AMRITA
VISHWA VIDYAPEETHAM

Program

Integrated MSc Physics with Minor in Scientific Computing

(For academic years starting from July 2018)

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Program Outcomes

PO1. **Scientific Knowledge and Pursuit:** Gain and apply knowledge of basic scientific and mathematical fundamentals, to develop deeper understanding of the Nature and apply it to develop new theories and models.

PO2. **Theoretical Methods & Problem Analysis:** Develop analytical skills to analyze complex phenomena using first principles enabling one to identify underlying structure.

PO3. **Experimental Skills and Development of solutions:** Use of research-based knowledge and research methods including design of physical/computational experiments, Design of solutions for complex chemistry/physics/ mathematics problems and evolve procedures appropriate to a given problem.

PO4. **Computational, Numerical and Data Analysis:** Numerical analysis and simulation modeling and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. **Modern Analytical Tool Usage:** Select, and apply appropriate techniques, resources, and modern analytical tools.

PO6. **Scientific Communication:** Communicate orally and in writing on complex scientific activities with peers, educators, science community, and with society at large, such as being able to comprehend and write effective scientific articles, make effective presentations, and give and receive clear instructions.

PO7. **Individual and team work:** Think critically and work independently, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO8. **Project management and finance:** Demonstrate knowledge and understanding of the scientific and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

PO9. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of scientific practice.

PO10. **The scientist and society:** Apply reasoning through the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional scientific practice.

PO11. **Environment and sustainability:** Understand the impact of scientific processes in societal and environmental contexts, and demonstrate the knowledge, and need for sustainable development.

PO12. **Life-long learning:** Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of scientific and technological changes for up-to-date research and teaching methods.

Program Specific Outcomes

PSO1. Students will demonstrate proficiency in mathematics and the mathematical concepts needed for a proper understanding of physics.

PSO2. Students will demonstrate knowledge of classical mechanics, electromagnetism, quantum mechanics, and thermal and statistical physics, and be able to apply this knowledge to analyze a variety of physical phenomena and related subjects like solid state, atomic & molecular, nuclear physics and other selected applied fields, including electronics.

PSO3. Students will show that they have learned laboratory skills, enabling them to take measurements in a physics laboratory and analyze the measurements to draw valid conclusions. In addition, students will demonstrate skills in solving problems numerically using computer programming, plotting tools, and related software.

PSO4. Students will be capable of oral and written scientific communication and will demonstrate that they can think critically and work independently as well as in a team and play beneficial role in the society as a person of science combined with value-based education, both in professional and personal lives.

Program Educational Objectives (Physics Programs)

Program Educational Objectives: PEOs are broad statements that describe the career and professional accomplishments in five years after graduation that the program is preparing graduates to achieve.

PEO1. To provide sufficient understanding of the fundamentals of mathematics, physics, with experimental and computational techniques and lay a foundation of lifelong learning

PEO2. To facilitate progressive careers in teaching, in pursuit of higher education, and academia and research, and research labs and related industry.

PEO3. To equip our students with sufficient communication and interpersonal, and teamwork skills to enable them to fulfill professional responsibilities, as well as being a knowledgeable person of science in day-to-day affairs.

PEO4. To expose them to value-based education with live-in-labs which will enable them to become ethical and responsible towards themselves, co-workers, the society and the Nation.

General Information

Code Numbering

Each course is assigned an 8-character Code number. The first two digits indicate the year of curriculum revision. The next three letters indicate the Department offering the course. The last three digits are unique to the course – the first digit indicates the level of the course (100, 200, 300, 400 etc.); the second digit indicates the type of the course, viz. 0, 1 and 2 indicate the core courses; 3,4,5,6 and 7 indicate the Elective courses; 8 indicates the Lab. or practical-based courses and 9 indicates Projects**.**

ABBREVIATIONS USED IN THE CURRICULUM

Cat	-	Category
Cr	-	Credits
ES	-	Exam Slot
L	-	Lecture
P	-	Practical
T	-	Tutorial

DISCIPLINES

AVP	-	Amrita Values Programmes
BUS	-	Business Management
CHY	-	Chemistry
CMJ	-	Communication and Journalism
COM	-	Commerce
CSA	-	Computer Science and Applications
CSN	-	Computer Systems and Network
CUL	-	Cultural Education
ECO	-	Economics
ELL	-	English Language and Literature
ENG	-	English
ENV	-	Environmental Sciences
FNA	-	Fine Arts
HIN	-	Hindi
KAN	-	Kannada
LAW	-	Law
MAL	-	Malayalam
MAT	-	Mathematics
MCJ	-	Mass Communication and Journalism
OEL	-	Open Elective
PHY	-	Physics
SAN	-	Sanskrit
SSK	-	Soft Skills
SWK	-	Social Work
TAM	-	Tamil

