apply knowledge of waves in cold, warm and hot isotropic plasma.
4. Well-versed with the waves in hot magnetized plasmas, stability and equilibrium.
5. Able to understand the transport processes in plasmas.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

<table>
<tr><th rowspan="2">Course Objectives (COs')</th><th colspan="5">Course Learning Outcomes (CLOs')</th></tr>
<tr><th>CLO1</th><th>CLO2</th><th>CLO3</th><th>CLO4</th><th>CLO5</th></tr>
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<tr><td>CO5</td><td></td><td></td><td></td><td></td><td bgcolor="#c0c0c0"></td></tr>
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COURSE CONTENTS

Unit-I: INTRODUCTION TO PLASMA AND ITS APPLICATIONS

Plasma a fourth state of matter, Occurrence of Plasma in Sun, Sun's atmosphere, Solar wind, Magnetosphere, Ionosphere and Van Allen Radiation Belts, Controlled Thermonuclear fusion, Magneto hydrodynamic generator, Plasma propulsion, theoretical description of Plasma phenomena, Pinch Effect & instabilities.

Unit-II: MOTION OF A CHARGED PARTICLE

Motion of a charged particle in a constant and uniform electromagnetic field, Uniform electrostatic field, Uniform magnetostatic field, drift due to external force, Charged particle in non-uniform magnetostatic fields, Equation of motion in the first order approximation, average force over one Gyration period, Gradient drift, parallel acceleration of the guiding centre, curvature drift, Charged particle motion in time varying electromagnetic fields, electric field with arbitrary time variation, Time varying magnetic field and space varying electric field.

Unit-III: WAVES IN COLD, WARM, HOT ISOTROPIC PLASMA

Magneto hydrodynamic equation for a compressible non-viscous conducting fluid, propagation perpendicular and parallel to magnetic field, effect of displacement current, damping of MHD waves, wave propagation in isotropic electron plasma, wave propagation in magnetized cold Plasmas, propagation in parallel and perpendicular to B_0 and arbitrary direction, waves in a fully ionized isotropic warm plasm.

UNIT– IV: WAVES IN HOT MAGNETIZED PLASMAS, STABILITY AND EQUILIBRIUM

waves in a warm electron gas in a magnetic field, waves in a flly ionized warm magnetoplasma, Plane wave in a hot isotropic plasma, electrostatic longitudinal & transverse waves in a hot isotropic plasma, wave propagation along & across the magnetostatic field in a hot plasma, Hydrodynamic equilibrium, Classification of instabilities, Two-stream instability, Gravitational instability, Resistive drift waves, Weibel instability.

Unit-V: TRANSPORT PROCESSES IN PLASMS

Particle interaction in plasmas, evaluation of scattering angle, Cross sections for the hard sphere model & Coulomb potential, Boltzmann equation and Boltzmann's H function, Boltzmann collision term for a weakly ionized plasma, the Foker-Planck equation, Electric conductivity in a non-magnetized Plasma, electric conductivity in a magnetized plasma, free diffusion, diffusion in a magnetic field, heat flow.

TEXT BOOKS

1. J.A. Bittencourt, Fundamentals of Plasma Physics, Springer, 3rd Edition, 2013.

REFERENCE BOOKS

1. Francis F. Chen, Introduction to Plasma Physics and controlled fusion, Springer, 3rd Edition, 2016

ADVANCED NUCLEAR PHYSICS	
Course Code:-25PHBS027	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: …. Marks
L T P : 3 1 0	**Course Category: Minor Stream Course Theory**
Prerequisite: Basic knowledge about thermodynamics	

COURSE OBJECTIVE (CO):

1. Recall the properties of deuteron and Schrodinger equation.
2. Describe the nuclear reaction and Calculate energy releases and kinematics for nuclear reactions and decays.
3. Solve the problems related to nuclear fission and fusion.
4. Compare and contrast interaction of charged particles and gamma ray with matter.
5. Critique the limitations and assumptions of various detectors.

COURSE LEARNING OUTCOME (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would

1. List the properties of deuteron in ground state and solve Schrodinger wave equation to explore the properties of deuteron.
2. Interpret the significance of nuclear cross-sections and reaction rates in nuclear processes.
3. Search for different nucleus for production of SHE elements.
4. Analyze the interaction in different region and different scattering process.
5. Design experiments to investigate specific particles with the help of detectors

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	■				
CO2	■	■			
CO3		■	■		
CO4				■	
CO5					■

COURSE CONTENTS

UNIT -I

TWO NUCLEON SYSTEMS & NUCLEAR FORCE

Two-body bound state: Properties of deuteron, Schrodinger equation and its solution for ground state of deuteron, r. m. s radius, , electromagnetic moment and magnetic dipole moment of deuteron, Central and tensor forces, n-p scattering, Scattering length and its significance, spin dependence of n-p interaction, effective range theory, Scattering from molecular hydrogen, low energy p-p scattering,

NATURE OF NUCLEAR FORCES: charge independence, charge symmetry and isospin invariance of nuclear forces, Meson theory

UNIT-II

NUCLEAR REACTIONS I:

Different types of nuclear reactions, Conservation laws in nuclear reactions, Collision between subatomic particles (Elastic and non-elastic), Q value of nuclear reactions, Cross section of nuclear reactions, Resonance scattering and Breit-Wigner dispersion relation; Compound nucleus formation and break-up, Statistical theory of nuclear reactions, evaporation probability

UNIT III

NUCLEAR REACTIONS II: Optical model,, Nuclear fission: fission reactions with example, spontaneous fission, liquid drop model, barrier penetration, Nuclear fusion (proton-proton cycle, carbon-nitrogen cycle), thermonuclear reactions, Nucleosynthesis and abundance of elements

UNIT- IV

INTERACTION OF CHARGED PARTICLES: Interaction of heavy charged particles with matter in low, medium and high velocity region. Range-Energy relationship for heavy charged particles, Energy and range straggling. Interaction of fast electrons in matter. Basic idea of gamma ray interaction with matter (Elastic scattering, Rayleigh scattering, Resonance scattering, Compton Scattering, photo electric effect, pair production, positron annihilation, photo nuclear reactions, absorption of gamma rays)

Unit V

LIGHT SENSING DETECTORS: Scintillation detectors: Scintillation mechanism and classification of scintillation materials, modes of energy transfer, Organic scintillators, Inorganic scintillators, Time characteristics of scintillator output, Photomultiplier tubes, Scintillation counter, Cherenkov detector.

TEXTBOOKS

1. Nuclear Physics: Principle and Application by John Lilley, Wiley Pub, 2006.
2. S. N. Ghoshal, Nuclear Physics, S. Chand Publishing, 2019.

REFERENCE BOOKS

1. R. L. Murray and K. E. Holbert, Nuclear Energy: an introduction to the concepts, systems and application of nuclear processes, Elsevier, 7th Edition, 2014.
2. R. R. Roy &B. P. Nigam, Nuclear Physics, New Age International Publisher, 2014.

MEDICAL PHYSICS	
Course Code: 25PHBS028	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: … Marks
L T P : 3 1 0	**Course Category: Minor Stream Course Theory**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. Introduce students to the field of Medical Physics.
2. Explain the fundamental principles of biopotential measurements.
3. Introduce students to Medical Instrumentation and its various applications.
4. Develop a deeper understanding of Radio Physics among students.
5. Enable students to demonstrate competency in measuring blood pressure and volume flow.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Demonstrate familiarity with key concepts in Medical Physics.
2. Apply knowledge and skills in conducting bio-potential measurements.
3. Invent the various new applications of Medical Instrumentation.
4. Demonstrate proficiency in Radio Physics concepts.
5. Apply knowledge to measure blood pressure and volume flow accurately.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')		Course Learning Outcomes (CLOs')			
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit-I: INTRODUCTION OF MEDICAL-PHYSICS

Definition and history of medical-physics: Physical properties applied to biology- Surface tension, Viscosity, adsorption, diffusion, osmosis, dialysis and colloids. Protein structure (Primary, Secondary, Tertiary and Quaternary structure): Amino-acids structure (Specify types); Photosynthesis process; Genetic code- symmetry, DNA structure, Tissue and turbid media.

Unit-II: BIO-POTENTIALS

Bioelectric signals: structure of neuron, resting potential, action potential, nernst equation; biopotential amplifier: input impedance, frequency characteristics, gain, CMRR calibration, noise, temperature sensitive stability. Compaind action potentials of the human body ECG, EEG, ERG, EOG (in brief); Transducers: Definition, types- resistive, capacitive and inductive transducers, LVDT.

Unit-III: MEDICAL-INSTRUMENTS& CHARACTERIZATION TECHNIQUES

Basic principle, construction and working of colorimeters, spectrophotometer, ECG machine, PH meter, centrifuge measurement. Electron microscope: SEM, TEM.

Unit-IV: RADIATION PHYSICS

Definition, units of radioactivity and radiation doses, X-Ray Crystallography as a method for a structure determination of biomolecules NMR. Nuclear detector (G M Counter), radioimmunoassays (in brief), Introduction to biophotonics.

Unit-V: MEASUREMENTS OF PRESSURE AND VOLUME FLOW OF BLOOD

Direct measurements of blood pressure, Indirect measurements of BP. Heart sounds, Phonocardiography, Ultrasonic blood flow meter; Laser Doppler blood flow meter

TEXT BOOKS

1. Introduction to Biophysics, P. Narayanan. New Age P.
2. Medical Instrumentation, by Khandpur, TMH
3. Laboratory Manuals of Biophysics Instruments, P.B. Vidyasagar
4. Biophysics, Vatsala Piramal, Dominant Publisher and Distributors, New Delhi-110002

REFERENCE BOOKS

1. Textbook of Biophysics, R.N. Roy
2. Photosynthesis, Hall and Rao.
3. Handbook of Biomedical Instrumentation, R.S. Khandpur.

RESEARCH METHODOLOGY	
Course Code: 25RMBS710	Continuous Evaluation: …… Marks
Credits: 2	End Semester Examination: … Marks
L T P : 2 0 0	**Course Type: Minor Stream Course Theory**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. Provide necessary background on research methodology to undergraduate students
2. Give understanding of hypothesis testing
3. Give understanding of different types sampling techniques.
4. Explain the concept of data and data types and Know about the Formats of Reports, introduction, and different parts of a report

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. have an idea about research methodology
2. understand the applications of sampling schemes and data types and data analysis
3. know how to write a report for a particular type of research work
4. understand the presentations method

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit-I

Meaning of research; objectives of research; basic steps of research; criteria of good research; types of research. Meaning of research problem; selection of research problem. Review of related literature- Meaning, necessity and sources.

Unit-II

Hypothesis- Meaning, function and types of hypotheses; Null/Alternative hypothesis, Variables- Meaning and types. Research design: Types of research design- exploratory, descriptive, diagnostic, and experimental.

Unit-III

Sampling- Meaning and types of sampling; Probability and Non-Probability. Tools and techniques of data collection- questionnaire, schedule, interview, observation, case study, survey etc. Statistics and its significance in research

Unit-IV

Research reports: Writing preliminaries, main body of research, references, and bibliography; Meaning and importance of workshop, seminar, conference, symposium etc. in research. Plagiarism- Concept and significance of plagiarism

Practical/Lab Work to be performed in Computer Lab

The practical will be taught using Excel software and/or using some statistical software like R /SPSS. Students are encouraged to use resources available on open sources.

TEXT BOOKS

1. Kothari, C.R Research Methodology: Methods and Techniques, 2nd Revised Ed. Reprint, New Age International Publishers, 2009

REFERENCE BOOKS

1. Lilien, Gary L. and Philip Kotler, Marketing Decision Making; A Model Building Approach, Harper & Row, New York, 1983.

2. Shenoy, GVS, et al., Quantitative Techniques for Managerial Decision Making, Wiley Eastern, 1983.

FUNDAMENTALS OF QUANTUM COMPUTING	
Course Code: 25PHBS029	Continuous Evaluation: ….. Marks
Credits: 3	End Semester Examination: …. Marks
L T P : 3 0 0	**Course Type: Minor Stream Course Theory**
Prerequisite: Quantum Mechanics	

COURSE OBJECTIVES

1. To introduce the foundational principles of quantum mechanics relevant to quantum computing, including quantum state representation and measurement.
2. To build a strong mathematical foundation using linear algebra, vector spaces, operators, and transformations essential for quantum computation.
3. To explore the nature and manipulation of qubits, entangled states, and their physical realizations across different quantum hardware platforms.
4. To understand interpretations of quantum mechanics, quantum nonlocality, and teleportation as a foundation for quantum communication protocols.
5. To train students in the theory and design of basic quantum circuits using standard quantum logic gates and reversible computing concepts.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Apply the postulates of quantum mechanics and Dirac notation to analyze and describe quantum states and their evolution.
2. Use linear vector space formalism to define quantum systems, operators, and transformations with physical significance.
3. Demonstrate understanding of qubits, entangled states, and implement their physical representations across various quantum technologies.
4. Interpret key quantum phenomena including wavefunction collapse, the EPR paradox, and teleportation using Bell states.
5. Construct and simulate basic quantum logic circuits using gates such as Pauli, Hadamard, Toffoli, and controlled gates, and assess their complexity.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENT

Unit I: Foundations of Quantum Computing:

Why Quantum Computing? Postulates of Quantum Mechanics, Dirac Notation: Kets and Bras, Superposition principle and Qubit measurement, Bloch Sphere Representation, Tensor Products and multi-qubit systems, Basics of Linear Algebra: Vectors, Complex Norms, Conjugates.

Unit II: Mathematical Structures

Linear Vector Space: addition and multiplication rules, Hilbert space, Dimension and Basis of a Vector Space, Dirac notation: scalar product, properties of kets, bras and bra-kets and their matrix representation, Operators: Hermitian Adjoint, properties of the Hermitian conjugate rules, Hermitian and skew-Hermitian, Projection operators, Commutators Algebra, uncertainty relation of operators, Inverse and Unitary operators, Infinitesimal and finite Unitary transformations, Eigen values and Eigen vectors of an operator, Parity Operator, Matrix representation of operators, Wave mechanics.

Unit III: Qubits and Quantum States

Dirac notation: bras, kets, and inner products, Superposition and normalization, Measurement and probability amplitudes, Multi-qubit states, tensor products, entangled states, Physical qubit implementations: Trapped Ions, Superconducting Qubits, Quantum Dots, GaAs and SQUID devices, NMR-based QC, Bose-Einstein Condensates for QC, Decoherence in hardware platforms, Supercooling and noise filtering techniques

Unit IV: Quantum States and Interpretations

Wave function collapse and measurement, Concept and physical implications of entanglement, Bell states and measurement outcomes, Einstein-Podolsky-Rosen (EPR) paradox, Bell inequality and CHSH game, Quantum teleportation: principles and circuits (intro), No-cloning theorem, Interpretations: Copenhagen, Many-Worlds

Chapter 5: Quantum Logic Gates and Circuits

Reversible logic, classical vs quantum logic, Pauli gates (X, Y, Z), Hadamard, phase gates, CNOT, CZ, SWAP gates, Quantum circuit diagrams and synthesis, Gate algebra and unitarity, Building simple quantum circuits Toffoli, Fredkin gates, Quantum circuit diagrams, Reversibility and Unitarity, Gate cascades and conditional operations, Classical algorithms and complexity classes (P, NP, etc.)

TEXTBOOKS

1. Michael A. Nielsen & Isaac L. Chuang – *Quantum Computation and Quantum Information,* Cambridge University Press
2. David J. Griffiths & Darrell F. Schroeter – *Introduction to Quantum Mechanics* (2nd or 3rd Edition), Pearson Publisher.
3. V. K. Thankappan – *Quantum Mechanics,* Publisher**:** New Age International

REFERENCE BOOKS

1. J. J. Sakurai & Jim Napolitano – *Modern Quantum Mechanics,* Cambridge University Press
2. Eleanor Rieffel & Wolfgang Polak – *Quantum Computing: A Gentle Introduction*: MIT Press
3. Mark M. Wilde – *Quantum Information Theory,* Cambridge University Press
4. Thomas G. Wong – *Introduction to Classical and Quantum Computing,* Springer
5. Chuck Easttom, Quantum Computing Fundamentals, Pearson Education, 1st Edition, 2022.
6. M.A. Nielsen and I.L. Chuang, Quantum computation and quantum information, Cambridge University Press, 2010.

FUNDAMENTALS OF QUANTUM COMPUTING LAB	
Course Code: 25PHBS030	Continuous Evaluation: …….. Marks
Credits: 1	End Semester Examination: …….. Marks
L T P : 0 0 2	**Course Type: Minor Stream Course Lab**
Prerequisite:	

COURSE OBJECTIVES

1. To introduce students to the Qiskit programming environment and the simulation of quantum circuits.
2. To develop conceptual and practical understanding of single- and two-qubit gates and their operations.
3. To provide hands-on experience in building and measuring quantum states, including superposition and entanglement.
4. To explore the relationship between classical and quantum logic through circuit design and visualization.
5. To enable students to observe quantum interference, phase effects, and measurement collapse through experiments.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Construct and simulate single-qubit and multi-qubit circuits using Qiskit and visualize their quantum state evolution.
2. Apply basic quantum logic gates (X, Y, Z, H, S, T, CNOT) and interpret their effects using Bloch sphere and measurement histograms.
3. Demonstrate the principles of superposition, entanglement, and measurement collapse in simple quantum systems.
4. Compare classical logic operations with quantum counterparts through XOR and NOT gate simulations.
5. Explain quantum phenomena such as phase kickback, interference, and the no-cloning theorem using practical circuit implementations.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

(A Student is supposed to complete/perform minimum ____ of experiments)

Basic Level (and Concepts)

1. Create a single qubit circuit and apply an X gate. Simulate and measure the output.
2. Implement the Hadamard gate and plot the output state on the Bloch Sphere.
3. Build a two-qubit entangled Bell state using H and CNOT gates. Measure the qubits.
4. Simulate quantum measurement collapse using a superposition state.
5. Use Qiskit to visualize the statevector and measurement histogram of a basic circuit.
6. Create and measure the output of a circuit using Pauli Y and Z gates.
7. Design a circuit to verify the no-cloning theorem.
8. Write a Python function that simulates a classical XOR gate and compare with quantum XOR.
9. Compare classical and quantum representations of a NOT operation.
10. Demonstrate the effect of phase gates (S, T) on a qubit state.
11. Apply a sequence of gates (X, H, S) to a single qubit and observe interference.
12. Build a 3-qubit circuit with various gate operations and visualize measurement.
13. Simulate the output of a Hadamard followed by Z gate and explain phase kickback.
14. Implement a basic circuit with controlled operations and measure outcomes.
15. Construct and simulate a circuit showing basis change using Hadamard gates.

TEXT BOOKS

1. M A Nielsen and I L Chuang, Quantum Computation and Quantum Information, Cambridge University Press, 2010.
2. Giuliano Benenti, Giulio Casati and Giuliano Strini, Principles of Quantum Computation and Information, Vol. I: Basic Concepts, Vol II: Basic Tools and Special Topics, World Scientific, 2004.
3. Arthur O. Pittenger, An Introduction to Quantum Computing, Birkhauser Boston Inc; 1st Edition, 2000.
4. P Kaye, R Laflamme and M Mosca, An Introduction to Quantum Computing, Oxford University Press, 2006.

REFERENCE BOOKS

1. G. Strang, Linear Algebra and its Applications, Cengage India Private Limited; 4th Edition, 2005.
2. Rajender. Bhatia, Matrix Analysis, Springer, 1997.