Curriculum Structure

	Course Title	L T P	Cr	ES		Course Code	Course Title	L T P	Cr	ES
	SEMESTER 1						**SEMESTER 2**			
18MAT107	Single Variable Calculus	3 1 0	4			18MAT116	Multivariate Calculus	3 1 0	4	
18MAT108	Vectors and Geometry	3 1 0	4			18MAT117	Introduction to Differential Equations	3 1 0	4	
18PHY105	Introduction to Mechanics	3 1 0	4			18PHY115	Electricity and Magnetism	3 1 0	4	
18CHY103	Chemistry I	3 0 0	3			18CHY114	Chemistry II	3 0 0	3	
18CSA102	Introduction to Programming I	3 0 2	4			18CSA112	Introduction to Programming II	3 0 2	4	
18ENG101	Communicative English	2 0 2	3			18ENG121	Professional Communication	1 0 2	2	
18CHY182	Chemistry Lab	0 0 2	1			18PHY184	Physics Lab I	0 0 2	1	
18CUL101	Cultural Education I	2 0 0	2			18CUL111	Cultural Education II	2 0 0	2	
	TOTAL		**25**				**TOTAL**		**24**	
	SEMESTER 3						**SEMESTER 4**			
18PHY206	Intermediate Mechanics I	3 1 0	4			18PHY211	Intermediate Mechanics II	3 1 0	4	
18PHY207	Introduction to Thermal & Modern Physics	3 1 0	4			18PHY212	Thermal and Materials Physics	3 1 0	4	
18MAT220	Introduction to Linear Algebra	3 1 0	4			18PHY213	Atomic, Molecular and Nuclear Physics	3 1 0	4	
18MAT210	Transforms and PDE	3 1 0	4			18PHY219	Waves and Optics	3 1 0	4	
18ENV300	Environmental Science and Sustainability	3 0 0	3			18MAT225	Numerical Methods	3 1 0	4	
	Language I	1 0 2	2				Language II	1 0 2	2	
18PHY281	Physics Lab II	0 0 3	1			18PHY282	Physics Lab III	0 0 3	1	
18AVP201	Amrita Value Programme I	1 0 0	1			18AVP211	Amrita Value Programme II	1 0 0	1	
	TOTAL		**23**				**TOTAL**		**24**	
	SEMESTER 5						**SEMESTER 6**			
18PHY301	Classical Mechanics	4 1 0	4			18PHY311	Mathematical Physics II	3 1 0	4	
18PHY302	Mathematical Physics I	3 1 0	4			18PHY312	Electrodynamics II	3 1 0	4	
18PHY303	Electrodynamics I	3 1 0	4			18PHY313	Statistical Mechanics	3 1 0	4	
18PHY304	Electronics I	3 1 0	4			18PHY314	Quantum Mechanics I	3 1 0	4	
18PHY390	Open Elective/Live in Lab (2nd Summer)	3 0 0	3			18PHY315	Electronics II	3 1 0	4	
18PHY386	Physics Lab IV	0 0 3	1			18PHY383	Physics Lab VI (Electronics II)	0 0 3	1	
18PHY387	Physics Lab V (Electronics I)	0 0 3	1			18SSK211	Life Skills II	1 0 2	2	
18SSK201	Life Skills I	1 0 2	2							
	TOTAL		**23**				TOTAL		23	
						TOTAL (for Exit-option students)		142		
	SEMESTER 7						**SEMESTER 8**			
18PHY507	Quantum Mechanics II	3 1 0	4			18PHY516	Condensed Matter Physics II	3 1 0	4	
18PHY505	Condensed Matter Physics I	3 1 0	4			18PHY517	Atomic and Molecular Spectroscopy	3 1 0	4	
18PHY506	Computational Physics I (Minor Course I)	3 1 0	4				Minor Course III	3 1 0	3/4	
	Minor Course II	3 0 1	4				Physics Elective II	3 0 0	3	
	Physics Elective I	3 0 0	3			18PHY590	Research Methodology and Seminar	1 0 1	2	
18PHY584	Physics Lab VII	0 0 6	2			18PHY585	Physics Lab VIIII	0 0 6	2	
18SSK301	Life Skills III	1 0 2	2							
	TOTAL		23				TOTAL	**18/19**		
	SEMESTER 9						**SEMESTER 10**			
18PHY603	Nuclear and Particle Physics	3 1 0	4			18PHY699	Thesis		15	
	Physics Elective III	3 0 0	3							
18PHY691	Mini project and Seminar		6							
	TOTAL		**13**				**TOTAL**		**15**	
							TOTAL CREDITS =	**211/212**		

Language Electives

Code	Paper I						Paper II			
18HIN101	Hindi I	1 0 2	2			18HIN111	Hindi II	1 0 2	2	
18KAN101	Kannada I	1 0 2	2			18KAN111	Kannada II	1 0 2	2	
18MAL101	Malayalam I	1 0 2	2			18MAL111	Malayalam II	1 0 2	2	
18SAN101	Sanskrit I	1 0 2	2			18SAN111	Sanskrit II	1 0 2	2	

Physics Electives

Code	PHYSICS ELECTIVES	L T P	Cr			Code	MINOR COURSE II & III	L T P	Cr
18PHY336	Space Physics	3 0 0	3			18CSA209	Data Structures and Algorithms	3 1 0	4
18PHY342	Nonlinear Optics	3 0 0	3			18CSA308	Machine Learning I	3 1 0	4
18PHY531	Introduction to Quantum Computing (Physics)	3 0 0	3			18CSA316	Machine Learning II	3 1 0	4
18PHY532	Advanced Statistical Mechanics	3 0 0	3			18MAT541	Probability and Statistics with R	3 1 0	4
18PHY534	Epistemological Foundations of Quantum Mechanics	3 0 0	3			18MAT542	Optimization Methods	3 1 0	4
18PHY535	Topics in Astrophysics	3 0 0	3			18PHY551	Computational Physics II	3 0 0	3
18PHY536	Plasma Physics	3 0 0	3			18PHY552	Computational Condensed Matter Physics	3 0 0	3
18PHY537	Fluid Dynamics	3 0 0	3			18PHY553	Nonlinear Dynamics	3 0 0	3
18PHY538	Solid State Electronic Devices	3 0 0	3						
18PHY539	Optoelectronics	3 0 0	3				**OPEN ELECTIVES (Physics)**		
18PHY540	Physics at Nanoscale	3 0 0	3			18OEL297	History and Philosophy of Science	3 0 0	3
18PHY541	Mesoscopic Physics and Quantum Conductors	3 0 0	3			18OEL298	EU History of Science and Technology	4 0 0	3
18PHY542	Thin Film Physics	3 0 0	3						
18PHY543	Methods of Experimental Physics	3 0 0	3						
18PHY320	Modern Optics	3 0 0	3						
18PHY545	Fourier Optics	3 0 0	3						
18PHY546	Lasers and Applications	3 0 0	3						
18PHY547	Physics of the Atmosphere	3 0 0	3						
18PHY633	Biophotonics	3 0 0	3						
18PHY636	Fibre Optic Sensors and Applications	3 0 0	3						
18PHY637	Fibre Optics and Technology	3 0 0	3						
18PHY638	Nanophotonics	3 0 0	3						

Open Electives

Course Code	Course Title	L – T – P	Cr.	ES
18OEL231	Advertising	3 0 0	3	J
18OEL232	Basic Statistics	3 0 0	3	J
18OEL233	Citizen Journalism	3 0 0	3	J
18OEL234	Creative Writing for Beginners	3 0 0	3	J
18OEL235	Desktop Support and Services	3 0 0	3	J
18OEL236	Development Journalism	3 0 0	3	J
18OEL237	Digital Photography	3 0 0	3	J
18OEL238	Emotional Intelligence	3 0 0	3	J
18OEL239	Essence of Spiritual Literature	3 0 0	3	J
18OEL240	Film Theory	3 0 0	3	J
18OEL241	Fundamentals of Network Administration	3 0 0	3	J
18OEL242	Gender Studies	3 0 0	3	J
18OEL243	Glimpses of Indian Economy and Polity	3 0 0	3	J
18OEL244	Graphics and Web-designing Tools	3 0 0	3	J
18OEL245	Green Marketing	3 0 0	3	J
18OEL246	Healthcare and Technology	3 0 0	3	J
18OEL247	History of English Literature	3 0 0	3	J
18OEL248	Indian Writing in English	3 0 0	3	J
18OEL249	Industrial Relations and Labour Welfare	3 0 0	3	J
18OEL250	Introduction to Ancient Indian Yogic and Vedic Wisdom	3 0 0	3	J
18OEL251	Introduction to Computer Hardware	3 0 0	3	J
18OEL252	Introduction to Event Management	3 0 0	3	J
18OEL253	Introduction to Media	3 0 0	3	J
18OEL254	Introduction to Right to Information Act	3 0 0	3	J
18OEL255	Introduction to Translation	3 0 0	3	J
18OEL256	Linguistic Abilities	3 0 0	3	J
18OEL257	Literary Criticism and Theory	3 0 0	3	J
18OEL258	Macro Economics	3 0 0	3	J
18OEL259	Managing Failure	3 0 0	3	J
18OEL260	Media Management	3 0 0	3	J
18OEL261	Micro Economics	3 0 0	3	J
18OEL262	Micro Finance, Small Group Management and Cooperatives	3 0 0	3	J
18OEL263	Negotiation and Counselling	3 0 0	3	J
18OEL264	New Literatures	3 0 0	3	J
18OEL265	Non-Profit Organization	3 0 0	3	J
18OEL266	Personal Effectiveness	3 0 0	3	J
18OEL267	Perspectives in Astrophysics and Cosmology	3 0 0	3	J
18OEL268	Principles of Marketing	3 0 0	3	J
18OEL269	Principles of Public Relations	3 0 0	3	J
18OEL270	Science, Society and Culture	3 0 0	3	J
18OEL271	Statistical Analysis	3 0 0	3	J
18OEL272	Teamwork and Collaboration	3 0 0	3	J
18OEL273	The Message of Bhagwad Gita	3 0 0	3	J
18OEL274	Understanding Travel and Tourism	3 0 0	3	J
18OEL275	Videography	3 0 0	3	J
18OEL276	Vistas of English Literature	3 0 0	3	J
18OEL277	Web-Designing Techniques	3 0 0	3	J
18OEL278	Organic Farming	3 0 0	3	J
18OEL279	Basic Legal Awareness on Protection of Women and Rights	3 0 0	3	J
18OEL280	Ritual Performances of Kerala	3 0 0	3	J
18OEL281	Documenting Social Issues	3 0 0	3	J
18OEL282	Fabrication of Advanced Solar Cell	3 0 0	3	J
18OEL283	Basic Concepts of X-ray Diffraction	3 0 0	3	J
18OEL284	Introduction to FORTRAN and GNUPLOT	3 0 0	3	J
18OEL285	Introduction to Porous Materials	3 0 0	3	J
18OEL286	Forensic Science	3 0 0	3	J
18OEL287	Introduction to solar Physics	3 0 0	3	J
18OEL288	Recycling Recovery and Treatment Methods for Wastes	3 0 0	3	J
18OEL289	Acting and Dramatic Presentation	2 0 2	3	J
18OEL290	Computerized Accounting	2 0 2	3	J

18OEL291	Kerala Mural Art and Painting	2 0 2	3	J
18OEL292	Painting	2 0 2	3	J
18OEL293	Reporting Rural Issues	3 0 0	3	J

Evaluation Scheme and Grading System

R.13 Assessment Procedure

R.13.1 The academic performance of each student in each course will be assessed on the basis of Internal Assessment (including Continuous Assessment) and an end-semester examination.

Normally, the teachers offering the course will evaluate the performance of the students at regular intervals and in the end-semester examination.

R.13.2 In theory courses (that are taught primarily in the lecture mode), the weight for the Internal Assessment and End-semester examination will be 50:50. The Internal assessment in theory courses shall consist of at least two periodical tests, weekly quizzes, assignments, tutorials, viva-voce etc. The weight for these components, for theory-based courses shall be 20 marks for the Continuous assessment, comprising of Quizzes, assignments, tutorials, viva-voce, etc. and 15 marks each for both the Periodical Tests. At the end of the semester, there will be an end-semester examination of three hours duration, with a weight of 50 marks, in each lecture-based subject.

R.13.3 In the case of laboratory courses and practical, the relative weight for internal assessment and End-semester examination will be 80:20.The weight for the components of internal assessment will be decided by the course committee/class committee at the beginning of the course.

Evaluation pattern for course having both Theory and Lab components:

Courses having only one hour per week for lecture/tutorial, be treated as a Lab. course, for evaluation purposes; and evaluation pattern will be 80 marks for continuous assessment of lab work and 20 marks for end-semester lab examination.

Courses having two hours per week for theory and/or tutorials, be given a weight of 60 marks and 40 marks for the Theory and Lab components, respectively; The Lab. component evaluation will be based on continuous evaluation, without any end-semester practical evaluation. 10 marks will be for continuous assessment of the theory portion, 10 marks for each of the two periodical tests, 30 marks for the theory end-semester examination and 40 marks for continuous assessment of lab work and

Courses having three hours per week for theory and/or tutorials, be given a weight of 70 marks and 30 marks for the Theory and Lab components, respectively; The Lab component evaluation will be based on continuous evaluation, without any end-semester practical evaluation. 15 marks will be for continuous assessment of the theory portion, 10 marks for each of the two periodical tests, 35 marks for the theory end-semester examination and 30 marks for continuous assessment of lab work.

R.13.4 It is mandatory that the students shall appear for the end-semester examinations in all theory and weight courses, for completion of the requirements of the course. Those who do not appear in the end-semester examinations will be awarded ‘F’ grade, subject to meeting the attendance requirement.

At the end of a semester, examinations shall be held for all the subjects that were taught during that semester and those subjects of the previous semester s for which the student s shall apply for supplementary examination, with a prescribed fee.

R.13.5 PROJECT WORK: The continuous assessment of project work will be carried out as decided by the course committee. At the completion of the project work, the student will submit a bound volume of the project report in the prescribed format. The project work will be evaluated by a team of duly appointed examiners.

The final evaluation will be based on the content of the report presentation by student and a viva-voce examination on the project. There will be 40% weight for continuous assessment and the remaining 60% for final evaluation.

If the project work is not satisfactory, he/she will be asked to continue the project work and appear for assessment later.

R.14 PUBLICATION / INTERNSHIP

R.14.1 All students, if they are to be considered for award of the Degree at the time of graduation, are required to have published ONE paper in Scopus-indexed Journal/Conference.

R.14.2 Additional 5-10 marks will be awarded for each Publication, subject to a maximum of ONE paper per semester.

The additional marks shall be awarded in the semester in which the paper is published or accepted for publication, if applied for, within10 days of the publication of results of the concerned semester. The additional marks can be awarded to any course(s) where the student has to improve his/her grade.

R.14.3 All publications shall be in Scopus-indexed Journals/Conferences and shall be as per the guidelines prescribed by the University.

R.14.4 Students who have undergone Internship at reputed organizations or National / International Institutions, with the prior approval of the concerned Departmental Chairperson and the Head of the School, may be considered for waiver of the requirement of publication, for the award of Distinction. However, the decision of the Departmental Chairperson and the Head of the School, in this regard, shall be final.

R.16 Grading

R.16.1 Based on the performance in each course, a student is awarded at the end of the semester, a letter grade in each of the courses registered.

Letter grades will be awarded by the Class Committee in its final sitting, without the student representatives.

The letter grades, the corresponding grade points and the ratings are as follows:

Letter Grade	Grade Points	Ratings
O	10.0	Outstanding
A+	9.5	Excellent
A	9.0	Very Good
B+	8.0	Good
B	7.0	Above Average
C	6.0	Average
P	5.0	Pass
F	0.0	Fail
FA	0.0	Failed due to insufficient attendance
I	0.0	Incomplete (awarded only for Lab courses/ Project /

		Seminar)
W		Withheld

R.16.2 'FA'grade once awarded stays in the record of the student and is replaced with the appropriate grade when he/she completes the course successfully later.