3. Zdzislaw Meglicki, William Gropp, Ewing Lusk, Quantum Computing without Magic, MIT Press, 2008.
4. DAVID McMAHON, Quantum Computing Explained, Wiley-IEEE Computer Society, 1st Edition, 2008.
5. Marco Lanzagorta, Jeffrey Uhlmann, Quantum Computer Science, Springer, 2008.

QUANTUM ALGORITHMS AND ERROR CORRECTION	
Course Code: 25PHBS031	Continuous Evaluation: ….. Marks
Credits: 3	End Semester Examination: ….. Marks
L T P : 3 0 0	**Course Type: Minor Stream Course Theory**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. To enable students to understand and analyze foundational and advanced quantum algorithms, including Shor's and Grover's algorithms.
2. To explain the working principles and mathematical structures behind the Quantum Fourier Transform and phase estimation.
3. To develop students' ability to design and evaluate quantum oracles and search techniques using tools like Qiskit.
4. To introduce students to the limitations and possibilities of quantum computing within the NISQ (Noisy Intermediate-Scale Quantum) era.
5. To equip students with theoretical and practical understanding of quantum error correction codes and error mitigation techniques in real quantum devices.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Analyze and implement key quantum algorithms (Deutsch-Jozsa, Simon, Shor, Bernstein-Vazirani, Grover) for problem-solving using quantum circuits.
2. Describe the mathematical formulation of QFT and apply it in understanding Shor's algorithm and quantum phase estimation.
3. Design oracle-based circuits and interpret search efficiency gains in Grover's algorithm with limitations of current hardware.
4. Assess performance metrics, resource allocation, and optimization techniques for quantum algorithms on NISQ devices.
5. Evaluate and apply quantum error correction codes such as Shor's code, Steane code, and surface codes in practical scenarios involving quantum noise and fault tolerance.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENT

Unit I: Algorithmic Foundations and Interference
Shannon's counting argument and quantum advantage, Deutsch Algorithm, Deutsch-Jozsa Algorithm, Bernstein-Vazirani Algorithm, Simon's Problem and Algorithm

Unit II: Shor's Algorithm and Quantum Fourier Transform
Modular arithmetic and periodicity, Quantum Phase Estimation, Quantum Fourier Transform and its implementation, Continued Fractions and Order Finding, Shor's algorithm for factorization

Unit III: Grover's Algorithm and Oracle Design
Unstructured search and classical limits, Amplitude amplification, Grover operator and iteration steps, BBBV Theorem, Oracle construction in Qiskit, Comments about limitations of quantum computers, Comments about implementation of quantum computers.

Unit IV: NISQ Devices and Variational Algorithms
NISQ model and constraints, Benchmarking and fidelity measurement, Variational Quantum Eigensolver (VQE), Quantum Approximate Optimization Algorithm (QAOA), Maxcut problem implementation

Unit V: Quantum Error Correction Techniques
Quantum noise and error types, Shor's 3-qubit and 9-qubit codes, Steane code and threshold theorem, Concatenated codes and scalable architectures, Surface code and decoding cycles, Syndrome extraction and scalable recovery. Device Level metrics, System Level Metrics, Benchmarking, NISQ model of computing: Current machines (5-50 qubit), NISQ model, NISQ Metrics, Qubit Mapping, Qubit Allocation problem. Error Mitigation Techniques for NISQ: Variability-Aware Mapping Diversity-Aware Mapping Reducing Measurement Errors Reducing Idling Errors. Quantum Approximation Optimization Algorithm: Maxcut problem, optimization for QAOA.

TEXT BOOKS

1. Michael A. Nielsen & Isaac L. Chuang – *Quantum Computation and Quantum Information,* Cambridge University Press
2. Thomas G. Wong – *Introduction to Classical and Quantum Computing,* Springer
3. Géza Giedke and Jens Eisert – *Quantum Error Correction* (Lecture Notes)
4. Sara Baase, "*Computer Algorithms - Introduction to design and analysis",* Pearson
5. Aho, Ullman & Hopcraft, "*The Design and Analysis of Algorithms*", Pearson Education, 2001

REFERENCE BOOKS

1. Eleanor Rieffel & Wolfgang Polak – *Quantum Computing: A Gentle Introduction*, Publisher: MIT Press

2. Mark M. Wilde – *Quantum Information Theory*, Publisher: Cambridge University Press.
3. Ashley Montanaro & Dominic Horsman (eds.) – *Quantum Algorithms: A Survey*, Publisher: Cambridge University Press (2021)
4. Asher Peres, Quantum theory: concepts and methods, Kluwer Academic Publishers.
5. Phillip Kaye, Raymond Laflamme, Michele Mosca, An introduction to quantum computing, Oxford University Press. T.H Cormen, Introduction to Algorithms, The MIT Press, 3rd Edition, 2009.
6. Richard Johnsonbaugh, Marcus Schaefer, "*Algorithms*", Pearson Education, 3rd edition, 2006

QUANTUM ALGORITHMS AND ERROR CORRECTION LAB	
Course Code: 25PHBS032	Continuous Evaluation: …. Marks
Credits: 1	End Semester Examination: …. Marks
L T P : 0 0 2	**Course Type: Minor Stream Course Lab**
Prerequisite:	

COURSE OBJECTIVES

1. To enable students to design and analyze quantum circuits involving multi-qubit entanglement and quantum communication protocols.
2. To introduce the implementation of quantum teleportation, entanglement swapping, and superdense coding using Qiskit.
3. To explore real-world quantum cryptographic schemes such as BB84 and Wiesner's quantum money protocol.
4. To understand the effects of noise and decoherence on quantum systems and analyze fidelity degradation.
5. To investigate foundational quantum mechanics principles like Bell inequalities through simulation-based experiments.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Construct and verify multi-qubit entangled states such as GHZ and Bell states, and perform quantum teleportation and entanglement swapping.
2. Implement and simulate quantum communication protocols like BB84 and superdense coding using Qiskit.
3. Analyze the behavior of quantum systems under noise and decoherence and assess fidelity using measurement outcomes.
4. Design and execute circuits for advanced quantum operations including fan-out, SWAP, and programmable gates.
5. Evaluate quantum non-locality through the CHSH test and interpret the results in the context of quantum entanglement and hidden variable theories.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS
(A Student is supposed to complete/perform minimum ____ of experiments)

1. Design a quantum teleportation circuit and verify the transfer of state.
2. Build a 3-qubit GHZ state and perform full measurement.
3. Implement a SWAP gate using three CNOT gates.
4. Create a Qiskit circuit to demonstrate superdense coding.
5. Program a custom unitary gate and integrate it in a 2-qubit quantum circuit.
6. Construct a 4-qubit entangled circuit and analyze the results.
7. Simulate the BB84 protocol using Qiskit and demonstrate eavesdropping.
8. Create a circuit implementing entanglement swapping.
9. Demonstrate teleportation with noise and explore fidelity degradation.
10. Design a Qiskit program for Wiesner's quantum money scheme (simplified).
11. Simulate a 3-qubit circuit using CNOT and H gates to study quantum fan-out.
12. Construct a parity-check circuit and validate results using different inputs.
13. Simulate the effect of decoherence on an entangled state.
14. Design a programmable Bell-state generator.
15. Measure Bell inequality violation using CHSH test in Qiskit.

TEXT BOOKS

1. M A Nielsen and I L Chuang, Quantum Computation and Quantum Information, Cambridge University Press, 2010.
2. Giuliano Benenti, Giulio Casati and Giuliano Strini, Principles of Quantum Computation and Information, Vol. I: Basic Concepts, Vol II: Basic Tools and Special Topics, World Scientific, 2004.
3. Arthur O. Pittenger, An Introduction to Quantum Computing, Birkhauser Boston Inc; 1st Edition, 2000.
4. P Kaye, R Laflamme and M Mosca, An Introduction to Quantum Computing, Oxford University Press, 2006.

REFERENCE BOOKS

1. G. Strang, Linear Algebra and its Applications, Cengage India Private Limited; 4th Edition, 2005.
2. Rajender. Bhatia, Matrix Analysis, Springer, 1997.
3. Zdzislaw Meglicki, William Gropp, Ewing Lusk, Quantum Computing without Magic, MIT Press, 2008.
4. DAVID McMAHON, Quantum Computing Explained, Wiley-IEEE Computer Society, 1st Edition, 2008.
5. Marco Lanzagorta, Jeffrey Uhlmann, Quantum Computer Science, Springer, 2008.

CLASSICAL AND QUANTUM INFORMATION PROCESSING	
Course Code: 25PHBS033	Continuous Evaluation: …. Marks
Credits: 3	End Semester Examination: ….. Marks
L T P : 3 0 0	**Course Type: Minor Stream Course Theory**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. To provide foundational understanding of classical information theory and its limitations in the context of quantum systems.
2. To introduce the formalism of the density matrix and explore various interpretations of quantum mechanics.
3. To explain the principles of quantum cryptography, quantum communication protocols, and their experimental foundations.
4. To familiarize students with the architecture of quantum networks and the classical-quantum interface challenges.
5. To equip students with skills in designing and simulating quantum circuits involving multi-qubit operations and quantum communication protocols using Qiskit.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Compare and contrast classical and quantum information theory, including the concepts of entropy, data compression, and computability.
2. Analyze quantum measurement processes using density matrices and explain key interpretations like Many-Worlds and hidden variable theories.
3. Demonstrate understanding of quantum cryptographic protocols including BB84, superdense coding, and quantum teleportation, and evaluate their theoretical and experimental implications.
4. Describe the layered architecture of a quantum network and identify design challenges at the interface of classical and quantum hardware.
5. Design, simulate, and test multi-qubit circuits involving entanglement, teleportation, and cryptographic protocols using Qiskit.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENT

Unit - I: Classical theory of information

Basic ideas of classical information theory, Measures of information (information content and entropy);Maxwell"s Demon; Data compression; The binary symmetric channel; error correcting codes; Classical theory of computation; Universal computer; Turing machine; Computational complexity; Uncomputable functions; Shortcomings of classical information theory and necessity of information theory.

Unit - II: Density Matrix and Interpretation

Density Matrix – Bloch Sphere and Density Matrix – Measurement Postulates.

The measurement problem, Schrodinger's cat and Wigner's friend, Decoherence and the CNOT gate, The Many-Worlds Interpretation, The idea of hidden variables, The Bell Inequality and the CHSH game, The GHZ game Wiesner's quantum money scheme, BB84 quantum key distribution, Superdense quantum coding, Quantum teleportation, Ruling out quantum Random Access Codes , A version of Holevo's Theorem.

Unit - III: Quantum Information and Quantum Cryptography

Classical Information theory, Shannon Entropy, Shannon's Noiseless Coding Theorem, Ven Neumann Entropy – EPR and Bell's inequalities – Cryptography – RSA Algorithm – Quantum Cryptography – Experimental Aspects of Quantum Computing

Unit IV: Quantum Network Architecture

Quantum data plane, measurement plane, control plane, Control processor architecture, Classical-quantum interface challenges, Quantum buses and interconnects, Real-time control and timing in QC systems

Unit V: Quantum Programming with Multiple Qubits

Building entangled state circuits, Complex circuits: teleportation, entanglement swapping, Quantum Adder and Reversible circuits, Qiskit multi-qubit programming, Visualizing quantum state evolution

TEXT BOOKS

1. Nielsen, M. A. & Chuang, I. L. – *Quantum Computation and Quantum Information,* Cambridge University Press
2. Mark M. Wilde – *Quantum Information Theory,* Cambridge University Press
3. Rieffel, E. & Polak, W. – *Quantum Computing: A Gentle Introduction,* MIT Press
4. Chuck Easttom, Quantum Computing Fundamentals, Pearson Education, 1st Edition, 2022.
5. M.A. Nielsen and I.L. Chuang, Quantum computation and quantum information, Cambridge University Press, 2010.
6. J. Preskill, Quantum information and Computation, CIT lecture notes.
7. E.Horowitz , Sahni & Sanguthevar Rajasekaran, "Fundamentals of Computer Algorithms", Galgotia Publications,1997

REFERENCE BOOKS

1. John Watrous – *The Theory of Quantum Information,* Publisher: Cambridge University Press
1. Shannon, C. E. – *A Mathematical Theory of Communication*
2. Michael Ben-Or et al. – *The Surface Code: A Blueprint for a Quantum Computer* (Preprint)
3. Qiskit Textbook (IBM Quantum) – *Learn Quantum Computation using Qiskit.* URL: https://qiskit.org/textbook
4. Asher Peres, Quantum theory: concepts and methods, Kluwer Academic Publishers.
5. Phillip Kaye, Raymond Laflamme, Michele Mosca, An introduction to quantum computing, Oxford University Press.
6. Aho, Ullman & Hopcraft, "*The Design and Analysis of Algorithms*", Pearson Education, 2001
7. S.E.Goodman, S.T.Hedetniemi, "*Introduction to the Design and Analysis of Algorithms*", McGraw Hill , 2002
8. Sara Baase, "*Computer Algorithms - Introduction to design and analysis",* Pearson

CLASSICAL AND QUANTUM INFORMATION PROCESSING LAB	
Course Code: 25PHBS034	Continuous Evaluation: …… Marks
Credits: 1	End Semester Examination: ….. Marks
L T P : 0 0 2	**Course Type: Minor Stream Course Lab**
Prerequisite:	

COURSE OBJECTIVES

1. To develop practical skills in constructing and analyzing multi-qubit entangled quantum states and protocols using Qiskit.
2. To implement core quantum communication techniques including teleportation, superdense coding, and quantum key distribution.
3. To explore real-world aspects of quantum cryptography through hands-on simulation of protocols such as BB84 and Wiesner's scheme.
4. To examine the role of noise and decoherence in quantum circuits and study methods to quantify and simulate these effects.
5. To investigate foundational principles in quantum mechanics, such as non-locality and measurement theory, through simulation-based experiments.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Design and execute quantum circuits for teleportation, GHZ state generation, and entanglement swapping using Qiskit.
2. Implement quantum cryptographic protocols and simulate secure key exchange and quantum currency schemes.
3. Analyze the behavior of entangled systems under decoherence and simulate the impact of noise on quantum fidelity.
4. Construct and test multi-qubit circuits including parity-checkers, fan-out circuits, and programmable Bell-state generators.
5. Demonstrate violations of classical assumptions through Bell inequality (CHSH) simulations, strengthening understanding of quantum non-locality.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS
(A Student is supposed to complete/perform minimum ____ of experiments)

1. Implement Deutsch's algorithm and validate the constant vs balanced function.
2. Design and simulate the Deutsch-Jozsa algorithm for 3 qubits.
3. Simulate the Bernstein-Vazirani algorithm and extract the hidden string.
4. Implement Simon's algorithm on a 2-qubit input and analyze periodicity.
5. Build Grover's search algorithm for a 2-qubit input and demonstrate search amplification.
6. Construct Shor's algorithm (conceptual structure) and simulate modular exponentiation.
7. Implement a 3-qubit bit-flip code and simulate single qubit error correction.
8. Simulate a noisy quantum channel using Qiskit noise models.
9. Measure and visualize fidelity loss using a simulated decoherence model.
10. Write a program to simulate a Variational Quantum Eigensolver (VQE) for a 2-qubit molecule.
11. Implement Quantum Approximate Optimization Algorithm (QAOA) for Maxcut problem.
12. Design a surface code circuit for detecting and correcting single-qubit errors.
13. Simulate an error mitigation strategy using readout error correction.
14. Implement quantum phase estimation algorithm and simulate eigenvalue extraction.
15. Perform benchmarking of a multi-qubit circuit and analyze depth and fidelity..

TEXT BOOKS

1. M A Nielsen and I L Chuang, Quantum Computation and Quantum Information, Cambridge University Press, 2010.
2. Giuliano Benenti, Giulio Casati and Giuliano Strini, Principles of Quantum Computation and Information, Vol. I: Basic Concepts, Vol II: Basic Tools and Special Topics, World Scientific, 2004.
3. Arthur O. Pittenger, An Introduction to Quantum Computing, Birkhauser Boston Inc; 1st Edition, 2000.
4. P Kaye, R Laflamme and M Mosca, An Introduction to Quantum Computing, Oxford University Press, 2006.

REFERENCE BOOKS

1. G. Strang, Linear Algebra and its Applications, Cengage India Private Limited; 4th Edition, 2005.
2. Rajender. Bhatia, Matrix Analysis, Springer, 1997.
3. Zdzislaw Meglicki, William Gropp, Ewing Lusk, Quantum Computing without Magic, MIT Press, 2008.
4. DAVID McMAHON, Quantum Computing Explained, Wiley-IEEE Computer Society, 1st Edition, 2008.
5. Marco Lanzagorta, Jeffrey Uhlmann, Quantum Computer Science, Springer, 2008.