Students who have secured an 'FA' in a course must re-register for the course or register for the course, if offered, under run-time re-do mode.

R.16.3 A student who has been awarded 'I' Grade in a Lab course, due to reasons of not completing the Lab., shall take up additional Lab. whenever offered next and earn a pass grade, which will be reflected in the next semester's grade sheet.
The 'I' grade, awarded in a Project/Seminar course, will be subsequently changed into appropriate grade, when the student completes the requirement during the subsequent semester. If he/she does not complete it in the next semester, it will be converted to 'F' grade.

R.16.4 A student is considered to have successfully completed the course and earned the credit, if he/she scores a letter grade 'P' or better in that course.

R.21 Semester Grade Point Average (SGPA)
On completion of a semester, each student is assigned Semester Grade Point Average (SGPA) which is computed as below for all courses registered by the student during that semester:

where is the credit for th course in that semester and Gpi is the grade point for that course.

The summation is over all the courses registered by the student during the semester, including the failed courses. The SGPA is rounded off to two decimals.

R.22 Cumulative Grade Point Average (CGPA)

The overall performance of a student at any stage of the Degree programme is evaluated by the Cumulative Grade Point Average (CGPA) up to that point of time.

where is the credit for th course in any semester and is the grade point for that course.

The summation is over all the courses registered by the student during all the semesters up to that point of time, including the failed courses. The CGPA is also rounded off to two decimals.

R.23 Ranking

The ranking of the students in a batch at any intermediate or final stage is based on CGPA. Only those students who have passed all courses up to that stage in the first attempt are considered for ranking. Students are eligible for final ranking, only if the programme is completed within the normal duration, i.e., within two years from joining the programme.

R.24 Classification of successful candidates:

R.24.1 A student shall be considered to have successfully completed the programme, if he/she has:

i) registered and successfully completed all the core courses, electives and projects as mentioned in the curriculum;

ii) earned the required minimum number of credits as specified in the curriculum corresponding to the programme, within the stipulated time;

iii) published a paper at a Scopus-indexed Journal/Conference.

R.24.2 Candidates who have successfully completed the programme, within a period of four semesters from entering the programme, shall be classified as follows:

Candidates securing a CGPA of 8.00 and above	– FIRST CLASS WITH DISTINCTION*
Candidates securing a CGPA between 6.50 and 7.99	– FIRST CLASS

and the same bementioned in the Degree certificate.

(*Subject to satisfying the condition mentioned at R.14.1 and having passed all the courses, in the first attempt, in four semesters, from the date of joining the programme).

If the programme is completed after four semesters of study, the candidates securing even a CGPA of 8.00 and above, shall be classified to have completed the programme, only with FIRST CLASS.

Syllabus and Course Outcomes

Cultural and Values Education

18AVP201 Amrita Values Programme I 1 0 0 1

Objectives

The student will gain understanding of the glory of Indian Itihasa (Epics) in general, wherefrom the student get inspired to follow the lifestyle of inspiring characters depicted in Ramayana.

Course Outcomes: After the completion of the course the student will be able to:

CO1 Appreciate the relevance of Ramayana in modern times.

CO2 Understand the family values and ideal human relationships portrayed in the Ramayana.

CO3 Understand Dharma and its universality, emphasizing its applicability in an individual’s life.

CO4 Evaluate one’s own personal ethics based on benchmarks from the Ramayana

CO5 Apply the spiritual values from Ramayana in resolving personal and social conflicts.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18AVP211 Amrita Values Programme II 1 0 0 1

Objectives

The student will gain understanding of the glory of Indian Itihasa (Epics) in general, wherefrom the student gets inspired to follow the lifestyle of inspiring characters depicted in Mahabharata.

Course Outcomes: The course will aim at:

CO1: Understanding the impact of itihasas on Indian civilization with reference to Mahabharata

CO2: Enabling students to appreciate the relevance of Mahabharata and Bhagavad-Gita in the modern world.

CO3: Understanding the four goals of life (Purusharthas) as presented in the Mahabharata

CO4: Assimilating the positive qualities of the characters depicted in the itihasa.

CO5: Analysis of the critical events and turning points in the Mahabharata with emphasis on the underlying values and principles.

Amrita University's Amrita Values Programme (AVP) is a new initiative to give exposure to students about richness and beauty of Indian way of life. India is a country where history, culture, art, aesthetics, cuisine and nature exhibit more diversity than nearly anywhere else in the world.

Amrita Values Programmes emphasize on making students familiar with the rich tapestry of Indian life, culture, arts, science and heritage which has historically drawn people from all over the world.

Students shall have to register for any two of the following courses, one each in the third and the fourth semesters, which may be offered by the respective school during the concerned semester.

Courses offered under the framework of Amrita Values Programmes I and II

Message from Amma's Life for the Modern World
Amma's messages can be put to action in our life through pragmatism and attuning of our thought process in a positive and creative manner. Every single word Amma speaks and the guidance received in on matters which we consider as trivial are rich in content and touches the very inner being of our personality. Life gets enriched by Amma's guidance and She teaches us the art of exemplary life skills where we become witness to all the happenings around us still keeping the balance of the mind.

Lessons from the Ramayana
Introduction to Ramayana, the first Epic in the world – Influence of Ramayana on Indian values and culture – Storyline of Ramayana – Study of leading characters in Ramayana – Influence of Ramayana outside India – Relevance of Ramayana for modern times.

Lessons from the Mahabharata
Introduction to Mahabharata, the largest Epic in the world – Influence of Mahabharata on Indian values and culture – Storyline of Mahabharata – Study of leading characters in Mahabharata – Kurukshetra War and its significance - Relevance of Mahabharata for modern times.

Lessons from the Upanishads
Introduction to the Upanishads: Sruti versus Smrti - Overview of the four Vedas and the ten Principal Upanishads - The central problems of the Upanishads – The Upanishads and Indian Culture – Relevance of Upanishads for modern times – A few Upanishad Personalities: Nachiketas, Satyakama Jabala, Aruni, Shvetaketu.

Message of the Bhagavad Gita
Introduction to Bhagavad Gita – Brief storyline of Mahabharata - Context of Kurukshetra War – The anguish of Arjuna – Counsel by Sri. Krishna – Key teachings of the Bhagavad Gita – Karma Yoga, Jnana Yoga and Bhakti Yoga - Theory of Karma and Reincarnation – Concept of Dharma – Concept of Avatar - Relevance of Mahabharata for modern times.

Life and Message of Swami Vivekananda
Brief Sketch of Swami Vivekananda's Life – Meeting with Guru – Disciplining of Narendra - Travel across India - Inspiring Life incidents – Address at the Parliament of Religions – Travel in United States and Europe – Return and reception India – Message from Swamiji's life.

Life and Teachings of Spiritual Masters India
Sri Rama, Sri Krishna, Sri Buddha, Adi Shankaracharya, Sri Ramakrishna Paramahamsa,

Swami Vivekananda, Sri Ramana Maharshi, Mata Amritanandamayi Devi.

Insights into Indian Arts and Literature

The aim of this course is to present the rich literature and culture of Ancient India and help students appreciate their deep influence on Indian Life - Vedic culture, primary source of Indian Culture – Brief introduction and appreciation of a few of the art forms of India - Arts, Music, Dance, Theatre.

Yoga and Meditation

The objective of the course is to provide practical training in YOGA ASANAS with a sound theoretical base and theory classes on selected verses of Patanjali’s Yoga Sutra and Ashtanga Yoga. The coverage also includes the effect of yoga on integrated personality development.

Kerala Mural Art and Painting

Mural painting is an offshoot of the devotional tradition of Kerala. A mural is any piece of artwork painted or applied directly on a wall, ceiling or other large permanent surface. In the contemporary scenario Mural painting is not restricted to the permanent structures and are being done even on canvas. Kerala mural paintings are the frescos depicting mythology and legends, which are drawn on the walls of temples and churches in South India, principally in Kerala. Ancient temples, churches and places in Kerala, South India, display an abounding tradition of mural paintings mostly dating back between the 9th to 12th centuries when this form of art enjoyed Royal patronage. Learning Mural painting through the theory and practice workshop is the objective of this course.

Course on Organic Farming and Sustainability

Organic farming is emerging as an important segment of human sustainability and healthy life. Haritamritam’ is an attempt to empower the youth with basic skills in tradition of organic farming and to revive the culture of growing vegetables that one consumes, without using chemicals and pesticides. Growth of Agriculture through such positive initiatives will go a long way in nation development. In Amma’s words “it is a big step in restoring the lost harmony of nature“.

Benefits of Indian Medicinal Systems

Indian medicinal systems are one of the most ancient in the world. Even today society continues to derive enormous benefits from the wealth of knowledge in Ayurveda of which is recognised as a viable and sustainable medicinal tradition. This course will expose students to the fundamental principles and philosophy of Ayurveda and other Indian medicinal traditions.

Traditional Fine Arts of India

India is home to one of the most diverse Art forms world over. The underlying philosophy of Indian life is “Unity in Diversity” and it has led to the most diverse expressions of culture in India. Most art forms of India are an expression of devotion by the devotee towards the Lord and its influence in Indian life is very pervasive. This course will introduce students to the deeper philosophical basis of Indian Art forms and attempt to provide a practical demonstration of the continuing relevance of the Art.

Science of Worship in India

Indian mode of worship is unique among the world civilisations. Nowhere in the world has the philosophical idea of reverence and worshipfulness for everything in this universe found universal acceptance as it in India. Indian religious life even today is a practical demonstration of the potential for realisation of this profound truth. To see the all-pervading consciousness in everything, including animate and inanimate, and constituting society to realise this truth can be seen as the epitome of civilizational excellence. This course will discuss the principles and rationale behind different modes of worship prevalent in India.

Temple Mural Arts in Kerala

The traditional percussion ensembles in the Temples of Kerala have enthralled millions over the years. The splendour of our temples makes art enthusiast spellbound, warmth and grandeur of colour combination sumptuousness of the outline, crowding of space by divine or heroic figures often with in vigorous movement are the characteristics of murals.

The mural painting specially area visual counterpart of myth, legend, gods, dirties, and demons of the theatrical world, Identical myths are popular the birth of Rama, the story of Bhīma and Hanuman, Shiva, as Kirata, and the Jealousy of Uma and ganga the mural painting in Kerala appear to be closely related to, and influenced by this theatrical activity the art historians on temple planes, wood carving and painting the architectural plane of the Kerala temples are built largely on the pan-Indians almost universal model of the Vasthupurusha.

Organic Farming in Practice

Organic agriculture is the application of a set of cultural, biological, and mechanical practices that support the cycling of farm resources, promote ecological balance, and conserve biodiversity. These include maintaining and enhancing soil and water quality; conserving wetlands, woodlands, and wildlife; and avoiding use of synthetic fertilizers, sewage sludge, irradiation, and genetic engineering. This factsheet provides an overview of some common farming practices that ensure organic integrity and operation sustainability.

Ayurveda for Lifestyle Modification:

Ayurveda aims to integrate and balance the body, mind, and spirit which will ultimately leads to human happiness and health. Ayurveda offers methods for finding out early stages of diseases that are still undetectable by modern medical investigation. Ayurveda understands that health is a reflection of when a person is living in harmony with nature and disease arises when a person is out of harmony with the cycles of nature. All things in the universe (both living and non-living) are joined together in Ayurveda. This leaflet endow with some practical knowledge to rediscover our pre- industrial herbal heritage.

Life Style and Therapy using Yoga

Yoga therapy is the adaptation of yogic principles, methods, and techniques to specific human ailments. In its ideal application, Yoga therapy is preventive in nature, as is Yoga itself, but it is also restorative in many instances, palliative in others, and curative in many others. The therapeutic effect comes to force when we practice daily and the body starts removing toxins and the rest is done by nature.

Insights into Indian Classical Music

The course introduces the students into the various terminologies used in Indian musicology and their explanations, like Nadam, Sruti, Svaram – svara nomenclature, Stayi, Graha, Nyasa, Amsa, Thala,- Saptatalas and their angas, Shadangas, Vadi, Samavadi, Anuvadi. The course takes the students through Carnatic as well as Hindustani classical styles.

Insights into Traditional Indian Painting

The course introduces traditional Indian paintings in the light of ancient Indian wisdom in the fields of aesthetics, the Shadanga (Six limbs of Indian paintings) and the contextual stories from ancient texts from where the paintings originated. The course introduces the painting styles such as Madhubani, Kerala Mural, Pahari, Cheriyal, Rajput, Tanjore etc.

Insights into Indian Classical Dance

The course takes the students through the ancient Indian text on aesthetics the Natyasastra and its commentary the AbhinavaBharati. The course introduces various styles of Indian classical dance such as Bharatanatyan, Mohiniyatton, Kuchipudi, Odissy, Katak etc. The course takes the students through both contextual theory as well as practice time.

Indian Martial Arts and Self Defense

The course introduces the students to the ancient Indian system of self-defense and the combat through various martial art forms and focuses more on traditional Kerala's traditional Kalari Payattu. The course introduces the various exercise technique to make the body supple and flexible before going into the steps and techniques of the martial art. The advanced level of this course introduces the technique of weaponry.

Social Awareness Campaign

The course introduces the students into the concept of public social awareness and how to transmit the messages of social awareness through various media, both traditional and modern. The course goes through the theoretical aspects of campaign planning and execution.

Temple Mural Arts in Kerala

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conserving wetlands, woodlands, and wildlife; and avoiding use of synthetic fertilizers, sewage sludge, irradiation, and genetic engineering. This factsheet provides an overview of some common farming practices that ensure organic integrity and operation sustainability.