QUANTUM MACHINE LEARNING	
Course Code: 25PHBS035	Continuous Evaluation: …… Marks
Credits: 3	End Semester Examination: …. Marks
L T P : 3 0 0	**Course Type: Minor Stream Course Lab**
Prerequisite:	

COURSE OBJECTIVES

1. Gain knowledge about quantum computing, quantum mechanics and analyze the quantum circuits
2. Learn about the fundamentals of Machine Learning
3. Utilize Qiskit for supervised learning
4. Learn unsupervised learning with Qiskit
5. Utilize the quantum neural networks with Pennylane

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Identify the need of quantum computing and quantum gates
2. Compare Classical vs. Quantum Machine Learning
3. Develop the Quantum Machine Learning programs
4. Incorporate the Unsupervised learning with Qiskit
5. Demonstrate the QNN, QCNN, QGAN using Qiskit and Pennylane

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs’)	Course Learning Outcomes (CLOs’)				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit-1 Introduction to Quantum Computing- Introduction to Superposition- Classical superposition- Quantum superposition- What is a Qubit?- Mathematical Representation on Qubits- Bloch Sphere- Quantum Gates- Entanglement-Multi-Qubits states-CNOT gate

Unit-2 Classical vs. Quantum Machine Learning- Examples of Typical Machine Learning Problems- The Three Ingredients of a Learning Problem- Risk minimization in Supervised Learning- Training in Unsupervised Learning- Methods in Machine LearningLinear Models- Neural Networks- Graphical and Kernel methods

Unit-3 Introduction to Quantum Machine Learning- Four approaches to QML-Parameterized quantum circuits (PQC)- Quantum Information Encoding- Training parameterized quantum circuits- Supervised learning- Quantum variational classification- Quantum kernel estimation- Quantum feature map and kernels- Quantum Support Vector classification (QSVM)

Unit-4 Introduction to Unsupervised learning- Principal Component Analysis- Clustering- Classifiers used in QML- Problem solving session- QML programming concepts in Qiskit- Analysis of Qiskit- Analysis of exercises created by Qiskit- Discussion about IBM Qiskit Summer School Challenge exercises

Unit-5 Introduction to Quantum Neural Networks- Quantum Convolutional Neural Networks (QCNN)- Hybrid QNN- Problem solving session on a real dataset- Classical Generative Adversarial Networks (GAN)- Quantum Generative Adversarial Networks (QGAN)- QGAN in Qiskit- Problem Solving session- Pennylane and AWS Quantum Braket introduction- Use cases in QML

TEXT BOOKS

1. Quantum Computation and Quantum Information. M. A. Nielsen and I. L. Chuang, Cambridge University Press
2. Ciaran Hughes, Joshua Isaacson, Anastatsia Perry, Ranbel F. Sun, Jessica Turner, “Quantum Computing for the Quantum Curious”, Springer, 2021
3. Maria Schuld and Francesco Petruccione, “Machine Learning with Quantum Computers”, Second Edition, Springer, 2021
4. Maria Schuld and Francesco Petruccione, “Supervised Learning with Quantum Computers”, Springer, 2018
5. Peter Wittek, “Quantum Machine Learning – What Quantum Computing Means to Data Mining”, Elsevier

REFERENCE BOOKS

1. An Introduction to Quantum Computing. P. Kaye, R. Laflamme, and M. Mosca, Oxford University Press, New York
2. Quantum Computer Science. N. David Mermin:, Cambridge University Press
3. Michael A. Nielsen and Issac L. Chuang," Quantum Computation and Information, Cambridge, 2002
4. Mikio Nakahara and Tetsuo Ohmi,"Quantum Computing", CRC Press, 2008
5. N. David Mermin, "Quantum Computer Science", Cambridge, 2007

QUANTUM MACHINE LEARNING LAB	
Course Code: 25PHBS036	Continuous Evaluation: 60 Marks
Credits: 1	End Semester Examination: 40 Marks
L T P : 0 0 2	**Course Type: Minor Stream Course Lab**
Prerequisite:	

COURSE OBJECTIVES

1. To introduce students to the Qiskit framework and the basics of quantum circuit design and simulation.
2. To build proficiency in implementing quantum gates and multi-qubit circuits using Python-based platforms.
3. To explore and implement quantum machine learning (QML) models such as QSVM, quantum classifiers, and quantum neural networks.
4. To train students in formulating and analyzing problem statements for real-world applications of quantum computing.
5. To guide students through the complete lifecycle of a quantum computing use case—from analysis and design to implementation and thesis documentation.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Develop and simulate quantum circuits using Qiskit and the circuit composer for single- and multi-qubit systems.
2. Apply Python programming to design and implement quantum gates and control logic.
3. Design and implement QML algorithms including quantum classifiers, QSVMs, quantum KNN, and quantum neural networks for practical problems.
4. Integrate tools like Qiskit and Pennylane to build, test, and optimize quantum computing projects.
5. Deliver a structured project including a demonstrable prototype, a technical report/thesis, and oral presentation of a real-world quantum application.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS
(A Student is supposed to complete/perform minimum ____ of experiments)

1. Introduction to Qiskit with some execises
2. Develop circuit composer in Qiskit lab
3. Demonstrate Quantum gates using Qiskit
4. Python basics and Project preparation phase 1 (Analysis of problem statement related to quantum computing)
5. Implement single and multiple qubit gates using python
6. Project preparation phase 2 (Design of the project based on problem statement using Qiskit or Pennylane)
7. Implementation of QML algorithms
8. Implementation of Quantum classifiers
9. Implementation of QSVM and Project preparation phase 3(Implementation of quantum problem statement in Qiskit or Pennylane)
10. Implementation of Quantum K Nearest Neighbour
11. Implementation of different QML models
12. Project presentation phase 4 demo (use case developed) and thesis preparation
13. Implementation of Quantum Neural Networks
14. Implementation of QCNN in healthcare applications
15. Project report submission (Thesis of use case developed)

TEXT BOOKS

1. Learn Quantum Computation Using Qiskit, Abraham Asfaw, Luciano Bello, et al. (IBM Quantum team), Open-source via qiskit.org/textbook
2. Quantum Machine Learning: What Quantum Computing Means to Data Mining, Peter Wittek, Academic Press (Elsevier)

REFERENCE BOOKS

1. Programming Quantum Computers: Essential Algorithms and Code Samples, Eric R. Johnston, Nic Harrigan, Mercedes Gimeno-Segovia, O'Reilly Media
2. Quantum Computation and Quantum Information, **Authors:** Michael A. Nielsen and Isaac L. Chuang**:** Cambridge University Press.
3. PennyLane Documentation and Tutorials, **Website:** https://pennylane.ai

MACHINE LEARNING FOR PHYSICS	
Course Code: 25PHBS037	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: … Marks
L T P : 3 1 0	**Course Type: Minor Stream Course**
Prerequisite:	

COURSE OBJECTIVES

1. To introduce the fundamental concepts and types of Machine Learning and their relevance in physical sciences.
2. To equip students with practical skills in Python-based ML tools for analyzing physical datasets.
3. To develop an understanding of statistical and neural network models and their use in modeling physical phenomena.
4. To expose learners to advanced ML techniques like unsupervised learning and feature extraction in physics contexts such as spectroscopy or phase identification.
5. To familiarize students with cutting-edge applications of physics-informed ML in solving differential equations, material prediction, and scientific discovery.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Differentiate between supervised, unsupervised, and reinforcement learning paradigms and identify their applications in physics.
2. Apply Python libraries like NumPy, pandas, matplotlib, seaborn, and scikit-learn to process and visualize experimental or simulated physics data.
3. Build and evaluate regression and classification models for physical phenomena such as phase transitions or curve fitting.
4. Design and implement neural networks and deep learning architectures to solve physics-inspired problems like quantum system modeling or image classification of microscopy data.
5. Integrate domain knowledge into ML models using Physics-Informed Neural Networks (PINNs) and apply symbolic regression tools to derive equations from data.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit 1: Foundations of Machine Learning and Tools
Introduction to Machine Learning: Types (supervised, unsupervised, reinforcement), Key concepts: features, labels, training, testing, validation, Introduction to datasets in physics: simulations, experiments, Python for ML: NumPy, pandas, matplotlib, seaborn, scikit-learn.

Unit 2: Statistical Learning and Linear Models
Regression: Linear, Polynomial, Ridge, Lasso – applications in curve fitting of physical data, Classification: Logistic Regression – applications in phase detection, event tagging, Model evaluation: MSE, R^2, confusion matrix, ROC curve, cross-validation, Overfitting, bias-variance tradeoff – relevance in physical measurements

Unit 3: Neural Networks and Deep Learning
Neural networks: Perceptron, activation functions, feed-forward architecture, Backpropagation, stochastic gradient descent, Implementing deep models using TensorFlow/Keras or PyTorch, Case studies: quantum system modeling, solving time-independent Schrödinger equation, Introduction to Convolutional Neural Networks (CNNs) for physical image data (e.g., SEM, microscopy)

Unit 4: Unsupervised Learning and Feature Extraction
Clustering: K-means, hierarchical clustering – application to experimental phase detection, Dimensionality reduction: PCA, t-SNE – used in spectroscopy, thermoelectric materials, Autoencoders and latent space – physical interpretation, Case study: Identifying distinct regimes in simulation data or experimental datasets

Unit 5: Physics-Informed ML and Applications
Physics-Informed Neural Networks (PINNs) – solving ODEs and PDEs (heat, wave, Poisson equations), Symbolic regression: discovering physical equations from data (e.g., PySR, Feyn, Eureqa), Applications: Materials science (property prediction from structure), High-energy physics (event classification), Astrophysics (exoplanet detection, GW signal processing), Ethical use of ML in scientific modeling and limitations of data-driven methods.

Text Books:

1. Machine Learning: A Probabilistic Perspective by Kevin P. Murphy.
2. Deep Learning by Ian Goodfellow, Yoshua Bengio, and Aaron Courville
3. Data-Driven Science and Engineering: Machine Learning, Dynamical Systems, and Control" by Steven L. Brunton and J. Nathan Kutz.

References Books:

1. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow" by Aurélien Géron
2. Machine Learning for Physics and Astronomy" by Viviana Acquaviva (Lecture Notes & Online Resources).
3. Raissi et al., *"Physics-Informed Neural Networks"*, JCP, 2019
4. Cranmer et al., *"Discovering Symbolic Models from Data"*, PNAS, 2020

ELECTRIC VEHICLE

Course Code: 25PHBS037	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: … Marks
L T P : 3 1 0	**Course Type: Minor Stream Course**
Prerequisite:	

COURSE OBJECTIVES

1. Understand the fundamental concepts of electric mobility and how EVs differ from internal combustion engine (ICE) vehicles.
2. Familiarize themselves with core EV components such as motors, batteries, controllers, and drivetrains.
3. Explore different types of energy storage systems with a focus on lithium-ion batteries and their safety.
4. Gain insight into EV charging technologies and their integration with renewable energy sources.
5. Recognize the environmental, economic, and policy implications of EV adoption at the national and global levels.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Differentiate between types of electric vehicles (BEV, HEV, PHEV) and describe their working principles.
2. Explain the structure and functioning of EV powertrain components including electric motors and regenerative braking.
3. Analyze battery specifications such as voltage, energy density, life cycle, and thermal management in lithium-ion systems.
4. Identify various EV charging standards and smart charging techniques relevant to infrastructure planning.
5. Evaluate the environmental benefits and policy incentives related to the transition from conventional to electric vehicles.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit 1: Basics of Electric Vehicles and E-Mobility
History and evolution of electric vehicles, Comparison of ICE (Internal Combustion Engine) and Electric Vehicles, Types of EVs: BEV, HEV, PHEV, FCEV, Advantages and challenges of EVs, Introduction to EV ecosystems in India and global scenario.

Unit 2: Fundamentals of EV Powertrain and Components
Structure of EV powertrain, Electric motor basics: DC, BLDC, PMSM, Controllers and power electronics in EVs, Regenerative braking: working principle and benefits, Drivetrain architecture and transmission in EVs.

Unit 3: Batteries and Energy Storage Systems
Basics of batteries: voltage, capacity, energy density, Types of batteries: Lead-acid, NiMH, Lithium-ion (focus on Li-ion), Battery Management Systems (BMS), Charging and discharging cycles, degradation, Thermal management and safety aspects

Unit 4: EV Charging Infrastructure and Grid Integration
Types of charging: slow, fast, rapid charging, Charging protocols (CHAdeMO, CCS, Bharat DC), On-board and off-board chargers, Smart charging, Vehicle-to-Grid (V2G) concept, Renewable energy integration in EV charging

Unit 5: Environmental Impact, Policies and Future Trends
Comparison of emissions: EV vs ICE vehicles, Lifecycle analysis and recycling of EV batteries, Government incentives, subsidies and EV policies (India-focused), Trends in EV R&D: solid-state batteries, hydrogen fuel cells, autonomous EVs, Career prospects and start-up ecosystem in EV domain

Text Books:

1. James Larminie & John Lowry, *"Electric Vehicle Technology Explained"*– Wiley, 2nd, Edition
2. Ehsani, Gao, Gay, Emadi, *"Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design"*– CRC Press

References Books:

1. David Andrea, *Battery Management Systems for Large Lithium-Ion Battery Packs* – Artech House.
2. Tariq Muneer & Mohammad Asif, *Electric Vehicles: Prospects and Challenges"* – CRC Press.

List of Multidisciplinary Courses (MDC) offered to

Four Year B.Sc. Physics programme in the Department of Physics

w.e.f. Academic Year 2025-26

Cat.	Code	Course Name	L	T	P	Credits
MDC I		Renewable Energy Sources	3	0	0	3
		Hybrid Electric Vehicle	3	0	0	3
		IPR in Business	3	0	0	3
		Library Information Sciences & Media Literacy	3	0	0	3
		Management Process & Organizational Behaviour	3	0	0	3
MDC II		Introduction to Bio-engineering	3	0	0	3
		Introduction to Robotics	3	0	0	3
		Psychology and Emotional Intelligence	3	0	0	3
		Indian Economy	3	0	0	3
		Creating an Entrepreneurial Mind	3	0	0	3
MDC III		Arduino based programming	3	0	0	3
		Electoral Literacy in India	3	0	0	3
		Personal Financial Planning	3	0	0	3
		Interior Design	3	0	0	3

RENEWABLE ENERGY SOURCES			
Year/Semester		Course Category	Multidisciplinary Course
Course Code		Course Title	Renewable Energy Sources
Continuous Evaluation: …. marks		End Semester Examination: …. marks	
Prerequisite: Nil		L T P : 3 0 0	Credits: 3

COURSE OBJECTIVES

1. To create awareness about sources of energy and able to estimate how long the available conventional fuel reserves will last.
2. To learn the fundamental concepts about solar energy systems and devices.
3. To design wind turbine blades and know about applications of wind energy for water pumping and Electricity generation.
4. To understand the working of OTEC system and different possible ways of extracting energy from Ocean, know about Biomass energy, mini-micro hydro systems and geothermal energy system.

COURSE LEARNING OUTCOMES (CLO) : At the end of the course, the student will be able to

1. Analyze the energy scenario of the world and nation.
2. Carry out a comparative analysis of different types of coal, including their treatment, Liquefaction and gasification.
3. Compare the liquid and gaseous fuels sourced from petroleum including their characterization.
4. Analyze the potential of alternate energy sources and their scope and limitations.

Mapping Matrix between Course Objectives and Course Learning Outcomes:

Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
CO1	x			
CO2		x		
CO3			x	
CO4				x

COURSE CONTENTS:

UNIT	COURSE CONTENTS	HOURS
UNIT-I	**Introduction to Energy Sources:** World energy futures, Conventional energy sources, Nonconventional energy sources, Prospects of Renewable energy sources. **Environmental Aspects of Electric Energy Generation:** Introduction Thermal pollution, Atmospheric pollution, Effects of Hydroelectric projects, Nuclear power generation and environment, Green House Gas Effects, Global Environmental awareness, Energy options for Indian Economy.	8
UNIT-II	**Solar Energy:** Introduction to solar radiation and its measurement, Introduction to Solar energy Collectors and Storage, Solar thermal electric conversion, Thermal electric conversion systems, Solar electric power generation, Solar photo-voltaic, Solar Cell principle, Semiconductor junctions, Conversion efficiency and power output, Basic photovoltaic	8

	system for power generation.	
UNIT-III	**Wind Energy and Wind Energy Conversion:** Introduction to wind energy conversion, the nature of the wind, Power in the wind, Wind data and energy estimation, Site Selection considerations, basic Components of a Wind energy conversion system, Classification of WEC Systems, Schemes for electric generation using synchronous generator and induction generator, wind energy storage.	8
UNIT-IV	**BIOMASS ENERGY** Biomass conversion technologies bio mass generation, classification of Bio Gas Plants material used in Bio Gas Plants., Selection of site & applications. **MHD & Hydrogen Energy:** Basic Principle MHD SYSTEM, advantages, Power OUTPUT of MHD Generation, future Prospects. Principle and classification of fuel cell energy, hydrogen as alternative fuel for Generation of Electrical Energy & applications. **Fuel Cell:** Fuel Cell, Management of Fuel, Thermonic power generation.	8
UNIT-V	**HYDRO POWER AND OTHER RENEWABLE ENERGY SOURCES** Hydropower: Introduction, Capacity and Potential, Small hydro, Environmental and social impacts. Tidal Energy: Introduction, Capacity and Potential, Principle of Tidal Power, Components of Tidal Power Plant, Classification of Tidal Power Plants. Ocean Thermal Energy: Introduction, Ocean Thermal Energy Conversion (OTEC), Principle of OTEC system, Methods of OTEC power generation. Geothermal Energy: Introduction, Capacity and Potential, Resources of geothermal energy.	8

TEXT BOOKS

1. Sukhatme. S.P., Solar Energy, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.
2. B. H. Khan, Non-Conventional Energy Resources, , The McGraw Hill
3. Twidell, J.W. & Weir, A. Renewable Energy Sources, EFN Spon Ltd., UK, 2006.
4. S. P. Sukhatme and J.K. Nayak, Solar Energy – Principles of Thermal Collection and Storage, Tata McGraw-Hill, New Delhi.
5. Garg, Prakash, Solar Energy, Fundamentals and Applications, Tata McGraw Hill.

REFERENCE BOOKS

1. G.D. Rai, Non-Conventional Energy Sources, Khanna Publications, New Delhi, 2011.
2. Godfrey Boyle, "Renewable Energy, Power for a Sustainable Future", Oxford University Press, U.K., 1996.
3. Khandelwal, K.C., Mahdi, S.S., Biogas Technology – A Practical Handbook, Tata McGraw- Hill, 1986.
4. Tiwari. G.N., Solar Energy – "Fundamentals Design, Modeling & Applications", Narosa Publishing House, New Delhi, 2002.
5. Freris. L.L., "Wind Energy Conversion Systems", Prentice Hall, UK, 1990.
6. Frank Krieth& John F Kreider ,Principles of Solar Energy, John Wiley, New York

ELECTRIC VEHICLES			
Year/Semester		Course Category	Multidisciplinary Course
Course Code		Course Title	Electric Vehicles
Continuous Evaluation: …. marks		End Semester Examination: ….. marks	
Prerequisite: Nil		L T P : 3 0 0	Credits: 3

COURSE OBJECTIVES

1. To acquire knowledge on the fundamental concepts, principles, and analysis of hybrid electric vehicles.
2. To understand the concept of electrical vehicles and its operations.
3. To understand the need for energy storage in hybrid vehicles.
4. To provide knowledge about various possible emerging technologies that can be used in electric vehicles.

COURSE LEARNING OUTCOMES (CLO): At the end of the course, the student will be able to

1. Realize the importance of electric transportation systems.
2. Understand the basics of electric vehicle components and configuration.
3. Understand the various charging types, comfort and safety methods.
4. Understand the application of electric vehicle in Smart grid.

Mapping Matrix between Course Objectives and Course Learning Outcomes:

Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
CO1	x	x	x	x
CO2	x	x	x	
CO3	x			
CO4				x

COURSE CONTENTS:

UNIT	COURSE CONTENTS	HOURS
UNIT-I	**ELECTRIC VEHICLES** History of Modern Transportation, Importance of Different Transportation Development Strategies to Future Oil Supply, Introduction to Electric Vehicles, History of hybrid and electric vehicles, Social, environmental importance and key challenges of hybrid and electric vehicles, Specifications of PHEVs, BEVs, EVs, Plug-in Hybrid Vehicle characteristics, The future of electric vehicles.	8
UNIT-II	**ENERGY STORAGE AND BATTERY TECHNOLOGY** Introduction to Energy Storage system, Battery Requirements for HEVs, PHEVs, and EVs, Types of batteries, Properties of batteries, Working principle and construction of lead-acid, nickel cadmium, nickel metal hydride, lithium ion batteries, Maintenance and charging of batteries, Diagnosing lead-acid battery faults, Advanced battery technology, Developments in electrical storage, Case studies	8

UNIT-III	**CHARGING AND STARTING SYSTEMS** Requirements of the charging system, Charging system principles, Alternators and charging circuits, Diagnosing charging system faults, Advanced charging system technology, New developments in charging systems, Requirements of the starting system, Starter motors and circuits, Types of starter motor, Diagnosing starting system faults, Advanced starting system technology, New developments in starting systems, Case studies.	8
UNIT-IV	**HYBRID ELECTRIC VEHICLE DRIVE TRAIN AND SAFETY** Requirement of drive train, Architecture of hybrid drive train, Sizing of components, Series configuration, Parallel configuration, parallel and series configuration, Security, Airbags and belt tensioners, Diagnosing comfort and safety system faults, Advanced comfort and safety systems technology, New developments in comfort and safety systems.	8
UNIT-V	**PERIPHERAL INTERFACES** **EMERGING TECHNOLOGIES** Introduction, Electric Vehicle Supply Equipments, Smart vehicles in smart grid, Vehicle-to-grid technologies: Unidirectional and Bidirectional, Need of Charging Station Selection (CSS) server, Smart grid technologies: Applications / Benefits, Smart meter, Smart charger: Purpose and benefits.	8

TEXT BOOKS

1. M. Ehsani, Y. Gao, and A. Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design” Second Edition,CRC Press, ISBN: 978-1-4200-5398-2, Aug. 2009.
2. Tom Denton,” Automobile Electrical and Electronic Systems” Elsevier Butterworth-Heinemann, Third edition, 2004.
3. A. Emadi ,”Advanced Electric Drive Vehicles, CRC Press, ISBN: 978-1-4665-9769-3, Oct. 2014.