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Life Style and Therapy using Yoga
Yoga therapy is the adaptation of yogic principles, methods, and techniques to specific human ailments. In its ideal application, Yoga therapy is preventive in nature, as is Yoga itself, but it is also restorative in many instances, palliative in others, and curative in many others. The therapeutic effect comes to force when we practice daily and the body starts removing toxins and the rest is done by nature.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18CUL101 CULTURAL EDUCATION I 2 0 0 2

Description
The student will be introduced to the foundational concepts of Indian culture and heritage.

Course Outcomes: After the completion of the course the student will be able to

CO1: Gain a positive appreciation of Indian culture, traditions, customs and practices

CO2: Understand the foundational concepts of Indian civilization like purusharthas, law of karma, etc, which contributes towards personality growth.

CO3: Understand the cultural ethos of Amrita Vishwa Vidyapeetham, and Amma's life and vision of holistic education

CO4: Imbibe spirit of living in harmony with nature

CO5: Get guidelines for healthy and happy living from the great spiritual masters.

Unit 1
Introduction to Indian Culture - Introduction to Amma's life and Teachings - Symbols of Indian Culture.
Unit 2
Science and Technology in Ancient India - Education in Ancient India - Goals of Life – Purusharthas - Introduction to Vedanta and Bhagavad Gita.
Unit 3
Introduction to Yoga - Nature and Indian Culture - Values from Indian History - Life and work of Great Seers of India.

TEXTBOOKS:
1. The Glory of India (in-house publication)
2. The Mother of Sweet Bliss, (Amma's Life & Teachings)

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18CUL111 CULTURAL EDUCATION II 2 0 0 2

Description
The students will be able to deepen their understanding and further their knowledge about the different aspects of Indian culture and heritage.

Course Outcomes: After the completion of the course the student will be able to

CO1: Get an overview of India and her contribution to the world in the field of science and literature

CO2: Understand the foundational concepts of ancient Indian education system and practices associated with them

CO3: Learn the important concepts of Vedas, Bhagavad-Gita and Yogasutras and their relevance to daily life

CO4: Familiarize themselves with the inspirational characters and anecdotes from the epics and Indian history

CO5: Gain a rational understanding of the underlying principles of Indian spirituality.

Contents
Unit 1
1. Relevance of Sri Rama and Sri Krishna in this Scientific Age
2. Lessons from the Epics of India
3. Ramayana & Mahabharata

Unit 2
4. Who is a Wise Man?
5. A Ruler's Dharma
6. The Story of King Shibi

Unit 3
7. Introduction to the Bhagavad Gita
8. Bhagavad Gita – Action without Desire

Unit 4
9. Role and Position of Women in India
10. The Awakening of Universal Motherhood

Unit 5

11. Patanjali'sA stanga - Yoga System for Personality Refinement
12. Examples of Heroism and Patriotism in Modern India

TEXTBOOKS:
Common Resource Material II (in-house publication)
Sanatana Dharma - The Eternal Truth (A compilation of Amma's teachings on Indian Culture)

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

Language Courses

18ENG101	**Communicative English**	**2-0-2-3**

Objectives:

To help students obtain an ability to communicate fluently in English; to enable and enhance the students skills in reading, writing, listening and speaking; to impart an aesthetic sense and enhance creativity. By the end of the course, the students will be able to:

CO1 – Demonstrate competency in all the four linguistic skills, viz. listening, speaking, reading and writing.

CO2 – Apply different styles of communication in professional context.

CO3 – Participate in different planned & extempore communicative activities.

CO4 - Interpret and discuss facts and information in a given context.

CO5 - Develop an appreciation for human values.

Course Contents:

Unit I

Kinds of sentences, usage of preposition, use of adjectives, adverbs for description, Tenses, Determiners- Agreement (Subject – Verb, Pronoun- Antecedent) collocation, Phrasal Verbs, Modifiers, Linkers/ Discourse Markers, Question Tags

Unit II

Paragraph writing – Cohesion - Development: definition, comparison, classification, contrast, cause and effect - Essay writing: Descriptive and Narrative

Unit III

Letter Writing - Personal (congratulation, invitation, felicitation, gratitude, condolence etc.) Official (Principal / Head of the department/ College authorities, Bank Manager, Editors of newspapers and magazines)

Unit IV

Reading Comprehension – Skimming and scanning- inference and deduction – Reading different kinds of material –Speaking**:** Narration of incidents / stories/ anecdotes- Current News Awareness

Unit V

Prose: John Halt's 'Three Kinds of Discipline' [**Detailed**]
Max Beerbohm's 'The Golden Drugget' [**Detailed**]
Poems: Ogden Nash- 'This is Going to Hurt Just a Little Bit' [**Detailed**]
Robert Kroetsch– 'I am Getting Old Now', Langston Hughes- 'I, Too' [**Detailed**]

Wole Soyinka- 'Telephone Conversation' [**Non- Detailed**]
Kamala Das- 'The Dance of the Eunuchs' [**Non-Detailed**]
Short Stories: Edgar Allan Poe's 'The Black Cat', Ruskin Bond's 'The Time Stops at Shamili' [**Non- Detailed**]

CORE READING:

1. Ruskin Bond, Time Stops at Shamli and Other Stories, Penguin Books India Pvt Ltd, 1989
2. Syamala, V. Speak English in Four Easy Steps, Improve English Foundation Trivandrum: 2006
3. Beerbohm, Max, The Prince of Minor Writers: The Selected Essays of Max Beerbohm (NYRB Classics), Phillip Lopate (Introduction, Editor), The New York Review of Book Publishers.
4. Edger Allan Poe. The Selected Works of Edger Allan Poe. A Running Press, 2014.
5. Online sources

References:

1. Ruskin Bond, Time Stops at Shamli and Other Stories, Penguin Books India Pvt Ltd, 1989
2. Martinet, Thomson, A Practical English Grammar, IV Ed. OUP, 1986.
3. Murphy, Raymond, Murphy's English Grammar, CUP, 2004
4. Online sources

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18ENG121	**Professional Communication**	**1- 0-2-2**

Objectives:

To convey and document information in a formal environment; to acquire the skill of self-projection in professional circles; to inculcate critical and analytical thinking. By the end of the course, the students will be able to:

CO1 – Demonstrate competency in oral and written communication.

CO2 – Apply different styles of communication in professional context.

CO3 – Participate in different planned & extempore communicative activities

CO4 – Interpret and discuss facts and information in a given context

CO5 – Develop critical and analytical thinking.

Unit I

Vocabulary Building: Prefixes and Suffixes; One word substitutes, Modal auxiliaries, Error Analysis: Position of Adverbs, Redundancy, misplaced modifiers**,** Dangling modifiers – Reported Speech.