REFERENCE BOOKS

1. Iqbal Hussain, “Electric & Hybrid Vehicles – Design Fundamentals”, Second Edition, CRC Press, 2011.
2. James Larminie, “Electric Vehicle Technology Explained”, John Wiley & Sons, 2003.
3. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, John Wiley & sons inc, 2012.

DEPARTMENT OF LAW			
Year/Semester		Course Category	Multidisciplinary Course (MDC)
Course Code		Course Title	IPR for Business
Continuous Evaluation: …. marks		End Semester Examination: ….. marks	
Prerequisite: Nil		L T P: 3 0 0	Credits: 3

COURSE OBJECTIVES:

The objective of this Multidisciplinary Course (MDC) is to familiarize the students with various types of IPR and its relevance to the businesses and their respective streams.

CO 1: To provide students with a basic understanding of various types of IPR and its relevance for business.

CO 2: To acquaint students with the strategies and management techniques associated with intellectual property assets, and the legal considerations and challenges involved.

CO 3: To familiarize the students with the challenges and legal considerations related to intellectual property disputes.

CO 4 To develop skills related to management of intellectual property in business.

COURSE LEARNING OUTCOMES

At the end of this course, the students would be able to:

CLO1: Define and discuss about the various types of IPR and its relevance for business

CLO2: Discuss the adjudicating bodies and mechanisms under each of these IPRs

CLO3: Analyze and resolve business disputes relating to IPR

CLO4: Apply the learning to the real-life situations in business

MAPPING COURSE OBJECTIVES (COs) & COURSE LEARNING OUTCOMES (CLOs)

	COURSE LEARNING OUTCOMES (CLOs)			
COURSE OBJECTIVES (COs)	CLO1	CLO2	CLO3	CLO4
CO1	√			
CO2		√		
CO3			√	
CO4				√

COURSE CONTENT

UNIT I

INTRODUCTION TO INTELLECTUAL PROPERTY AND BUSINESS

- Concept of IPR in business and its types
- International Context - Introduction to the leading International Instruments concerning Intellectual Property Rights: the Berne Convention, Universal Copyright Convention, The Paris Convention, Patent Co-operation Treaty, TRIPS, The World Intellectual Property Organization (WIPO), World Trade Organization (WTO) and the UNESCO
- Innovation as a Business Strategy and relevance of protecting the ideas legally
- National IPR Policy

UNIT II: COPYRIGHT

- Concept of Copyright and importance for businesses
- Media business – protecting performer's rights
- Performers' and Broadcasters' Rights Law
- Assignment, Transmission, Licensing of Copyrights
- Infringement of Copyrights and remedies

UNIT III: TRADEMARKS

- Trademark – value of and relevance for businesses
- Protecting brand value- acquiring trademark nationally and internationally
- Trade mark disputes – case studies

UNIT IV: PATENTS

- Protecting innovation – acquiring patents nationally and internationally
- Product and process patents
- Assigning patents and its commercialization
- Patent Disputes

UNIT V: INDUSTRIAL PROPERTIES

- Industrial designs – protection - Procedure for Registration of Designs • Copyright under Design
- Semiconductor Integrated Circuits Layout-Designs
- Plant varieties – commercialization - Monsanto cases
- Geographical Indications
- Biotechnology and IPR

UNIT VI: REGISTRATION AND ENFORCEMENT MECHANISMS

- Registration authorities of various IPRs
- IP Management and assertion of rights through declarations – use of copyright, trademark signs
- IP Litigation – Approach of courts – landmark cases

TEXT BOOKS:

- WIPO DL-101 General Course on Intellectual Property (online)
- Elizabeth Verkey and Jithin Saji Issac, *Intellectual Property*, Eastern Book Company 2021
- Anurag K. Agarwal, *Business and Intellectual Property: Protect your Ideas*, IIM Ahmedabad. Random House India (2016)
- *Handbook on IP Commercialisation - Strategies for Managing IPRs and Maximising Value* Jakarta: ASEAN Secretariat, November 2019

REFERENCES BOOKS:

- ICSI Study Material, Intellectual Property Rights: Law and Practice, A. Ramaiya, Guide to the Companies Act, LexisNexis, 19th Ed. 2020 (in 6 volumes)
- WIPO, *Enterprising Ideas A Guide to Intellectual Property for Startups*, 2023
- Manuals published by Office of the Controller General of Patents, Designs & Trade (CGPDTM), available at https://ipindia.gov.in/
- Guide Books by WIPO –Intellectual Property for Business, available at https://www.wipo.int/publications/en/series/index.jsp?id=181

Department of Library & Information Science			
Year/Semester		Course Category	MDC
Course Code		Course Title	Library Information Science & Media Literacy
Continuous Evaluation: …. marks		End Semester Examination: ….. marks	
Prerequisite: Nil		L T P : 3 0 0	Credits: 3

Course Objectives (CO) - The Course is designed with the following objectives:

CO-1:To know the library collection and their classifications.
CO-2: To discuss the library information services.
CO-3: To understand the importance of media
CO-4: To grasp the significance of motive of media

Course Learning Outcomes (CLO) – The Syllabus has been prepared in accordance with the NEP-2020. Upon completion of this course, learners will be able to:

CLO-1: Explain the library collection and their classifications.
CLO-2: Analyse the library information services.
CLO-3: Analyse the media roles.
CLO-4: Analyse the motive of media.

Mapping Matrix between Course Objectives and Course Learning Outcomes:

	CO-1	**CO-2**	**CO-3**	**CO-4**
CLO-1	√			
CLO-2		√		
CLO-3			√	
CLO-4				√

COURSE CONTENTS:

UNIT I: Library Collection

- Type of Information Sources : Primary, Secondary and Tertiary
- Reference Collection: Type of reference sources
- Indexing and Abstracting Journals
- Multimedia Collection
- Arrangement of Information Sources : Classification

UNIT II: Information Services

- Bibliography: Type of Bibliography
- Reviews Literature
- Citation Style
- Citation Analysis: Web of Science and Scopus
- Online Databases : Structure and Retrieval

UNIT III: Media Literacy

- Introduction to Media Literacy
- Type of media: Traditional versus social media
- Bias in media

UNIT IV: Motive of Media

- Media tycoons and conditions in which media works
- Research and Publication ethics

Recommended Books:

1. Richard E. Rubin & Rachel G. Rubin ,Foundations of Library and Information Science, 5th Edition. ISBN-9781783304776, Facet Publication, UK
2. https://en.unesco.org/themes/media-and-information-literacy/resources

Management Process & Organizational Behaviour	
Course Code:	Continuous Evaluation: …. Marks
Credits: 3	End Semester Examination: ….. Marks
Prerequisite: NIL	Course Category: Multidisciplinary

COURSE OBJECTIVES

1. To understand the functions and responsibilities of managers.
2. To acquaint the students with the fundamentals of managing business.
3. To understand individual and group behaviour at work place so as to improve the effectiveness of an organization.
4. To analyse human behaviour in the organization setting in order to manage it in accordance to the intentions.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Demonstrate the roles, skills and functions of management.
2. Analyse the causes and consequences of applying different business strategies.
3. Analyse and compare individual behaviour related to motivation and rewards.
4. Identify group behaviour, leadership styles and the role of leaders in a decision making process.

MAPPING BETWEEN COURSE OBJECTIVES AND COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO 1	CLO 2	CLO 3	CLO 4
CO 1				
CO 2				
CO 3				
CO 4				

COURSE CONTENTS

Unit I: Introduction to the management

Management Concept, Nature, Process and significance, levels of management, managerial skills, functions of management, management and administration, evolution of management, Role of management and insights from Indian practices and ethos.

Unit II: Functions of the management

Planning: Types of Plans & The planning process; Organizing: Common organisational structures; Staffing: features and necessity; Leading: types of leaders; Controlling: functions and types

Unit III: Introduction to Organizational Behaviour

Meaning, importance and scope of OB; abilities: meaning and forms, attitudes: framework, work related attitudes, personality: types, assessment, perception: process, factors influencing perception, perceptual errors

Unit IV: Foundation of Group Behaviour

Defining and classifying groups; need to join groups, stages of group development; group dynamics: group properties as roles, norms and size; group decision making techniques, conflict management

TEXT BOOKS

1. Stephen Robbins, Organizational Behavior, 16th edition (2012), Pearson Education.
2. K. Aswathappa, Organizational Behaviour, 13th edition (2016), Himalaya Publishing House.
3. Fred Luthans, Organizational Behavior, 14th edition (2017), McGraw-Hill.

SUGGESTED READINGS

1. Gregory Moorhead & Ricky W. Griffin, Organizational Behaviour, 11th edition (2009), Jaico Publication.
2. Tripathy PC and Reddy PN, Principles of Management, 6th edition (2011), McGraw-Hill.

Introduction to Bioengineering	
Course Code:	Continuous Evaluation: … Marks
Credits: 3	End Semester Examination: … Marks
Prerequisite: NIL	Course Category: Multidisciplinary

AIM:
To engage and motivate outstanding engineering students to build their career in interdisciplinary areas. To utilize the technologies in solving healthcare problems.

COURSE OBJECTIVES (CO):
1. To familiarize the students with the different biological concepts.
2. To impart an understanding about bioengineering.
3. To gain a better understanding of different imaging systems and AI
4. To comprehend the significance of the bioengineering application in various fields.
5.

COURSE LEARNING OUTCOMES (CLO):
1. Improve biological concepts using an engineering approach.
2. Explain the importance of biological phenomenon in bioengineering.
3. Learn to understand the different imaging system and applications of AI.
4. Able to understand the application of living organisms in various fields.

MAPPING MATRIX:

CO's \ CLO's	**01**	**02**	**03**	**04**
01	✓			
02	✓	✓		
03			✓	
04				✓

Unit I: Human Physiology & Biomolecules: Biomolecules:Molecules of the life – Monomeric unit and polymeric structure –sugar , starch and cellulose ,Amino acid and proteins; Nucleotides and DNA/RNA; introduction to organ systems.

Unit II: Introduction to Bioengineering: Fundamental similarities and difference between science and engineering- human as the best machines, comparison between eye camera, flying of a bird and aircraft.Bio engineering (production of artificial limbs, joints and other parts of body).

Unit III: Basic Medical Imaging & Data Science: MRI, Ultrasound, application of AI in health care. Biological concepts applied in data science.

Unit IV: Application of Bioengineering: Applications of bioengineering in Agriculture, Medicine (vaccine production), Environment (sewage treatment), superbug, Basics of biosensors and biochips.

TEXT BOOKS:

1. Environmental Engineering and science by Gilbert M. Masters and Wendell P. Ela. 2008 PHI Learning Pvt. Ltd.
2. Biology : a Gopal approach Campbell , N.A Reece, J.B Urry ,Lisa; Cain M.L Wasserman , S.A Minorsky,P.VJackson, R.B Person Education ltd.

REFERENCE BOOKS:

1. Joseph Bronzino, "Biomedical Engineering and Instrumentation", PWS Engg . , Boston.
2. Principles of Biochemistry(V Edition) by Nelson, D.L; and Cox, M.M.W.H Freeman and company.
3. J.Webster, "Bioinstrumentation", Wiley & Sons. 3. Joseph D.Bronzino, "The Biomedical Engineering handbook", CRC Press.
4. Masters, G. M., "Introduction to Environmental Engineering and Science", Prentice-Hall of India Pvt. Ltd.,1991.

Department of Mechanical Engineering			
Year/Semester	1st Year/1st Semester	Course Category	Multidisciplinary Course
Course Code		Course Title	Introduction to Robotics
Continuous Evaluation: …. Marks		End Semester Examination: …. Marks	
Prerequisite: Nil		L T P : 3 0 0	Credits: 3

COURSE OBJECTIVES (CO)

1. Review of Industrial Control Devices and Circuits; Basic Ladder Logic and Control
2. Programmable Logic Controllers and Applications;
3. Robot Fundamentals; Mechanisms and Actuators, Sensors and Detectors;
4. Modeling and Control of Manipulators; Robot Applications and Programming.

COURSE LEARNING OUTCOMES (CLO) : At the end of the course, the student will be able to

1. Explain basic concepts of Programmable Logic Controller (PLC) and Industrial automation.
2. Determine basic programming languages and instructions of a PLC and Use a particular Programmable Logic Controller (PLC) for various applications.
3. Design an automated system for industrial derive to meet defined operational specifications.
4. Explain basic concept, type and components of Robotic system and Define the principles and benefits of the various actuators, drives and sensors. Solve forward kinematics of any serial robot, compute position and orientation of end effectors as a function to joint variables.

Mapping Matrix between Course Objectives and Course Learning Outcomes:

Course Objectives	CLO1	CLO2	CLO3	CLO4
CO1	x			
CO2		x		
CO3			x	
CO4				x

COURSE CONTENTS:

UNIT	COURSE CONTENTS	HOURS
UNIT-I	**Introduction to Industrial Automation :** Introduction to Industrial Automation Review of industrial control devices I/O devices (Electronics Circuit breakers, timers, relays)	8
UNIT-II	**Programmable Logic controllers (PLC)** **2.1 Introduction to Programmable Logic controllers** ➢ Introduction to PLCs ➢ Overview of number systems and logic concepts ➢ PLC Programming Procedures and Devices ➢ Inputs (sensors) and Outputs (actuators) connected to PLC ➢ PLC and DCS programming software **2.2 Input/output and Memory Interaction** ➢ PLC input/output systems and programming devices ➢ PLC Memory and Input/output Interaction ➢ Discrete input/output system ➢ Analog input/output system	8

	➢ Special input/output modules: PID, Fuzzy-logic…. **2.3 Programming a PLC** ➢ Programming languages and instructions ➢ Programming ON/OFF Inputs ➢ Creating Ladder diagrams ➢ Register Basics ➢ PLC Timers and Counters ➢ PLC Arithmetic functions ➢ Number comparison functions ➢ Data handling Functions ➢ PLC functions with BITS ➢ System programming and implementation: Control task definitions, strategies, program organization and implementations ➢ Programming practice: Siemens" PLC S7-300, S7-400 (practice on available PLC type)	
UNIT-III	**Introduction, Fundamentals of Robotics** ➢ Introduction ➢ Types of Robots ➢ Robot Anatomy and Key Components ➢ Sensors and Actuators in robots ➢ Position, Velocity, Acceleration, Force and Torque ➢ Touch and Tactile sensors ➢ Proximity and Range Sensors ➢ Hydraulic and Pneumatic Actuation systems ➢ Robot Applications	**8**
UNIT-IV	**Robot Motion Analysis (Kinematics)** ➢ Representation of Rigid body motion ➢ Transformation of Coordinates ➢ Homogenous Transformation ➢ Forward Kinematics ➢ Inverse Kinematics	**8**
UNIT-V	**Dynamics, Mechanism & Actuation** **5.1. Dynamic Models of Rigid-Body Systems** ➢ Euler Lagrange Equations ➢ Newton Euler formulation 5.2 Mechanical Structure (Links, Joints, Actuators, transmissions), Joint Mechanisms.	**8**

TEXT BOOKS

1. J. J. Craig, Introduction to robotics ,3rd edition, Pearson Education,2005
2. Herman Bruyninckx, Robot Kinematics and Dynamics, August 21, 2010

REFERENCE BOOKS

1. B. Siciliano, L. Sciavicco, et al, Robotics modeling planning and control, Springer, 2009

Department of Psychology			
Year/Semester	1st Year/1st	Course Category	MDC
Course Code		Course Title	Psychology and Emotional Intelligence
Continuous Evaluation: …. marks		End Semester Examination : ….. marks	
Prerequisite: NIL		L T P : 3 0 0	Credits: 3

COURSE OBJECTIVES

1. To provide an overview of the basic concepts in psychology
2. To introduce the students with different fields of psychology
3. To enhance their knowledge about environmental and social factors and their impact on our life.
4. To help in better communication and enhance adjustment in life and work.
5. To create awareness about the applications of psychology in various fields of life.

COURSE LEARNING OUTCOMES

1. Describe the basic concepts in psychology
2. Get equipped with various psychological techniques used to assess human behavior at various developmental stages
3. Develop an overview of psychology that would lead to better communication and enhance adjustment in work and personal life
4. Learn the skills for applying knowledge to real life situations so as to improve interpersonal interactions and adjustment in life

MAPPING BETWEEN COURSE OBJECTIVES AND COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO 1	CLO 2	CLO 3	CLO 4
CO 1				
CO 2				
CO 3				
CO 4				
CO 5				

COURSE CONTENTS

Unit-I:
Nature and fields of psychology; Learning, memory and problem solving; Motivation, types of motives

Unit-II:
Psychology and Life , Human-environment relationship; Environmental effects on human behaviour: Noise, pollution, crowding, natural disasters; Promoting pro-environmental behaviour;
Psychology and social concerns: Aggression, Violence and Peace, Discrimination and Poverty, health, impact of television on behaviour.

Unit III:
Developing Psychological Skills effective psychological and interpersonal skills for facilitating personalsocial development. Effective psychological skills: Observational skills, Interviewing skills, Counselling skills — empathy, authenticity, positive regard, and Communication skills — listening.

Unit-IV:
Applications of Psychology in Daily Life : Events, Education, Health, Workplace.

TEXT BOOKS

1) Ciccarelli, S. K & Meyer, G.E (2008). Psychology (South Asian Edition). New Delhi: Pearson
2) Michael, W., Passer, Smith, R.E.(2007). Psychology The science of mind and Behavior. New Delhi: Tata McGraw-Hill.

REFERENCE BOOKS

1) Chadha, N.K. & Seth, S. (2014). The Psychological Realm: An Introduction. Pinnacle Learning, New Delhi.
2) Glassman, W.E. (2000). Approaches to Psychology (3rd Ed.) Buckingham: Open University Press.
3) Feldman. S.R. (2009).Essentials of understanding psychology (7^{th}Edition), New Delhi: Tata McGraw Hill.

a.

Department of Economics			
Year/Semester		Course Category	Multidisciplinary Course
Course Code		Course Title	Indian Economy
Continuous Evaluation: …. Marks		End Semester Examination: …. Marks	
Prerequisite: Nil		L T P : 3 0 0	Credits: 3

COURSE OBJECTIVES

1. To introduce about different demography terms and trends.
2. To make students familiar with growth and its distribution.
3. To discuss the major changes in agriculture sector over-time.
4.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. review major demographic indicators
2. comprehend the concept of inequality
3. analyse agriculture sector

MAPPING BETWEEN COURSE OBJECTIVES AND COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)		
	CLO 1	CLO 2	CLO 3
CO 1			
CO 2			
CO 3			

COURE CONTENTS

Unit-I

Population and Human Development

Demographic trends and issues; education; health and malnutrition. Demographic features of India's population.

Unit-II

Growth and Distribution

Trends and policies in poverty; inequality and unemployment.