Unit II

Instruction, Suggestion & Recommendation - Sounds of English: Stress, Intonation - Essay writing: Analytical and Argumentative

Unit III

Circulars, Memos – Business Letters - e – mails

Unit IV
Reports: Trip report, incident report, event report - Situational Dialogue - Group Discussion
Unit V
Listening and Reading Practice - Book Review
References

1. FelixaEskey. Tech Talk, University of Michigan. 2005
2. Michael Swan. Practical English Usage, Oxford University Press. 2005
3. Anderson, Paul. Technical Communication: A Reader Centered Approach, V Edition, Hercourt, 2003.
4. Raymond V. Lesikar and Marie E. Flatley. Basic Business Communication, Tata Mc Graw Hill Pub. Co. New Delhi. 2005. Tenth Edition.
5. Thampi, G. Balamohan. Meeting the World: Writings on Contemporary Issues. Pearson, 2013.
6. Lynch, Tony. Study Listening. New Delhi: CUP, 2008.
7. Kenneth, Anderson, Tony Lynch, Joan Mac Lean. Study Speaking. New Delhi: CUP, 2008.
8. Marks, Jonathan. English Pronunciation in Use. New Delhi: CUP, 2007.
9. Syamala, V. Effective English Communication For You (Functional Grammar, Oral and Written Communication): Emerald, 2002.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18HIN101	HINDI I	1-0-2 [2cr]

Objectives:
To teach Hindi for effective communication in different spheres of life:- Social context , Education, Research & Media.
Course Outcomes: By the end of the course, the students will be able to:

CO1 – To understand the nature & culture of the language

CO2 – Ability to understand the structure of the language in different context.

CO3 – To understand the functional skills of the language

CO4 - Enhance the social contribution of modern literature

CO5 - Develop research and secondary reading ability

Unit-1
a) Introduction to Hindi Language, -other Indian Language's, Official Language, link Language Technical terminology..
b) Hindi alphabet: ParibhashaAurBhed.
c) Shabda: ParibhashaAurBhed, RoopantharkiDrishti se
d) Sangya -ParibhashaAurBhed,SangyakeRoopanthar-ling, vachan, karak
e) Sarvanaam- ParibhashaAurBhed.

Unit-2
a) Common errors and error corrections in Parts of Speech –with emphasis on use of pronouns, Adjective and verb in different tenses –gender& number
b) Conversations, Interviews, Short speeches.

Unit -3
a) Letter writing –ParibhashaAurBhed, Avedanpatra (request letter) & Practice
b) Translation-ParibhashaAurBhed, English to Hindi

Unit- 4
Peom :
a) Maithilisharangupth: sakhivemujsekahakarjaate
b) Suryakanthtripatinirala :Priyatam
c) Mahadevivarma- adhikaar
d) Shiyaramsharangupth:ekphoolkichah
e)Anamika:'Bejagah'
Unit- 5
Kahani
a) Kafan - Premchand ,
b) Rajasthan ki Ek Gaav kee theerthyatra - Beeshmasahni
c) Raychandrabhai :By Mahathma Gandhi - Sathya ke prayog
d) Rajani - Mannu Bhandari

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18HIN111	**HINDI II**	**1-0-2[2cr]**

Objectives:
Appreciation and assimilation of Hindi Literature through Oral & visual technique.
By the end of the course, the students will be able to:

CO1 – Develop the creativity & language competence.

CO2 – To improve the writing and analytical skills

CO3 –Enhancing critical thinking.

CO4 –A good exposure with the different styles of literary writing.

CO5 – To understand the post-modern trends of literature.

Unit -1
a) Visheshan- ParibhashaAurBhed.special usage of adverbs, changing voice and conjunctions in sentences.
b) kriya- ParibhashaAurBhed, rupantharkidrushti se-kaal
c) padhparichay.
d) Vigyapan Lekhan (Advertisement writing), Saar Lekhan (Precise writing).

Unit -2
Communicative Hindi – MoukhikAbhivyakthi –understanding proper pronunciation, Haptics …etc in Interviews ,short speeches .

Unit -3
Film review,Audio –Visual-Media in Hindi – Movies appreciation and evaluation.News

reading and presentations in Radio and Tv channels in Hindi, samvaadhlekhan,

Unit -4

a) Harishankarparasaiyi- SadacharkaThavis
b) Jayashankarprasadh – Mamata
c) Mannubandari- Akeli
d) Habibtanvir- Karthus

Unit -5

Kavya Tarang

a) Himadri thung shrung se (poet- Jayasankar prasad)
b) Dhabba (poet- kedarnath sing) ,
c) Proxy (poet- Venugopal),
d) Machis(poet –Suneeta Jain) ,
e) Vakth. (poet – Arun kamal)
f) Fasal (poet- Sarveshwar Dayal Saxena)

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18KAN101 KANNADA I 1-0-2[2cr]

CO-1: To enable the students to acquire basic skills in functional language.
CO-2: To develop independent reading skills and reading for appreciating literary works.
CO-3: To analyse language in context to gain an understanding of vocabulary, spelling, punctuation and speech

UNIT – 1

- Railway Nildanadalli – K. S. Narasimha Swamy
- Amma, Aachara Mattu Naanu – K. S. Nisar Ahamad
- Kerege Haara – Janapada
- Simhaavalokana – H.S. Shivaprakash

UNIT – 2

- Dhanwantri Chikitse - Kuvempu
- Mouni - Sethuram
- Meenakshi Maneya Mestru - Kuvempu

UNIT – 3

- Sukha –H.G Sannaguddayya
- Mobile Thenkara Jen Nonagala Jhenkara – Nagesh Hegade
- Namma Yemmege Maatu Tiliyitu – Goruru Ramaswamy Iyangar

UNIT – 4

Language structure

- Usage of punctuation marks
- Introduction to words (right usage)

- Reading skills
- Sentence formation (simple & complex)
- Translation- English to Kannada

References:

1. Kannada Samskruti Kosha – Dr. Chi. C Linganna
2. Kannada Sanna Kathegalu – G H Nayak
3. Lekhana Kale – N. Prahlad Rao
4. Kannada Sahithya Charithre – R. Sri Mugali

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18KAN111	KANNADA II	1-0-2[2cr]

Course Outcomes:

CO-1: To enable the students to acquire basic skills in functional language.
CO-2: To develop independent reading skills and reading for appreciating literary works.
CO-3: To develop functional and creative skills in language.
CO-4: To enable the students to plan, draft, edit & present a piece of writing.

UNIT – 1

- Bettada Melondu Maneya Maadi – Akka Mahadevi
- Thallanisadiru Kandya – Kanakadasa
- Avva – P. Lankesh
- Neevallave – K. S. Narasimha Swamy

UNIT – 2

Gunamukha – Drama by P. Lankesh

UNIT – 3

Karvalo – Novel by Poornachandra Thejaswi

UNIT – 4

Letter Writing –

Personal (congratulation, invitation, condolence etc.)

- Official (To Principal, Officials of various departments, etc.,)
- Report writing
- Essay writing
- Precise writing

Prescribed text:

1. Gunamukha by P. Lankesh (Lankesh Prakashana)
2. Karvalo by Poornachandra Thejaswi (Mehtha publishing house)

Reference

1. Saamanyanige Sahithya Charitre (chapter 1 to 10) – Bangalore University Publication
2. Hosa Kannada Saahithya Charithre – L.S Sheshagiri Rao
3. Kacheri Kaipidi – Kannada Adhyayana Samsthe (Mysuru University)

4. Kannada Sahithya Charithre – R. Sri Mugali
5. H.S.Krishna Swami Iyangar – *Adalitha Kannada – Chetana Publication, Mysuru*

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18MAL101 Malayalam I

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

CO1 – Inculcate philosophical thoughts and practice.