Unit-III

Agriculture

Importance of Agriculture; Causes of backwardness and low productivity; Land Reforms: Need, Implementation and Critical Evaluation

TEXT BOOKS

1. Jean Dreze and Amartya Sen, 2013. *An Uncertain Glory: Indiaand its Contradictions*, Princeton UniversityPress.
2. Pulapre Balakrishnan, 2007, The Recovery of India: Economic Growth in the Nehru Era, *Economic and Political Weekly*,November.
3. Rakesh Mohan, 2008,―Growth Record ofIndian Economy: 1950-2008.AStory of Sustained Savings and Investment, *Economic and Political Weekly*,May.
4. S.L. Shetty, 2007,―India‘s SavingsPerformancesincethe Advent ofPlanning,in K.L. Krishna and A. Vaidyanathan, editors, *Institutions and Markets in India's Development.*
5. Himanshu, 2010,―TowardsNew Poverty LinesforIndia, *Economicand Political Weekly*,January.

ARDUINO BASED PROGRAMMING	
Course Code:	Internal Examination: …. marks
Credits: 3	External Examination: …. marks
L T P : 3 0 0	Course Category: Multi-Disciplinary Course
Prerequisite:	

Course Objectives (CO) - The Course is designed with the following objectives:

1. Provide students with a comprehensive understanding of the Arduino platform, its components, and its applications in various fields.
2. Introduce students to programming using the Arduino IDE, covering topics like variables, data types, control structures, functions, and basic debugging.
3. Teach students how to interface various sensors with Arduino, enabling them to gather real-world data.
4. Enable students to control output devices such as LEDs, motors, and servos using Arduino, expanding their ability to create interactive projects.
5. Guide students through the process of conceptualizing, designing, and implementing Arduino-based projects, fostering creativity and problem-solving skills.

Course Learning Outcomes (CLO):

The Syllabus has been prepared in accordance with the NEP-2020. Upon completion of this course, learners will be able to

1. Demonstrate a clear understanding of Arduino's architecture, components, and capabilities.
2. Write, upload, and debug Arduino sketches using the Arduino IDE.
3. Integrate various sensors and retrieve data from the physical world.
4. Control actuators to produce desired physical effects or actions.
5. Design and complete Arduino-based projects from ideation to implementation.

Mapping Matrix between Course Objectives and Course Learning Outcomes:

	CO1	CO2	CO3	CO4	CO5
CLO1	●				
CLO2		●			
CLO3			●		
CLO4				●	
CLO5					●

COURSE CONTENTS:

Unit -1: Introduction

Brief introduction on embedded system, what is Arduino, types of Arduino and their strengths, installation of Arduino IDE and its interface with hardware, Arduino circuit, First program on LED Blinking: debug the code, restart the program in different ways, basic simulation.

UNIT III: Programming Basics for Arduino

Introduction to IDE, Variables, Data Types, Functions, Scope, Conditions, Loops, Arrays, Various programming languages, selection of programing language, need of Flow Diagram.

UNIT III: Sensors

Basic working techniques of following sensors: Infra-Red sensor, Ultrasonic sensor, Color sensor, Light sensor, Sound sensor, DTMH module, DHT module, Selection of sensor, how to interface with sensors, how to design analog/digital sensors, applications of sensors.

Unit -4: Interfacing to Actuators

What are Actuators, DC Motor, DC geared Motor, Stepper Motor, Servo Motor, Driving system, types of driving system, H-Bridge Motor Driver, Advanced Motor Driver, Push Botton, Potentiometer, RGB.

Unit -5: Project

LED Blinking, Running LEDs, Sand Glass filling of LEDs, Seven segment display, DC motor driving, Blue-tooth based remote control car, Line follower, obstacle avoider/path finder etc.

RECOMMENDED TEXT BOOKS:

1. Exploring Arduino: Tools and techniques for Engineering wizardry by Jeremy Blum, 2nd edition, Wiley.
2. Make: Getting Started with Arduino, 3e: The Open Source Electronics Prototyping Platform, by Massimo Banzi and Michael Shilon, 3rd edition.

REFERENCE BOOKS:

1. Arduino for Dummies by John Nussey, 2nd edition.
2. Arduino Cookbook: Recipes to Begin, Expand, and Enhance Your Projects, Brian Jepson, Michael Margolis and Nicholas Robert Weldin, 3rd edition, O'Reily publisher.

Department of Political Science			
Year/Semester		Course Category	MDC
Course Code		Course Title	Electoral Literacy in India
Continuous Evaluation : … marks		End Semester Examination : …. Marks	
Prerequisite: Nil		L T P : 3 0 0	Credits: 3

Course Objectives (CO) - The Course is designed with the following objectives:

1. To know the meaning and nature of the electoral democracy in India
2. To discuss electoral institutions in India
3. To understand the procedural aspect of elections in India
4. To grasp the significance of elections and electoral aspects of democracy, the electoral model code of conduct, issues, and challenges in India's democracy.

Course Learning Outcomes (CLO) – The Syllabus has been prepared in accordance with the NEP-2020. Upon completion of this course, learners will be able to:

1. The student shall be able to understand the meaning, definition, and significance of elections in India.
2. The course will help the students to analyse and understand electoral institutions, and their role and functions in the conduct of free and fair elections.
3. The student shall be able to know the party system of India.
4. The course will help the student understand issues and challenges in conducting free and fair elections in India.

Mapping Matrix between Course Objectives and Course Learning Outcomes:

Course Learning Objectives (Cos)	**Course Learning Outcome (CLOs)**				
	CLO1	**CLO2**	**CLO3**	**CLO4**	**CLO5**
CO1					
CO2					
CO3					
CO4					

COURSE CONTENTS:

UNIT I: Elections in India

- Suffrage, Types, and Methods of Elections
- Parliamentary elections: Lok Sabha & Rajya Sabha
- Presidential Elections
- State Legislative Assembly Elections
- Local Body Elections

UNIT II: Electoral Institutions

- Election Commission (EC)
- State Election Commission

- Constitution: Part-15

UNIT III: Political Parties in India

- One-party, Two Party, Multi-party system
- Model Code of Conduct, Party Funding, and Campaign

UNIT IV: Elections: Issues and Challenges

RECOMMENDED TEXTBOOKS:

1. Subhash C. Kashyap, Our Political System, 2nd, National Book Trust, India, 2008, ISBN: 8123752520
2. D. D. Basu, Introduction to The Constitution Of India, 26th Edition, Lexis Nexis, ISBN: 978-9388548861
3. Bidyut Chakrabarty, Rajendra Kumar Pandey, Indian Government and Politics, Sage Text, ISBN: 8132100581

REFERENCE BOOKS:

1. Sanjay Kumar, Elections in India: An Overview, 1st, Routledge, ISBN: 9781032033136
2. https://eci.gov.in/
3. https://www.lokniti.org/
4. Websites of State Election Commission
5. NCERT, Chapter-3 Indian Constitution at Work

Department of Hotel Management	
Interior Decoration	
Course Code: 23MDCXXX	Continuous Evaluation: …. Marks
Credits: 3	End Semester Examination: …. Marks
L T P: 3 0 0	Course Title: Interior Decoration
Prerequisite: NIL	

Course Objectives: -

CO 1: To explain and introduce to basics of Interior design and décor.

CO 2: To explain and inform about elements and principles of design.

CO 3: To explain the Importance of window and lightings in enhancing décor of the interiors.

CO 4: To introduce and explain about the use of furniture and accessories in Interior décor and design.

CO 5: To explain the use of different wall and floor finishes in enhancing the décor and design.

Course Outcomes: -

CLO 1: At the end of the first unit students would be able to understand the basics of Interior design and décor.

CLO 2: At the end of the Second unit students would be able to utilize elements and principles of design in décor enhancement.

CLO 3: At the end of the third unit students would be able to understand the Importance of window and lightings in enhancing décor of the interiors.

CLO 4: At the end of the fourth unit students would be able to explain and use furniture and accessories in Interior décor and design.

CLO 5: At the end of the fifth unit students would be able to use different wall and floor finishes in enhancing the décor and design

MAPPING MATRIX OF COURSE OBJECTIVES (COs') AND COURSE LEARNING OUTCOMES (CLOs)

CLO / CO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CO 1					
CO 2					
CO 3					
CO 4					
CO 5					

COURSE CONTENTS

- Unit I

  INTRODUCTION TO INTERIOR DESIGN AND DÉCOR: Beauty, Expensiveness, Functionalism, Common terms used in décor
- Unit II

  ELEMENTS AND PRINCIPLES OF DESIGN: Line, form, texture and colour (basic elements), The concept of light, space and pattern as elements, Colour Associations, Understanding colour, The colour wheel, Properties of colour –Warm /Cool, Advancing/Receding, Heavy/Light, Earthy /Acid, Additive and Subtractive colour, Colour Perception, Physical and psychological effect of colour, Colour Balance, Colour Emphasis, Colour Contrast, Effect of light on colour, Choice of colours, Planning a colour scheme of a room, Harmony, Balance, Scale and Proportion, Rhythm, Emphasis
- Unit III

  WINDOW AND LIGHTINGS: The purpose of a window, Types of windows, The importance of suitable window treatments, Selecting fabrics for curtains (practical and visual), Curtain headings, Calculating fabric requirements, Types of window treatments. LIGHTINGS: Introduction to lighting Lighting, Levels- Lux and Lumen, Categories- Ambient, Task, Accent, Exterior and Emergency, The importance of a good lighting system, Artificial lighting -Tungsten, Fluorescent, Discharge, CFL, Halogen.., Types of light distribution-direct, semi direct, indirect, diffused, Methods of lighting-architectural and non-architectural, Lighting in various areas of the hotels, Light fittings, Selection of lighting systems and energy check list
- Unit IV:

  FURNITURE AND ASSESSORIES: The functional aspect-furniture elements, structure, finish, upholstery, The decorative aspects- styles of furniture, Furniture items placed in the guestrooms, Standard sizes of furniture, Furniture arrangement—Guidelines. ACCESSORIES: Various types of accessories and their guidelines, Flower Arrangement as an accessory Indoor Plants as an accessory.
- Unit V:

  WALL AND FLOOR FINISHES:

  WALL FINISHES: Paint, Wallpaper, Fabric, Laminates Wood panelling, Ceramic Tiles, Glass, Textured.

  FLOOR FINISHES: Ceramic, Marble Terrazzo, Granite, Concrete, Wood, Resilient (Vinyl, Asphalt, Rubber, Linoleum), Carpets (Types and Maintenance)

TEXT BOOK:

The Handbook of Interior Design by Jo Ann Asher Thompson, Nancy H.

REFERENCE BOOKS:

1. The Interior Design Reference & Specification Book: Everything Interior Designers Need to Know Every Day, by Chris Grimley, Linda O'Shea, and Mimi Love
2. The Interior Design Handbook by Frida Ramstedt
3. Residential Interior Design: A Guide To Planning Spaces by Courtney Nystuen and Maureen Mitton

List of Ability Enhancement Courses (AEC) offered to
Four Year B.Sc. Physics programme in the Department of Physics
w.e.f. Academic Year 2025-26

S. No.	Code	Course Name	L	T	P	Credits
1		Functional English I	2	0	0	2
2		Functional English II	2	0	0	2
3		Hindi / German / French	2	0	0	2
4		Hindi / German / French	2	0	0	2

Department of English			
Year/Semester		Course Category	AEC
Course Code	23MDCXXX	Course Title	Functional English-I
Continuous Evaluation : …. Marks		End Semester Examination : …. Marks	
Prerequisite: Nil		L T P : 2 0 0	Credits: 2

Course Objectives (CO) - The Course is designed with the following objectives:

1. To enhance and strength communication skills in English Language
2. To facilitate holistic and integrated development of LSRW skills - Listening, Speaking, Reading Writing abilities
3. To understand a wide range of lexical and prosodic features of the language.
4. To grasp the significance of critical reading-writing capacities and professional communication skills in the students.

Course Learning Outcomes (CLO) – The Syllabus has been prepared in accordance with the NEP-2020. Upon completion of this course, learners will be able to:

1. Demonstrate comprehensive and fluent communication in standard English – written & spoken
2. Apply the skills to engage in group discussions, debate, deliver speeches and such others.
3. Analyse texts on various parameters expected/demanded during different situations and circumstances
4. Integrate the knowledge and skills to prepare basic/preliminary research documents, official documents and deliver presentations on a given topic

Mapping Matrix between Course Objectives and Course Learning Outcomes:

Course Educational Objectives (CEOs)	**Course Learning Outcomes (CLOs)**			
	CLO 1	**CLO 2**	**CLO 3**	**CLO4**
CEO 1	√			
CEO 2		√		√
CEO 3			√	√
CEO 4	√	√	√	√

COURSE CONTENTS:

Unit – I : Speaking Skills

English Communication - Aims & Objectives - Basics of Communication - Barriers to Communication - Non-Verbal Communication - Active Listening - Effective Speaking – Speech - Art of Public Speaking – Pronunciation - Stress & Intonation in English – Debate – Conversations-Presentation Skills- Group Discussions – Interviews - Formal Presentations.

Unit-II : Listening Skills-

Types of Listening-Top Down and Bottom-Up Approach- Signposting in Listening-Global listening Vs Local Listening - Interpreting information over spoken language-Understanding tone and intention in spoken language-Listening to understand information and responding to questions asked

Unit – III: Effective Reading

Reading strategies (Skimming, Scanning, Inferring) –Predicting and responding to content – Speed Reading – Note Making – Use of Extensive reading texts – Vocabulary Extension - Guessing from Context –

Unit – IV: Writing Skills

Formal Letters, Memos & Email – Discourse Markers- - Art of Condensation - Report Writing - Article Writing - Writing Proposals – Preparing Minutes of Meeting.

TEXT BOOK

1. Swan, Michael. *Practical English Usage*. New Delhi: Oxford University Press, 2005.
2. Murphy, Herta A. *Effective Business Communication*, New Delhi: McGraw Hill, 2008.

REFERENCE BOOK AND OTHER MATERIALS

1. Koneru, Aruna. *Professional Speaking Skills*. New Delhi: Oxford University Press, 2015.
2. Sanjay Kumar and Pushp Lata. *Technical Communication*, New Delhi: Oxford University Press, 2008.
3. Koneru, Anuna. *Professional Communication*, New Delhi: McGraw Hill Pvt. Ltd, 200.
4. Rizvi, M. Ashraf. *Effective Technical Communication*, New Delhi: McGraw Hill, 2018.
5. Barun K. Mitra, Personality Development and Soft Skills, Oxford University Press, New Delhi, 2011.

Department of English			
Year/Semester		Course Category	AEC
Course Code	23MDC	Course Title	Functional English-II
Continuous Evaluation : …. Marks		End Semester Examination : …. Marks	
Prerequisite: Nil		L T P : 2 0 0	Credits: 2

Course Objectives (CO):
The Course is designed with the following objectives:

1. To know the use of descriptive, narrative, and expository modes of writing.
2. To discuss how to recognize and correct basic grammatical errors, specifically errors of subject/verb agreement, verb tense, pronoun agreement, usage of prepositions and articles.
3. To grasp the significance of academic and idiomatic vocabulary.
4. To understand, read, analyze, and respond to assigned readings with an understanding of structure and mechanics.

Course Learning Outcomes (CLO): – The Syllabus has been prepared in accordance with the NEP-2020. Upon completion of this course, learners will be able to:

1. Illustrate the stylistic conventions of academic writing.
2. Analyse readings critically by evaluating the various contexts (social, historical, or personal) surrounding and underpinning each text.
3. Evaluate various texts while identifying and highlighting their main ideas and messages
4. Develop independent perspectives and arguments via persuasive support and successful incorporation of research thus developing their own voice and creating a balance between their own voice and source summaries.
5. Assess counter arguments in order to present a more compelling argument

Mapping Matrix between Course Objectives and Course Learning Outcomes:

Course Objectives (COs)	**Course Learning Outcomes (CLOs)**				
	CLO 1	**CLO 2**	**CLO 3**	**CLO 4**	**CLO 5**
CO 1	✓				
CO 2			✓	✓	
CO 3		✓			
CO 4				✓	✓

CONTENTS

Unit I: Reading strategies

Understanding the basic elements of academic writing: summary, analysis, close reading, claim, evidence and argument, Types of academic writing (descriptive, analytical, persuasive, and critical), Skimming, Scanning and Note Making for Academic Writing

Unit II: Paragraph Writing

Structure of the paragraph, Use of coherence and cohesion-topic sentence for paragraph Abstract Writing, Fine tuning title and finalizing keywords, The art of summarizing

Unit III: Writing Research Proposal

Selecting Research topic, Framing research problem and literature review

Writing Research Proposal – Writing Research questions and Hypothesis

Review of Research paper -Writing Research Proposal – Methodology and conclusion

Critical Review, Conclusions, and Implications -Paraphrasing and Explaining -Finalizing and reviewing Research proposal -Controlling language

Unit IV: Referencing, Citation and Proof Reading

Bringing it all together

TEXT BOOKS

1. Nzanmongi Jasmine Patton et al. *A Handbook For Academic Writing and Composition*. New Delhi: Pinnacle Learning, 2014.
2. Christine Raisanen and Lennart A. Bjork. *Academic Writing: A University Writing Course*. Lund: Studentlitteratur, 2003.
3. Janet Giltrow, Richard Gooding, & Daniel Burgoyne et al. *Academic Writing: An Introduction*. Peterborough, Ontario: Broadview Press, 2005.

REFERENCE BOOKS AND OTHER RESOURCES

1. Liz Hamp-Lyons and Ben Heasley. *Study Writing: A Course in Writing Skills for Academic Purposes*. Cambridge: CUP, 2006.
2. Renu Gupta. *A Course in Academic Writing*. New Delhi: Orient Black Swan, 2010.
3. Ilona Leki. *Academic Writing: Exploring Processes and Strategies* (2nd Ed.). New York: CUP,1998.
4. Gerald Graff and Cathy Birkenstein. *They Say/I Say: The Moves That Matter in Academic Writing*. New York: Norton, 2009.
5. John Eastwood. *Oxford Practice Grammar*. Oxford: OUP, 2005.
6. Michael Wallace. *Study Skills*. Cambridge: CUP, 2004.

GERMAN LANGUAGE-I	
Course Code: 23UAEC301	Continuous Evaluation: …. Marks
Credits: 2	End Semester Examination: …. Marks
L T P: 2 0 0	Course Type: AEC
Prerequisite: Nil	

COURSE OBJECTIVE (CO)

- To develops oral and written skills of understanding, expressing and exchanging Information/ interacting.
- To develops the ability to construct sentences and frame questions.
- To provide German language as a competitive edge in career choices.
- To know the culture of the countries where the German language is spoken.
- This may be useful in the field of employment opportunities as well as helping them to develop projects on browsing German websites

COURSE LEARNING OUTCOMES (CLO)

- After completion of this student will be able to read and write short, simple texts.
- After completion of this student will have Fluency in reading and writing.
- After completion of this student will be able understand a dialogue between two native speakers and to take part in short, simple conversations using the skills acquired.
- student will able to know the culture of the countries where the German language is spoken.
- Developing pronunciation so that they can read the text and e-mail during their employment, instructing them to write their own CV and developing a fundamental conversation with any German national.

MAPPING MATRIX OF COURSE OBJECTIVES (COs) & COURSE LEARNING OUTCOMES (CLOs)

	CO1	CO2	CO3	CO4	CO5
CLO1	●				
CLO2		●			
CLO3			●		
CLO4				●	
CLO5					●

COURSE CONTENTS

UNIT-I : INTRODUCTION

Grüße, Wortschatz

UNIT-II : THEMEN

Das Alphabet, die Aussprache, die Zahlen, Land und Stadt beschreibung, Berufe, rede über Dinge, die Zeit, Mahlzeiten und Getränke

UNIT-III : GRAMMATIK

Plural, Artikel, Possessive Artikel, Adjektive, Sich vorstellen, Verben (regulär, unregelmäßig, Pronomen), Nominativ Pronomen, Präpositionen,

UNIT-IV : WORTSCHATZ

emanden vorstellen, Nationalitäten, Länder, Zahlen, Über die Wochentage sprechen, Die Monate des Jahres, Die Berufe, Die Farben, Die Gegensätze, Die Sätze mit der Zeit

UNIT-V : MÜNDLICHER AUSDRUCK

Mündliche und Höraktivitäten

TEXT BOOK

1. Tangram aktuell 1 (Lektion 1-4 Kursbuch + Arbeitsbuch, Lektion 5-8 Kursbuch + Arbeitsbuch, Übungsheft)

REFERENCE BOOKS

2. Wolfgang Hieber: Lernziel Deutsch, Teil 1. Max Hueber Verlag

3. Korbinian Braun, u.a.: Deutsch als Fremdsprache IA, Grundkurs. Ernst Klett Stuttgart

4. Rolf Brüseke: Starten Wir! A1. München: Hueber Verlag

GERMAN LANGUAGE-II	
Course Code: 23UAEC401	Continuous Evaluation: …. Marks
Credits: 2	End Semester Examination: ….. Marks
L T P: 2 0 0	Course Type: AEC
Prerequisite: Nil	

COURSE OBJECTIVE (CO)

- Students will demonstrate their ability to recognize, identify, extract and/or differentiate key information conveyed in spoken announcements, instructions, and in interactions between native speakers on familiar topics.
- Students will demonstrate effective speaking and listening skills in German on informal and some formal topics related to personal, professional, academic, and leisure activities
- To develop awareness of the nature of language and language learning

COURSE LEARNING OUTCOMES (CLO)

- After completion of this student will be able to read and write short, simple texts.
- After completion of this student will have Fluency in reading and writing.
- After completion of this student will able to use language creatively and spontaneously.
- Students will get awareness of cross-cultural and intercultural difference.

MAPPING MATRIX OF COURSE OBJECTIVES (COs) & COURSE LEARNING OUTCOMES (CLOs)

COURSE LEARNING OUTCOME / COURSE OBJECTIVES	CLO 01	CLO 02	CLO 03	CLO 04
CO 01	✓			
CO02		✓		
CO 03			✓	
CO 04				✓

COURSE CONTENTS

UNIT-I : THEMEN

Einkaufen, Tagesablauf, Lebenslauf , Nach dem Weg fragen, Wegbeschreibungen, Der Körper, Ereignisse der Vergangenheit erzählen

UNIT-II : GRAMMATIK

Trennbare und untrennbare Verben, Dativ , Modalverben, Präteritum von sein, haben, Perfekt

UNIT-III : WORTSCHATZ

Kleidung, Haushaltswaren, Sachen zum Essen und Trinken, Verkehrsmittel, Namen von Orten und Sehenswürdigkeiten, Information über Deutschland, Ordinalzahlen

UNIT-IV : KOMPOSITION

Themen zum schreiben wie Deutschland und Delhi, was haben Sie am wochenende gemacht, Traummann/Traumfrau

UNIT-V: Mündlicher Ausdruck

Sprechen uber die Stadt, Das Haus, Meine Famile

TEXT BOOK

1. Tangram aktuell 1 (Lektion 1-4 Kursbuch + Arbeitsbuch, Lektion 5-8 Kursbuch + Arbeitsbuch, Übungsheft)

REFERENCE BOOKS

2. Wolfgang Hieber: Lernziel Deutsch, Teil 1. Max Hueber Verlag

3. Korbinian Braun, u.a.: Deutsch als Fremdsprache IA, Grundkurs. Ernst Klett Stuttgart

4. Rolf Brüseke: Starten Wir! A1. München: Hueber Verlag

Website pages:

1. https://www.nthuleen.com/teach.html

FRENCH LANGUAGE -I	
Course Code: 23UAEC302	Continuous Evaluation: ….. Marks
Credits: 2	End Semester Examination: ….. Marks
LTP: 2 0 0	Course Type: AEC
Prerequisite: Nil	

COURSE OBJECTIVE (CO)

1. To develop listening, speaking, reading and writing requisites of a language.
2. To develop the ability to construct sentences and frame questions.
3. To equip the students with cultural elements and communication strategies which will help them communicate in varied situations.
4. To familiarize the students with the French and Francophone culture.

COURSE LEARNING OUTCOMES (CLO)

1. After completion of this course, the student will be able to express and interactin French used in daily conversations.
2. The student will be able to write short and simple texts.
3. The student will be able to initiate and respond to various situations usingFrench language skills.
4. The student can understand and respond effectively to the cultural elements ofthe French and Francophone culture

MAPPING MATRIX OF COURSE OBJECTIVES (COs) & COURSELEARNING OUTCOMES (CLOs)

COURSE OBJECTIVES	Course Learning Outcome			
	CLO 01	CLO 02	CLO 03	CLO 04
CO 01	✓			
CO02		✓	✓	
CO 03			✓	
CO 04				✓

Course Contents

S. No	Unités	Objectifs de Communication	Grammaire	Lexique
1	**La Salutation et l'Introduction**	Saluer. Entrer en Contact. S'Excuser. Remercier. Se Présenter/ Présenter Quelqu'un.	Les Pronoms Personnels Sujets. L'Alphabet. Les Articles Indéfinis. Les Verbes en -ER au Présent.	Salutations, Les Nombres. Les Objets de la Classe. La Nationalité.
2	**On Partage des Renseignements**	Demander de Se Présenter. Donner des Renseignements Personnels.	Etre et Avoir au Présent. Les Verbes en -ER au Présent. Les Adjectifs de Nationalités. L'Interrogation.	Les Adjectifs de Nationalité, Métiers et Secteurs Professionnels, L'Expression des Goûts et Intérêts
3	**Ma Ville et Mon Quartier**	Décrire et Qualifierune Ville ou un Quartier. Localiser. Demander et Donnerla Directions.	Le Verbe Vivre. Les Articles Définis. Il ya/ Il n'y a pas. Les Prépositions. Les Adjectifs Qualificatifs. L'Impératif.	Les Prépositions de Localisation. Le Lexique des Sites. Etablissements et Service d'une Ville.
4	**Mes Intérêts et Goûts**	Parler de Ses Goûts et de Ses Loisirs. Donner Son Impression sur le Caractère de Quelqu'un.	Le Présent des Verbesen -ER, et du Verbe Faire. La Négation, Les Adjectifs Possessifs.	Avoir l'air. Loisirs. L'Expression des Goûts. Fairedu/ de la. Ma Famille.

TEXT BOOK

- Version Originale 1, Livre de l'élève: Denyer M. & Agustin Garmendia A. & Olivieri M L L., éd. Maisons des Langues, Paris. 2013.

REFERENCE BOOKS

- Alter Ego 1, Livre d'élève, Berthet A. & Hugo C. & Kizirian M. V. &Sampsonis B. & Waendendries M., éd Hachette, Paris, 2006.
- Connexions 1, Loiseau Y. & Mérieux R., éd. Didier, Paris, 2004.
- Le Nouveau Sans Frontiers, Vol. 1, P. Dominique, J. Girardet et al,CLE International, Paris, 2013.
- Le Robert & Nathan Conjugation, Paperback, Le Robert Nathan,201

FRENCH LANGUAGE-II	
Course Code: 23UAEC402	Continuous Evaluation: …. Marks
Credits: 2	End Semester Examination: …. Marks
LTP: 2 0 0	Course Type: AEC
Prerequisite: 23UAEC302	

COURSE OBJECTIVE (CO)

1. To develop listening, speaking, reading and writing requisites of alanguage.
2. To develop the ability to construct sentences and frame questions.
3. To equip the students with cultural elements and communication strategies which will help them communicate in varied situations.
4. To familiarize the students with the French and Francophone culture.

COURSE LEARNING OUTCOMES (CLO)

1. After completion of this course, the student will be able to express andinteract in French used in daily conversations.
2. The student will be able to write short and simple texts.
3. The student will be able to initiate and respond to various situations using French language skills.
4. The student can understand and respond effectively to the culturalelements of the French and Francophone culture.

MAPPING MATRIX OF COURSE OBJECTIVES (COs) &COURSE LEARNING OUTCOMES (CLOs)

COURSE OBJECTIVES	Course Learning Outcome			
	CLO 01	CLO 02	CLO 03	CLO 04
CO 01	✓			
CO02		✓	✓	
CO 03			✓	
CO 04				✓

Course Contents

1	**Journée typique**	Parler de Nos Habitudes, Exprimer l'Heure, S'Informer sur l'Heure, le Momentet la Fréquence.	Les Verbes Pronominaux au Présent. Les Verbes Aller et Sortir	L'Heure, Les Moments de la Journée. Les Activités Quotidiennes. Les Adverbs.La Météo.
2	**Achats**	S'informer sur un Produit. Acheter et Vendre un Produit. Donner Son Avis. Parler du Temps qu'il Fait	Les Adjectifs Interrogatifs. Les Adjectifs Démonstratifs. Le Genre et le Nombre. Le Verbe Prendre.	Les Vêtements. Les Couleurs. Les Fruits et Les Légumes.
3	**Alimentation**	Parler des Plats etdes Aliments. Commander un Menu dans un Restaurant. Situer une Action dans le Futur	Le Future Proche: Aller +Infinitif. Les Partitifs. Les Pronoms COD. Le Future.	Les Aliments. Le Lexique des Quantités.
4	**Expérience Vécue**	Parler de Faits Passés. Parler de nos Expériences. Parler de Ce que Nous Savons Faire.	Le Passé Composé. L'Imparfait.	Les Verbes Savoir, Pouvoiret Connaître. Les Adjectifs Qualificatifs. Le Lexique des Savoirs et Compétences. Le Récit deVie.

TEXT BOOK

- Version Originale 1, Livre de l'élève: Denyer M. & Agustin Garmendia A. & Olivieri M L L., éd. Maisons des Langues, Paris. 2013.

REFERENCE BOOKS

- Alter Ego 1, Livre d'élève, Berthet A. & Hugo C. & Kizirian M. V. &Sampsonis B. & Waendendries M., éd Hachette, Paris, 2006.
- Connexions 1, Loiseau Y. & Mérieux R., éd. Didier, Paris, 2004.
- Le Nouveau Sans Frontiers, Vol. 1, P. Dominique, J. Girardet et al, CLE International, Paris, 2013.
- Le Robert & Nathan Conjugation, Paperback, Le Robert Nathan,

List of Value Added Courses (VAC) offered to Four Year B.Sc. Physics programme in the Department of Physics w.e.f. Academic Year 2025-26

S. No.	Code	Course Name	L	T	P	Credits
1		Indian Constitution & Polity	2	0	0	2
2		Environment Protection & Sustainable Development	2	0	0	2
3		Sports, Yoga & Fitness	0	0	4	2

DEPARTMENT OF LAW			
Programme: Undergraduate program			
Year/Semester		Course Category	Value Added Course (VAC)
Course Code	23VAC	Course Title	Indian Constitution & Polity
Continuous Evaluation: …. Marks		End Semester Examination: …. Marks	
Prerequisite: Nil		L T P : 2 0 0	Credits: 2

Course Objectives (CO) - The Course is designed with the following objectives:

1. To acquaint the students with the fundamental concepts of democracy, diversity and the Constitution.
2. To make students understand the functioning of the three wings of the State
3. To make the students appreciate the purpose of decentralised administration under the Constitution and its functioning
4. To make students analyse and discuss various rights and duties under the Constitution of India

Course Learning Outcomes (CLO) – At the end of this course, the learners are expected to:

1. Explain the concept of democracy, diversity and the Constitutional Values
2. Describe the functioning of the three wings of the State
3. Sketch the functioning of decentralised administration under the Constitution of India and appreciate the political dimensions.
4. Examine the scope of various rights and duties under the Constitution of India.

MAPPING COURSE OBJECTIVES (COs) & COURSE LEARNING OUTCOMES (CLOs)

	COURSE LEARNING OUTCOMES (CLOs)			
COURSE OBJECTIVES (COs)	**CLO1**	**CLO2**	**CLO3**	**CLO4**
CO1	√			
CO2		√		
CO3			√	
CO4				√

COURSE CONTENT
UNIT I
DEMOCRACY, DIVERSITY AND THE CONSTITUTION

- Concept of democracy and importance of right to vote
- Electoral Politics
- Concepts of diversity and discrimination on the grounds of gender, religion and caste
- Concept of democratic government
- Constitution design and salient features
- Preamble to the Constitution of India

UNIT II
THE THREE WINGS OF THE STATE

- The definition of State in Constitution of India
- Parliament, the State legislature and the making of laws
- Concept of cooperative federalism
- The Executive and Administration
- Role of Governor and the President of India
- The Judiciary

UNIT III
LOCAL GOVERNMENT AND ADMINISTRATION

- Panchayati Raj System
- Rural and Urban administration
- Social and Economic Justice for the marginalised
- Directive Principles of State Policy

UNIT IV
RIGHTS AND DUTIES

- Fundamental Rights (Part III of the Constitution)
- Protection of Fundamental Rights – Writ petitions in High Court and Supreme Court of India
- Fundamental Duties
- The concept of Fraternity and secularism
- Public utilities and privatization

RECOMMENDED TEXT BOOKS:

1. J.N. Pandey, Constitutional Law of India, 59^{th} Ed. (2022) Central Law Agency
2. The Constitution of India, Eastern Book Company (2022) – Bare Act with complete legislative history

REFERENCE BOOKS:

1. M.P. Jain, *Indian Constitutional Law* (8th Ed.) 2018 Lexis Nexis
2. M.P. Singh, *V.N. Shukla's Constitution of India*, 14^{th} Ed (2022), reprint 2023
3. H.M. Seervai, *Constitutional Law of India* (4th Ed., 2008), latest reprint 2023 Law & Justice Publishing

Department of Environmental Sciences			
Programme: Undergraduate program			
Year/Semester	1ST/I or II	Course Category	Value Added Course (VAC)
Course Code		Course Title	Environmental Protection & Sustainable development
Continuous Evaluation: …. Marks		End Semester Examination: …. Marks	
Prerequisite: Nil		L T P : 2 0 0	Credits: 2

Course Objectives (CO) - The Course is designed with the following objectives:

1. To provide a comprehensive understanding of the relationship between humans and the environment.
2. Aims to introduce students to the different components of the environment.
3. To develop the understanding of pollution, its causes, and their effects
4. To gain the knowledge of climate change and the contemporary issues

Course Learning Outcomes (CLO) – The Syllabus has been prepared in accordance with the NEP-2020 and based on the UGC curriculum framework. Upon completion of this course, learners will be able to:

1. Demonstrate to safeguard the Earth's environment and its resources.
2. Explain sustainable development, its goals, challenges, and global strategies.
3. Analyse the environmental pollution and sensitize themselves to adverse health impacts of pollution.
4. Appraise the concept of climate change, its science and response measures.

MAPPING COURSE OBJECTIVES (COs) & COURSE LEARNING OUTCOMES (CLOs)

	COURSE LEARNING OUTCOMES (CLOs)			
COURSE OBJECTIVES (COs)	**CLO1**	**CLO2**	**CLO3**	**CLO4**
CO1	√			
CO2		√		
CO3			√	
CO4				√

COURSE CONTENTS

Unit I
Human and Environment

Introduction to earth environment, Scope and importance. Components of environment: Lithosphere, Hydrosphere, Biosphere, Atmosphere. The man- environment interaction, Population growth and natural resource exploitation, Industrial revolution, and impact on the environment, Global environmental challenges at global, regional and local level.

Unit II

Natural Resources, Sustainable Development & Sustainable living

Overview of natural resources: Definition of resource; Classification of natural resources-, renewable, and non-renewable. Resources: Forests, wetlands, Status and challenges. Water resources: Types of water resources, issues and challenges; Soil and mineral resources: Important minerals; Environmental problems due to extraction of minerals, Soil as a resource and its degradation. Energy resources: renewable and non-renewable sources of energy. Introduction to sustainable development: Sustainable Development Goals (SDGs)- targets and indicators, challenges, and strategies for SDGs. Ways to live in sustainable manner- Conservation of energy, water at home, plantation, waste segregation, kitchen gardening.

Unit III

Conservation of Biodiversity and Ecosystems

Biodiversity and its distribution: Biodiversity as a natural resource; Levels and types of biodiversity; Biodiversity in India and the world; Biodiversity hotspots; Major ecosystem types in India and their basic characteristics, forests, wetlands, grasslands, agriculture, coastal and marine; Ecosystem services- classification and their significance. Threats to biodiversity and ecosystems. Major conservation policies: in-situ and ex-situ conservation approaches; Major protected areas; National and International instruments for biodiversity conservation: The role of traditional knowledge, community-based conservation. Major International Environmental Agreements: Convention on Biological Diversity (CBD); Cartagena Protocol on Biosafety, Ramsar Convention on Wetlands of International Importance, The Wildlife (Protection) Act, 1972, The Biological Diversity Act, 2002.

Unit IV

Environmental Pollution and Health

Understanding of pollutant and pollution; Types of Pollution, Air pollution: Sources of air pollution; Primary and secondary pollutants; Criteria pollutants, Indoor air pollution; Adverse health impacts of air pollutants, National Ambient Air Quality Standards. Water pollution: Sources of water pollution; River, lake and marine pollution, groundwater pollution; water quality Water quality parameters and standards; adverse health impacts of water pollution on human and aquatic life. Soil pollution and solid waste: Soil pollutants and their sources; Solid and hazardous waste; Impact on human health. Noise pollution: Definition of noise; Unit of measurement of noise pollution; Sources of noise pollution; Noise standards; adverse impacts of noise on human health. Thermal and Radioactive pollution: Sources and impact on human health and ecosystems.

Unit V

Climate Change: Impacts, Adaptation and Mitigation

Understanding climate change: Natural variations in climate, Anthropogenic climate change from greenhouse gas emissions– past, present and future; Projections of global climate change with special reference to temperature, rainfall, climate variability and extreme events, Climate change projections for the Indian sub-continent. Observed impacts of climate change on ocean and land systems; Sea level rise, changes in marine and coastal ecosystems; Impacts on forests and natural ecosystems; Impacts on animal species, agriculture, health. the concept of vulnerability, adaptation and resilience, Synergies between adaptation and mitigation measures, Concept of carbon neutrality, net zero targets, Carbon capture and storage, National climate action plan and Intended Nationally Determined Contributions (INDCs).

Unit 6
Case Studies and Field Work

The students are expected to be engaged in one of the following or similar identified activities. Field visits to identify local issues, make observations including data collection and prepare a brief report, or Documentation of campus biodiversity or Campus environmental management activities such as solid waste disposal, water management, and sewage treatment.

TEXT BOOKS:

1. Masters, G. M., & Ela, W. P. (2008). Introduction to environmental engineering and science Englewood Cliffs, NJ: Prentice Hall.
2. Jackson, A. R., & Jackson, J. M. (2000). Environmental Science: The Natural Environment and Human Impact. Pearson Education.
3. Rajagopalan, R. (2011). Environmental Studies: From Crisis to Cure. India: Oxford University Press
4. Environmental Studies for Undergraduate Courses by Erach Bharucha, UGC New Delhi

REFERENCE BOOKS:

1. A.K De Environmental Chemistry New age Publisher, 2016.
2. "Ecology & Environment" P D Sharma, Rastogi Publications, 2009.
3. www.ipcc.org; https://www.ipcc.ch/report/sixth-assessment-report-cycle/.
4. Central Pollution Control Board Web page for various pollution standards. https://cpcb.nic.in/ standards/

Department of Physical Education & Sports			
Programme: Undergraduate program			
Year/Semester		Course Category	Value Added Course (VAC)
Course Code	23VAC	Course Title	Sports, Yoga & Fitness
Continuous Evaluation: …. Marks		End Semester Examination: …. Marks	
Prerequisite: Nil		L T P : 0 0. 4	Credits: 2

Course Objectives (CO) - The Course is designed with the following objectives:

1. To know about the physical body
2. To discuss about improve range of motion, mobility and coordination in body
3. To understand the ways to improve strength, balance and flexibility.
4. To grasp the significance of yoga and sports in fitness
5. To construct environment for individual and community health.

Course Learning Outcomes (CLO)–The Syllabus has been prepared in accordance with the NEP-2020. Upon completion of this course, learners will be able to :**(BLOOM'S TEXONOMY)**

1. Explain the role of yoga and fitness in life.
2. Apply the rules of healthy and fit life
3. Analyse the ways and methods of yoga and sports
4. Recommend the practices of Asanas and different sports
5. Integrate the concept of yoga and sports in all round development of students and beings.

Mapping Matrix between Course Objectives and Course Learning Outcomes: **COURSE CONTENTS:**

	COURSE LEARNING OUTCOMES (CLOs)				
COURSE OBJECTIVES (COs)	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	√				
CO2		√			
CO3			√		
CO4				√	
CO5					√

UNIT-I: Health and Wellness

• Meaning Definition and Importance of Health and Wellness • Dimensions of Health and Wellness
• Role of Exercise in maintaining Health and Wellness
• Stress and Its management through Exercise
• Nutrition for Health and Wellness
• Practical-Exercise for Health and Wellness
  → Warming –Up
  → Stretching Exercises
  → Strengthening Exercises

- → Cardiovascular Exercises
- → Flexibility and Agility Exercises ¬ Limbering Down
- → Relaxation Techniques (IRT, QRT, DRT etc.)

UNIT-II Yoga and Fitness

- • Importance of Yoga and Fitness
- • Types and Principles of Asanas
- • Fitness Components
- • Specific Exercises for Strength,Flexibility, Speed,Agility & Coordinative Abilities
- • Yoga, Fitness and Personality
- • General Specific Warm up • Aerobics / Zumba Dance
- • Asanas
- • Recreation for Fitness
- • Report preparation, Records and PPT

UNIT-III Sports and Psychology

- • Definition of Sports Psychology
- • Adolescence-Problems related with Adolescence i.e.physical problems, Peer group Relationship, Career Selection,Drug Abuse, Psychological and Emotion problems
- • Importance of Sports Psychology

UNIT-IV Sports and Recreation

- • Meaning Definition and Concept of Sports Fitness and Recreation
- • Objectives, Characteristics and principles of Sports Fitness and Recreation
- • Importance, Purpose, Benefits of Fitness and Recreation
- • Types of Recreation
- • Recreation through Sports and Games
- • Use of Leisure Time Activities and their educational values
- • Traditional, Folk and Indigenous Games
- • Three Days outdoor camp and Hiking
- • Cycling, tie up with District/State Associations
- • Visits to Recreational Clubs

TEXT BOOKS:

1. Foundations of Physical Education, Chales A. Bucher
2. Foundations of Physical Eduction, M.L.Kamlesh
3. History and Principles in Physical Education, Dr. Karan Singh
4. Essentials of Physical Education, Dr. Ajmer Singh
5. Foundations of Physical Education, Dr. A.K.Uppal

REFERENCE BOOKS:

1. Physical Education, Manu Sood, New SP Books
2. Health the basis of life: Dr. John Maclay
3. Natural Health & Yoga, Brij Bhushan
4. Health Education, S.K.Mangal
5. Essential of Physical Education, Dr. Ajmer Singh & Dr. Bains

List of Skill Enhancement Courses (SEC) offered to
Four Year B.Sc. Physics programme in the Department of Physics
w.e.f. Academic Year 2025-26

Courses on Soft Skills

S. No.	Code	Course Name	L	T	P	Credits
1	24SS151	Effective Communication Skills	0	0	2	1
2	24SS252	Teamwork & Interpersonal Skills	0	0	2	1
3	24SS353	Presentation Skills	0	0	2	1
4	24SS454	Professional Skills	0	0	2	1
5	24SS555	Aptitude & Reasoning	0	0	2	1

Courses on Technical Skills

S. No.	Code	Course Name	L	T	P	Credits
1	24SS101	Digital Literacy & IT Skills	0	0	2	1
2	24SS202	Advanced Excel Skills	0	0	2	1
3	24SS303	Statistical Analysis with SPSS	0	0	2	1
4	24SS404	R language programming	0	0	2	1
5	24SS505	Programming with MATLAB	0	0	2	1

Department Of Training & Placement			
Training Cell			
Programme	Faculty of Science & Humanities		
Year / Semester	1 / 1	Course Category	SEC (soft skills)
Course Code		Course Title	Effective Communication Skills
Continuous Evaluation: …. Marks		End Term Examination: …. Marks	
Prerequisite: Nil		L T P: 0 0 2	Credits: 1

Training Objectives (TO): -

- TO1. To define and understand communication and its process.
- TO2. To make student practice on communication skills via LSRW approach via instructing, engaging, assessing and re engaging.
- TO3. To enhance the confidence and motivation of a student by honing his communication skills.

Training Learning Outcomes (TLO): -

After the completion of the training, the student will have ability:

- TLO1. To communicate effectively and interact with people with confidence.
- TLO2. To demonstrate and differentiate between various forms of communication.
- TLO3. To apply effective communication skills confidently which a student need to get ahead in job and life.

Mapping Matrix of Training Objectives (TO) & Training Learning Outcomes (TLO)			
TRAINING LEARNING OUTCOMES (TLO) ➔ TRAINING OBJECTIVES (TO) ↓	TLO1	TLO2	TLO3
TO1			
TO2			
TO3			

Unit	Course Contents	Student Engagement Activity
Unit-I	**Verbal Communication Skills** • Communication Process & its importance • 7 C's of Communication • Formal & Informal Conversation • Requirements of effective verbal communication	Conversation Cards Activity
Unit-II	**Nonverbal Communication Skills** • Importance of nonverbal skills in effective communication • Types of nonverbal (body language) skills • Barriers to nonverbal communication	Power of Body Language Activity
Unit-III	**Listening Skills** • Role of listening skills in effective communication • Barriers to listening • Overcoming listening barriers • Empathetic listening & avoiding selective listening	Chinese Whisper Activity
Unit-IV	**Reading & Writing Skills** • Types of reading strategies to enhance improve reading skills • Types of written communication	The What IF Activity
Unit- V	**Visual Communication** • Types of visual communication • Importance of visual communication • Picture narration/description technique	Interpret The Picture Activity

Learning Resources	
Text Book	***Communication Skills*** by Sanjay Kumar & Pushp Lata: Oxford University Press, 2019.
Suggested Reference Book	***Personality Development & Communication Skills-1*** by C B Gupta: Scholar Tech Press,2019.

Pedagogy

- The training will be based on the concept of learning by practice.
- The training will involve 30% of the training time on briefing and demonstration & the remaining 70% will be focusing on student's engagement in training activities.
- The training will follow a circular approach where students are engaged, evaluated, given feedback and then re engaged.

Internal (Continuous Assessment & Evaluation) & End Term (Assessment & Evaluation) for Effective Communication Skills Course

<table>
<tr><th>Unit No.</th><th>Unit Name</th><th>Internal Assessment Parameter</th><th>Internal Marks (70)</th><th>End Term Assessment Parameters</th><th>End Term Marks (30)</th></tr>
<tr><td>I</td><td>Verbal Communication Skills</td><td>Speech Activity</td><td>15</td><td rowspan="3">Written Test</td><td rowspan="3">10</td></tr>
<tr><td>II</td><td>Non Verbal Communication Skills</td><td>Role Play</td><td>15</td></tr>
<tr><td>III</td><td>Listening Skills</td><td rowspan="3">Oral Assessment / Written Assessment</td><td>10</td></tr>
<tr><td>IV</td><td>Reading & Writing Skills</td><td>20</td><td rowspan="2">Viva</td><td rowspan="2">20</td></tr>
<tr><td>V</td><td>Visual Communication</td><td>10</td></tr>
</table>

Department Of Training & Placement			
Training Cell			
Programme	Faculty of Science & Humanities		
Year / Semester	1 / 2	Course Category	SEC (soft skill)
Course Code	24SS252	Course Title	Teamwork & Interpersonal Skills
Continuous Evaluation: …. Marks		End Term Examination: …. Marks	
Prerequisite: Nil		L T P: 0 0 2	Credits: 1

Training Objectives (TO): -

- TO1. To make the students learn & demonstrate effective teamwork, leadership & interpersonal skills.
- TO2. To equip the students with capability of handling stress and utilization of work time effectively.
- TO3. To make the students understand the importance and application of Emotional Quotient, Critical Thinking & Problem Solving Skills.

Training Learning Outcomes (TLO): -

After the completion of the training, the student will have ability:

- TLO1. To be confident working in a team and leading it as well.
- TLO2. To categorize the work and achieve expected performance within the time frame & will be able to adapt himself to work under various kinds of stress and re-energies himself to bounce back from such situations.
- TLO3. To get benefitted from Emotional Quotient in building stronger professional relationships and achieving career and personal goals.
- TLO4. To face complex problems and effectively deal with it in the job due to Critical Thinking & Problem Solving Skills.

Mapping Matrix of Training Objectives (TO) & Training Learning Outcomes (TLO)

Training Learning Outcomes (TLO)➔ Training Objectives(TO)🡻	TLO1	TLO2	TLO3	TLO4
TO1	■			
TO2		■		
TO3			■	■

Unit	Course Contents	Student Engagement Activity
Unit - I	**Team Management** • Team communication & team conflict resolution • Role of a team leader • Team goal setting & understanding team development • Team dynamics & multicultural team activity • Johari Window Model	Collaborative Working Game Activity
Unit-II	**Time Management** • Time management matrix • Pareto Principle (80/20 rule) • Development process of plan of action	What You Did Yesterday Activity
Unit-III	**Leadership** • Difference between leadership & management • Types of leadership style • Core leadership skills	Lead The Blindfolded Activity
Unit-IV	**Stress Management** • Sign of stress & its impact • Types of stress • Techniques of handling stress	Keeping Cool Activity
Unit - V	**Emotional Intelligence** • Emotional intelligence & emotional competence • Components & behavioral skills of emotional intelligence	Guess The Emotion Game Activity
Unit - VI	**Critical Thinking** • Types of thinking & Characteristics • Critical thinking standards • Barriers to critical thinking	Think Pair Share Activity

Learning Resources	
Text Book	***Communication Skills*** by Sanjay Kumar & Pushp Lata: Oxford University Press, 2019.
Suggested Reference Book	***Personality Development & Communication Skills-1*** by C B Gupta: Scholar Tech Press, 2019.(ISBN No. – 9382209131)

Pedagogy

- The training will be based on the concept of learning by practice.
- The training will involve 30% of the training time on briefing and demonstration & the remaining 70% will be focusing on student's engagement in training activities.
- The training will follow a circular approach where students are engaged, evaluated, given feedback and then re engaged.

Internal (Continuous Assessment & Evaluation) & End Term (Assessment & Evaluation) for Teamwork & Interpersonal Skills

Unit No.	Unit Name	Internal Assessment Parameter	Internal Marks (70)	End Term Assessment Parameters	End Term Marks (30)
I	Team Management	Role Play / Group Activity	10	Written Test	10
II	Time Management		10		
III	Leadership		10		
IV	Stress Management	Assignment	10	Viva	20
V	Emotional Intelligence	Written Test	10		
VI	Critical Thinking		20		

Department Of Training & Placement			
Training Cell			
Programme	Faculty of Science & Humanities		
Year / Semester	2 / 3	Course Category	SEC (soft skill)
Course Code	24SS353	Course Title	Presentation Skills
Continuous Evaluation: …. Marks		End Term Examination: ….. marks	
Prerequisite: Nil		L T P: 0 0 2	Credits: 1

Training Objectives (TO):-

- TO1. To develop the public speaking skills in the student.
- TO2. To make the students learn and adapt to the necessary etiquettes required working and growing in corporate culture.
- TO3. To make the students learn to speak in a debate session by putting his arguments and making others accept his viewpoint convincingly.

Training Learning Outcomes (TLO): -

After the completion of the training, the student will have ability:

- TLO1. To be confident in presenting himself in front of audience.
- TLO2. To become professional in his approach towards work culture.
- TLO3. To enhance the level communication skills while interacting with others.

Mapping Matrix of Training Objectives (TO) & Training Learning Outcomes (TLO)			
Training Learning Outcomes (TLO)➔ Training Objectives(TO)🡻	TLO1	TLO2	TLO3
TO1			
TO2			
TO3			

Unit	Course Contents	Student Engagement Activity
Unit-I	**Importance of Presentation Skills** • 4 P's of presentation skills – plan, prepare, practice & present • Guidelines for effective presentation	PPT Presentation Activity
Unit-II	**Storytelling Skills** • 4 P's of storytelling skills – people, place, plot & purpose • Types of storytelling techniques • Importance of storytelling skills	Start From Where I Stopped Activity
Unit-III	**Corporate Culture Etiquettes** • Importance of professional behavior at work place • Understand & implementation of etiquettes at work place • Importance of values & ethics • Types of professional / corporate etiquettes	Etiquettes Role Play Activity
Unit-IV	**Debate / Extempore** • Difference between debate, extempore & group discussion • Learning argument /counter argument in debate	Current Affair Topic Speech Activity
Unit-V	**Art of Creating Impression** • Importance of creating first impression • 6 ways to master the art of creating impression	Speech Activity
Unit-VI	**Problem Solving** • Types of problems & its solutions Problem solving process & tools	Think Pair Share Activity

Learning Resources	
Text Book	***Communication Skills*** by Sanjay Kumar & Pushp Lata: Oxford University Press, 2019.
Suggested Reference Book	***Personality Development & Communication Skills-1*** by C B Gupta: Scholar Tech Press, 2019.(ISBN No. – 9382209131)

Pedagogy

- The training will be based on the concept of learning by practice.
- The training will involve 30% of the training time on briefing and demonstration & the remaining 70% will be focusing on student's engagement in training activities.
- The training will follow a circular approach where students are engaged, evaluated, given feedback and then re engaged.

Internal (Continuous Assessment & Evaluation) & End Term (Assessment & Evaluation) for Presentation Skills

Unit No.	Unit Name	Internal Assessment Parameter	Internal Marks (70)	End Term Assessment Parameters	End Term Marks (30)
I	Importance of Presentation Skills	Presentation Activity	20	Written Test	10
II	Storytelling Skills	Speech Activity	15		
III	Corporate Culture Etiquettes	Assignment	10		
IV	Debate/Extempore	Speech Activity / Written Activity	15	Viva	20
V	Art of Creating Impression		10		
VI	Problem Solving				

Department Of Training & Placement			
Training Cell			
Programme	Faculty of Science & Humanities		
Year / Semester	2 / 4	Course Category	SEC (soft skill)
Course Code	24SS454	Course Title	Professional Skills
Continuous Evaluation: ….. Marks		End Term Examination: …. Marks	
Prerequisite: Nil		L T P: 0 0 2	Credits: 1

Training Objectives (TO): -

- TO1. To encourage students to learn and apply the effective writing skills.
- TO2. To make the students learn various types of business correspondence letters, cover letters & resume.
- TO3. To encourage students to learn as to how to talk and convince people in GD & interview.
- TO4. To make the students learn to build rapport for building positive relationships professionally at workplace.

Training Learning Outcomes (TLO): -

After the completion of the training, the student will have ability:

- TLO1. To understand the importance of professional writing required in workplace.
- TLO2. To explore different formats in resume, cover letters & other business related letters.
- TLO3. To develop knowledge, skills and understanding people in-group and individually.
- TLO4. To apply communication strategies either in-group or one on one basis and will be confident to lead the discussion among them.

Mapping Matrix of Training Objectives (TO) & Training Learning Outcomes (TLO)				
Training Learning Outcomes (TLO) → **Training Objectives(TO)↓**	TLO1	TLO2	TLO3	TLO4
TO1				
TO2				
TO3				
TO4.	-	-	-	

Unit	Course Contents	Student Engagement Activity
Unit-I	**Email Writing** • Importance of email communication skills • Basic rules of effective email writing • Structure of email – address, subject, message text, attachments, signature	Email Practice Activity
Unit-II	**Resume Writing** • Difference between Resume, CV & Bio data • Guidelines of resume writing • Resume preparation of the student	Resume Making Activity
Unit-III	**Letter Writing** • Types of Letter Writing – Application, Leave, etc. • Cover letter	Letter Writing Activity
Unit--IV	**Group Discussion (GD)** • Characteristics of GD & subject knowledge • Do's & Don'ts in GD • Strategies of GD • Types of GD	Group Discussion Practice Activity
Unit-V	**Interview Skills** • Preparation of the interview & company details information • Do's & Don'ts in interview • Types of Interviews • Strategies of interview	Mock Interview Practice Activity
Unit-VI	**Negotiation Skills** • Importance of negotiation skills • Four phases of negotiation skills • Barriers to negotiation & overcoming it • Win-win negotiation	Win-Win Activity

Learning Resources	
Text Book	***Communication Skills*** by Sanjay Kumar & Pushp Lata: Oxford University Press, 2019.
Suggested Reference Book	***Personality Development & Communication Skills-1*** by C B Gupta: Scholar Tech Press, 2019.(ISBN No. – 9382209131)

Pedagogy

- The training will be based on the concept of learning by practice.
- The training will involve 30% of the training time on briefing and demonstration & the remaining 70% will be focusing on student's engagement in training activities.
- The training will follow a circular approach where students are engaged, evaluated, given feedback and then re engaged.

Internal (Continuous Assessment & Evaluation) & End Term (Assessment & Evaluation) for Professional Skills

Unit No.	Unit Name	Internal Assessment Parameter	Internal Marks (70)	End Term Assessment Parameters	End Term Marks (30)
I	Email Writing	Written Assignment	10	Written Test	10
II	Resume Writing		10		
III	Letter Writing		10		
IV	Group Discussion	Group Discussion Activity	15	Viva	20
V	Interview Skills	Mock Interview Activity	15		
VI	Negotiation Skills	Role Play	10		

Department Of Training & Placement			
Training Cell			
Programme	Faculty of Science & Humanities		
Year / Semester	3 / 5	Course Category	SEC (soft skill)
Course Code	24AR555	Course Title	Aptitude & Reasoning
Continuous Evaluation: …. Marks		End Term Examination: …. Marks	
Prerequisite: Nil		L T P: 0 0 2	Credits: 1

Training Objectives (TO): -

- TO1. To understand the basic concepts of quantitative ability and logical reasoning.
- TO2. To make student practice on the concepts of quantitative ability and logical reasoning.
- TO3. To prepare the students for aptitude and reasoning round in placement selection process & other competitive exams.

Training Learning Outcomes (TLO): -

After the completion of the training, the student will have ability:

- TLO1. To understand the basic concepts of quantitative ability.
- TLO2. To solve campus placements aptitude papers covering Quantitative Ability.
- TLO3. To Compete in various competitive exams like CAT, CMAT, GATE, GRE, GATE, UPSC, GPSC etc.

Mapping Matrix of Training Objectives (TO) & Training Learning Outcomes (TLO)			
TRAINING LEARNING OUTCOMES (TLO) → TRAINING OBJECTIVES (TO) ↓	TLO1	TLO2	TLO3
TO1			
TO2			
TO3			

A-Quantitative Ability

UNIT - I

- Number System
- Percentage
- Profit, Loss and Discount
- Simple Interest and Compound Interest

UNIT – II

- Allegation and Mixture
- Average
- Ratio, Proportion and Variation, Problem on Ages and Numbers

- Time and Work
- Time, Speed and Distance

UNIT – III

- Permutation and Combination
- Probability
- Data Interpretation
- Geometry and Menstruations
- Sequence, Series & Progression and Logarithmic

B- Logical Reasoning

UNIT - IV

- Number Series and Alphabet Series
- Direction Sense Test
- Coding -Decoding
- Blood Relation

UNIT – V

- Syllogism
- Dice, Cube and Cuboids
- Seating Arrangement

UNIT – VI

- Clock and Calendar
- Critical Reasoning
- Order and Ranking, Ven diagram, Analogy

Learning Resources	
Text Books	***Quantitative Aptitude for Competitive Examinations*** by R S Aggarwal: S Chand Publishing, 2022.
	A Modern Approach to Logical Reasoning by R S Aggarwal: S Chand Publishing, 2022.

Pedagogy-

- The training will be based on the concept of learning by doing and practice.
- The training will involve 50% of the training time on teaching the concepts and the remaining 50% will be focusing on practice.
- The training will follow a circular approach where students are taught, evaluated and given the feedback.

Internal (Continuous Assessment & Evaluation) & End Term (Assessment & Evaluation) for Aptitude & Reasoning

Unit No.	Unit Name	Internal Assessment Parameter	Internal Marks (70)	End Term Assessment Parameters	End Term Marks (30)
I	Quantitative Ability	Written Assignment	10	Written Test	30
II			10		
III			10		
IV	Logical Reasoning		15		
V			15		
VI			10		

DIGITAL LITERACY & IT SKILLS	
Course Code:	Continuous Evaluation: -- Marks
Credits: 1	End Semester Examination: -- Marks
L T P : 0 0 2	**Course Type:** Skill Enhancement course (Technical skills)
Prerequisite: NIL	

COURSE OBJECTIVE

1. To familiarize the students with basic knowledge of computer system along with its components.
2. To understand the working of internet with the discussion of different computer networks.
3. To get in-depth knowledge of the features of MS word and MS presentation in order to fulfill the basic requirement for Managers.
4. To get knowledge of basic and advance features of MS-Excel.
5. To provide broad introduction of data analytics with respect to business domain.
6. To focus on the theoretical understanding of Artificial intelligence and why it plays a major role in business analytics.

COURSE LEARNING OUTCOMES

1. Understand the basic fundamental components of computersincluding the working of internet.
2. Familiarize in working of MS-Word including creating and modifying the text documents and its conversion into different other formats like pdf. etc.
3. Students will be able to apply different formulas in the Excel sheets to solve complex business problems.
4. Ability to create a good interactive presentation using MS-PowerPoint.
5. Ability to enhance the data analytics practices executed in the business world.
6. Ability to identify the characteristics of datasets and compare the trivial data and big data for various applications.
7. Ability to select and implement machine learning techniques and computing environment that are suitable for the applications under consideration.
8. Demonstrate the types of machine learning: Supervise learning, unsupervised learning, and deep learning.
9. Describe popular algorithms Classification, Regression, Clustering, and Dimensional Reduction.
10. Analyse the factors that influenced the advancements of AI in recent years.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives	Course Learning Outcomes									
	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6	CLO7	CLO8	CLO9	CLO10
CO1										
CO2										
CO3										
CO4										
CO5										
CO6										

COURSE CONTENT

UNIT I

What is Computer, Basic Applications of Computer; Components of Computer System, Central Processing Unit (CPU), Evolution of computer hardware, problem solving using computers, flow charting techniques and writing algorithms, Computer Memory,Basic of Computer networks; LAN, WAN; Concept of Internet; Applications of Internet; connecting to internet; World Wide Web; Web Browsing software's, Search Engines; Understanding URL; Domain name; IP Address; Using e-governance website

UNIT II

MS Word: Features, Creating, Saving and Opening Documents in Word, Interface, Toolbars, Ruler, Menus, Keyboard 100 Shortcut, Editing, Previewing, Printing,& Formatting a Document, Advanced Features of MS Word, Find & Replace, Using Thesaurus, Using Auto-Multiple Functions, Mail Merge, Handling Graphics, Tables & Charts, Converting a word document into various formats like- Text, Rich Text format, Word perfect, HTML,PDF etc.
MS Power Point: Introduction to presentation – Opening new presentation, Different presentation templates, setting backgrounds, selecting presentation layouts. Creating a presentation - Setting Presentation style, Adding text to the Presentation. Formatting a Presentation - Adding style, Colour, gradient fills, Arranging objects, Adding Header & Footer, Slide Background, Slide layout. Adding Graphics to the Presentation- Inserting pictures, movies, tables etc into presentation, Drawing Pictures using Draw. Adding Effects to the Presentation- Setting Animation & transition effect. Printing Handouts, Generating Standalone Presentation viewer.

UNIT III

MS-Excel: Worksheet basics, creating worksheet, entering into worksheet, heading information, data, text, dates, alphanumeric values, saving & quitting worksheet, Opening and moving around in an existing worksheet, Toolbars and Menus, Keyboard shortcuts, Working with single and multiple workbook, working with formulae & cell referencing, Auto sum, Copying formulae, Absolute & relative addressing, Worksheet with ranges, formatting of worksheet, Previewing & Printing worksheet, Graphs and charts, Database, Creating and Using macros, Multiple worksheets- concepts, creating and using.

UNIT IV

Introduction to data analytics (DA), types of events and characteristics in the business analytics, different sources of data, data preparation, and data cleaning, Analytical tools, Big Data and Cloud technologies, different data science techniques and their applicability in business via case studies, Rules & processes that help an analytical organization run smoothly, like Data Governance, Data Privacy, and Data Quality.

UNIT V

Introduction to Machine Learning, ML vs Traditional programming, Issues in machine learning. Types of machine learning: Learning associations, Supervised learning (Classification and Regression Trees, Support vector machines), Unsupervised learning (Clustering), Instance-based learning (K-nearest Neighbour, Locally weighted regression, Radial Basis Function), Reinforcement learning (Learning Task, Q-learning, Value function approximation, Temporal difference learning)., Significance of ML in Business Analytics, Analysing different real-time case studies in business domain with ML application, Introduction to Artificial Intelligence, role of AI in business domain, Practical application of AI.

TEXT BOOKS:

1. Professional Office Procedure by Susan H Cooperman, Prentice Hall
2. Information Technology:Principles , Practices and Opportunities by James A Senn, Prentice Hall
3. Understanding Machine Learning. Shai Shalev-Shwartz and Shai Ben-David. Cambridge University Press. 2017.
4. Foundations of Data Science. Avrim Blum, John Hopcroft and Ravindran Kannan. January 2017.

REFERENCE BOOKS:

1. Fundamentals of computers - V.Rajaraman - Prentice- Hall of India
2. Microsoft Office 2007 Bible - John Walkenbach,Herb Tyson, Faithe Wempen, caryN. Prague, Michael R.groh, Peter G.Aitken, and Lisa a.Bucki -Wiley India pvt.ltd.

Department of Mathematics			
Year/Semester	1 Year/ 2nd Semester	Course Category	Skill enhancement course (SEC) (Technical Skills)
Course Code		Course Title	Advance Excel Skills
Continuous Evaluation: …. Marks		End Semester Examination: …. Marks	
Prerequisite: Nil		L T P : 0 0 2	Credits: 1

COURSE OBJECTIVES (CO)

1. To develop understanding of excel
2. To apply different formulae
3. To understand the making of different charts in excel

COURSE LEARNING OUTCOMES (CLO)

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

1. To optimize the use of MS-Excel for powerful data analysis.
2. To apply correct data visualization technique to gain optimal presentation of data.
3. To apply enhanced features of MS-Excel

MAPPING BETWEEN COURSE OBJECTIVES AND COURSE LEARNING OUTCOMES

CO \ CLO	CLO 1	CLO 2	CLO 3
CO 1	✓		
CO 2		✓	
CO 3			✓

COURSE CONTENTS

Unit I

Workbook and worksheets- Navigation with keyboard, Tabs and ribbons, file menu, quick access toolbar, create print and save workbook, worksheet basics, protecting excel workbook and worksheet, importing and exporting data, co-authoring; Data and Formatting-Adding Data ,Cut Copy Paste , Data fill ,Data Movement , Cell Formatting ,Conditional Formatting, Cell Operations , Reusable Lists , Data Validation , Sorting And Filtering , Tables.

Unit II

Understanding formulas; operators in formula; named ranges; calculations; functions in formulas; relative and absolute addressing; referencing cells outside the worksheet and workbook; functions - logical, summarizing, text, lookup, reference, data and time, math functions; error handling, formula auditing

Unit III

Charts types and uses, Chart depiction – column, line, pie, bar, bubble, histogram Analysis - Pivot Table, Pivot Charts, What If Analysis

TEXT BOOKS/ REFRENCES BOOKS

1. Manisha Nigam, "Data Analysis with Excel", BPP publications, 2019.
2. Paul McFedries, Excel Data Analysis for Dummies, 5th Edition, 2022.

Department of Mathematics			
Year/Semester	2nd Year/ 3rd Semester	Course Category	Skill enhancement course (SEC) (Technical skills)
Course Code		Course Title	Statistical Analysis with SPSS
Continuous Evaluation: …. Marks		End Semester Examination: …. Marks	
Prerequisite: Nil		L T P : 0 0 2	Credits: 1

COURSE OBJECTIVES (CO)
1. To train students in SPSS Software
2. To know about the data handling in SPSS
3. To understand about the diagrammatic representation of data

COURSE LEARNING OUTCOMES (CLO)
On successful completion of the course, students will be able to do following:
1. Basics of SPSS
2. Understanding of data handling in SPSS
3. Diagrammatic representation of data

MAPPING BETWEEN COURSE OBJECTIVES AND COURSE LEARNING OUTCOMES

CO \ CLO	CLO 1	CLO 2	CLO 3
CO 1	✓		
CO 2		✓	
CO 3			✓

COURSE CONTENTS

Unit I

Data handling: open SPSS data file – save – import from other data source – data entry – labeling for dummy numbers - recode in to same variable – recode in to different variable – transpose of data – insert variables and cases – merge variables and cases.

Unit II

Data handling: Split – select cases – compute total scores – table looks – Changing column - font style and sizes

Unit III

Diagrammatic representation: Simple Bar diagram – Multiple bar diagram – Sub-divided Bar diagram - Percentage diagram - Pie Diagram – Frequency Table – Histogram – Scatter diagram – Box plot.

TEXT BOOKS/ REFRENCES BOOKS

1. Clifford E.Lunneborg (2000). Data analysis by resampling: concepts and applications. Dusbury Thomson learning. Australia.
2. Everitt, B.S and Dunn, G (2001). Applied multivariate data analysis. Arnold London.
3. Jeremy J. Foster (2001). Data analysis using SPSS for windows. New edition. Versions 8-10. Sage publications. London.
4. Michael S. Louis – Beck (1995). Data analysis an introduction, Series: quantitative applications in the social sciences. Sage. Publications. London.

Department of Mathematics			
Year/Semester	2^{nd} Year/ 4^{th} Semester	Course Category	Skill enhancement course (SEC)
Course Code		Course Title	R language Programming
Continuous Evaluation: …. Marks		End Semester Examination: …. Marks	
Prerequisite: Nil		L T P : 0 0 2	Credits: 1

COURSE OBJECTIVES (CO)

1. To have an idea about the introduction in R language
2. To know about the basics of R
3. To understand the analysis part in excel

COURSE LEARNING OUTCOMES (CLO)

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

1. Develop an R script and execute it
2. Install, load and deploy the required packages, and build new packages for sharing and reusability
3. Extract data from different sources using API and use it for data analysis

MAPPING BETWEEN COURSE OBJECTIVES AND COURSE LEARNING OUTCOMES

CO \ CLO	CLO 1	CLO 2	CLO 3
CO 1	✓		
CO 2		✓	
CO 3			✓

COURSE CONTENTS

Unit I

Introduction: R interpreter, Introduction to major R data structures like vectors, matrices, arrays, list and data frames, Control Structures, vectorized if and multiple selection, functions.

Unit II

Installing, loading and using packages: Read/write data from/in files, extracting data from web-sites, clean data, transform data by sorting, adding/removing new/existing columns, centring, scaling and normalizing the data values, converting types of values, using string in-built functions

Unit III

Statistical analysis of data for summarizing and understanding data, Visualizing data using scatter plot, line plot, bar chart, histogram, and box plot.

TEXT BOOKS/ REFRENCES BOOKS

1. Cotton, R., Learning R: a step-by-step function guide to data analysis. 1st edition. O'reilly Media Inc. Additional Resources:

2. Gardener, M. (2017). Beginning R: The statistical programming language, WILEY.

3. Lawrence, M., & Verzani, J. (2016). Programming Graphical User Interfaces in R. CRC press. (ebook)

Department of Mathematics			
Year/Semester	3rd Year/ 5th Semester	Course Category	Skill enhancement course (SEC)
Course Code		Course Title	Programming with MATLAB
Continuous Evaluation: … Marks		End Semester Examination: ….. Marks	
Prerequisite: Nil		L T P : 0 0 2	Credits: 1

COURSE OBJECTIVES (CO)

- To introduce the software MATLAB for numerical simulation and scientific computation
- To enable students to make use of symbol tools of this computer algebra system
- To introduce MATLAB programming

COURSE LEARNING OUTCOMES (CLO)

- Understand the basics of MATLAB.
- Apply MATLAB software for basic matrix computation problems through loops.
- Demonstrate MATLAB software to solve various mathematical problems numerically.

MAPPING MATRIX OF COURSE OBJECTIVES (CO) & COURSE LEARNING OUTCOMES (CLO)

Course Learning outcome / Course objectives	CLO 1	CLO 2	CLO 3
CO 1	✓		✓
CO 2	✓	✓	
CO 3			✓

COURSE CONTENT

Unit I

Practicing MATLAB environment with simple exercises to familiarize Command Window, History, Workspace, Current Directory, Figure window, Edit window, Shortcuts, Help files. Data types, Constants and Variables, Character constants, operators, Assignment statements. Control Structures: For loops, While, If control structures, Switch, Break, Continue statements.

Unit II

Input-Output functions, Reading and Storing, Data, Vectors and Matrices, commands to operate on vectors and matrices, matrix Manipulations. Arithmetic operations on Matrices, Relational operations on Matrices, Logical operations on Matrices.

Unit III

Polynomial Evaluation, Roots of Polynomial, Arithmetic operations on Polynomials, Graphics: 2D plots, Printing labels, Grid & Axes box, Text in plot, Bar and Pie chart. Linear equations.

TEXT BOOKS/RECOMMENDED BOOKS

1. Stephen J.Chapman, "Programming in MATLAB for Engineers", Cengage Learning, 2011.
2. Pratap R., Getting started with MATLAB: A Quick introduction for Scientists & Engineers, Oxford University Press, 2010.
3. Bansal R.K, Goel A.K., Sharma M.K., "MATLAB and its Applications in Engineering", Pearson Education, 2012.
4. Amos Gilat, "MATLAB-An Introduction with Applications", Wiley India, 2009

SUMMER INTERNSHIP (Faculty of Science , Humanities& Social Science)	
Course Code:	Continuous Evaluation: 60 Marks
Credits: 4	End Semester Examination: -- Marks
Duration : 6 to 8 Weeks	Course Type: Skill Enhancement Course
Prerequisite: Nil	

COURSE OBJECTIVES

- To have qualitative improvements in the UG students of FSH.
- To provide experiential learning to students to work in the real life situation.
- Expose the student to professional role models or mentors who will provide the student with support in the early stages of the internship and provide an example of the behaviours expected in the intern's workplace.
- Assist the student's development of employer-valued skills such as teamwork, communications and attention to detail.

COURSE LEARNING OUTCOMES

On completion of course, students will be

- Able to demonstrate various aspects of theory as well as practical.
- Able to build and expand network of professional relationships and contacts.
- Develop a solid work ethic and professional demeanour, as well as a commitment to ethical conduct and social responsibility.
- At the end of the course, a student will be competent in their domain area.

PROJECT IDENTIFICATION

- The internships will be conducted after examination of the 4 semesters.
- The Internship will be of 4 credits.
- Projects will be undertaken by the students in collaboration with Student-Faculty, NGO, Government Departments and Industries.
- Projects will be identified keeping in mind application of knowledge & skills, relevance of project in terms of expectation of society.
- Allocation of the project to the students with active participation of students, faculty and concern authorities.

MONITORING OF THE PROJECTS

- Project should be supervised by faculty mentor and place where students is undertaking the project.
- Effective monitoring of project progress undertaken by the students through by digital technologies.
- Active involvement of industry & faculty supervisor.
- Weekly monitoring of the project through Faculty mentor & Industry person.
- All the project have to analyze in-depth and the outcome of the project should be identified

ASSESSMENT DETAILS

Assessment of SIP include the following:

- Formative & submissive assessment three times during the internship.

- During the final assessment students have to submit a hard copy of the project, the presentation has to be given by the students.
- Report on Project taken up.
- Viva Voce.
- Final Presentation in front of the industry experts and Faculty mentor.

PERIODIC MONITORING

Student will be monitored on periodic basis, both by the In-charge at the Industry and the Faculty In-charge. The Industry In-charge will submit the Mid-Term and End-Term Evaluation report. However, the faculty In-charge will take periodic presentation to keep a check on the progress.

DURATION:	**3 to 4 Weeks (After 4th Semester End Term Examination)**
EVALUATION PROCESS	1. Student will prepare the report on the work done. 2. Student will prepare the presentation on the learning outcomes. 3. Student will give presentation about the learning achieved.

EVALUATION	• **Formative/Continuous Evaluation : 60 %** • **End Semester Evaluation : 40 %**

EVALUATION PARAMETER FOR SUMMER INTERNSHIP PROJECT (SIP)

1. Evaluation Parameter for Formative Assessment (Summer Internship Project)

Continuous Assessment will perform by respective faculty & Industry coordinators within stipulated time period. Evaluation Parameter classified as follows:

S. No.	Basis of Evaluation Parameter with Time frame	Marks
1.	Synopsis Presentation (Week 1st)	15
2.	Relevance and linkage of the Identify issue with functional area of discipline (Week 1st)	10
3.	Survey of Literature (Week 2nd)	10
4.	Research Methodology & Data collection(3rd to 4th Week)	15
5.	Overall understanding of the area of study(3rd to 4th Week onwards)	10
	Total Marks	**60**

2. Evaluation Parameter for End Term Assessment (Summer Internship Project

S. No.	Basis of Evaluation Parameter	Marks
1.	Quality Of Content Design	10
2.	Identification of Contemporary Issue	10
3.	Innovation in learning Process	10
4.	Presentation of Content & Delivery Mechanism	10
	Total Marks	**40**

Annexure

Multi-disciplinary course syllabus of

1. Creating an Entrepreneurial Mind
2. Personal Financial Planning