CO2 – To understand the post modern trends of literature.

CO3 –To understand the literary cultural era of a particular region

CO4 – Familiarise with the Malayalam literary maestro.

CO5 –Expansion of ideas in writing.

Unit 1

Ancient poet trio:*Adhyatmaramayanam*,*LakshmanaSwanthanam (Lines: valsasoumitre… mungikidakayal),*Ezhuthachan -Medieval period classics – *Jnanappana(Lines:201 to 298*),Poonthanam.

Unit 2

Modern Poet trio: *EnteGurunathan,* VallatholNarayanaMenon- Critical analysis of the poem.

Unit 3

Short stories from period 1/2/3:*Poovanpazham*-VaikaomMuhammedBasheer-Literary & Cultural figures of Kerala and about their literary contributions.

Unit 4

Literary Criticism: *BharathaParyadanam-VyasanteChiri*–Ithihasa studies-KuttikrishnaMararu-Outline of literary Criticism in Malayalam Literature-Introduction to KuttikrishnaMararu& his outlook towards literature &life.

Unit 5

Error-freeMalayalam: **1**.Language; **2**.Clarity of expression; **3**.Punctuation-Thettillatha Malayalam – Writing-**a**. Expansion of ideas; **b**.PrecisWriting; **c**. Essay Writing; **d**.Letter writing; **e**.RadioSpeech;**f**.Script/Feature/Script Writing;**g**.NewsEditing;**h**.Advertising;**i.**Editing;j.EditorialWriting;**k**.Critical appreciation of literary works (Any one or two as an assignment).

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18MAL111 Malayalam II (102 2)

Course Outcomes: After successful completion of the course, the students will be able to:

CO1 – To understand the different cultural influence of linguistic translation.

CO2 – To identify the romantic elements of modern literature.

CO3 –To analyse the autobiographical aspects.

CO4 – To create awareness of the historical,political and socio cultural aspects of literature.

CO5 –Expansion of ideas in writing.

Unit1

Ancient poet trio: *Kalayanasougandhikam,(Lines: kallum marangalum… namukkennarika vrikodara),*KunjanNambiar - Critical analysis of his poetry-Ancient Drama: *Kerala Sakunthalam* (Act 1), Kalidasan (Translated by Attor Krishna Pisharody).

Unit 2

Modern/romantic/contemporary poetry: *Chandanakkattil* –G.Sankara kurupu-Romanticism – modernism.

Unit 3

Memoirs from Modern Poets: *Theeppathi*, Balachandran Chullikkadu-literary contributions of his time.

Unit 4

Partof an autobiography/travelogue: *Kannerum Kinavum*, Chapter: Valarnnu Varunnoratmavu, V.T.Bhattathirippadu-Socio-cultural literature-historical importance.

Unit 5

Error-free Malayalam-**1**.Language; **2**.Clarity of expression; **3**.Punctuation-Thettillatha Malayalam-Writing-**a**.Expansion of ideas;**b**.PrécisWriting;**c.** Essay Writing; **d**.Letter writing;**e**.RadioSpeech;**f**.Script/Feature/ScriptWriting;**g**.NewsEditing;**h.**Advertising;**i**.Editing ; **j**.Editorial Writing;**k**.Critical appreciation of literary works (Any one or two as an assignment).

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18SAN101	**SANSKRIT I**	**1-0-2[2cr]**

CO-1: To familiarize students with Sanskrit language and literature.
CO-2: To read and understand Sanskrit verses and sentences.
CO-3: Self-study of Sanskrit texts and to practice communication in Sanskrit.
CO-4: To help the students imbibe values of life and Indian traditions propounded by the scriptures.
CO-5: To be able to speak in Sanskrit.

Module I

Introduction to Sanskrit language, Devanagari script - Vowels and consonants, pronunciation, classification of consonants, conjunct consonants, words – nouns and verbs, cases – introduction, numbers, Pronouns, communicating time in Sanskrit. Practical classes in spoken Sanskrit. (7 hours)

Module II

Verbs- Singular, Dual and plural — First person, Second person, Third person.
Tenses – Past, Present and future – Atmanepadi and parasmaipadi-karthariprayoga. (8hrs)

Module III

Words for communication and moral stories. (4 hrs)

Module IV

Chanakya Neethi first chapter (first 15 Shlokas) (6 hrs)

Module V

Translation of simple sentences from Sanskrit to English and vice versa.(5hs)

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18SAN111	**SANSKRIT II**	**1-0-2[2cr]**

Course Outcomes:

CO-1: To familiarize students with Sanskrit language and literature.

CO-2: To read and understand Sanskrit verses and sentences.

CO-3: Self-study of Sanskrit texts and to practice communication in Sanskrit.

CO-4: To help the students imbibe values of life and Indian traditions propounded by the scriptures.

CO-5: To be able to speak in Sanskrit.

Module I

Seven cases, Avyayas, sentence making with Avyayas, Saptha kakaras. **(5hrs)**

Module II

Kthavathu' Prathyayam, Upasargas, Kthvatha,Thumunnantha, Lyabantha Prathyayam. Three Lakaras – brief introduction, Lot lakara **(5hrs)**

Module III

New words and sentences for the communication, Slokas, moral stories(panchathanthra) Subhashithas, riddles (Selected from the Pravesha Book) **(5hrs)**

Module IV

Introduction to classical literature, classification of Kavyas, classification of Dramas - Important five Maha kavyas **(5hrs)**

Module V

Translation of paragraphs from Sanskrit to English and wise -verse **(5hrs)**

Module VI

Bhagavad - Geeta fourteenth chapter (all 27 Shlokas) **(5hrs)**

Essential Reading:

1, Praveshaha; Publisher : Samskrita bharati, Aksharam, 8th cross, 2nd phase, girinagar, Bangalore -560 085
2, Sanskrit Reader I, II and III, R.S. Vadhyar and Sons, Kalpathi, Palakkad
3, PrakriyaBhashyamwritten and published by Fr. John Kunnappally
4, Sanskrit Primer by Edward Delavan Perry, published by Ginn and Company Boston
5, Sabdamanjari, R.S. Vadyar and Sons, Kalpathi, Palakkad
6, Namalinganusasanam by Amarasimha published by Travancore Sanskrit series
7, SubhashitaRatnaBhandakara by Kashinath Sharma, published by Nirnayasagarpress

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

Environmental Studies

18ENV300 ENVIRONMENTAL SCIENCE AND SUSTAINABILITY 3 0 0 3

Course outcomes:

CO1: Integrate facts and concepts from ecological, physical and social sciences to characterize some common socio-environmental problems.

CO2: Develop simple integrated systems and frameworks for solving common interconnected socio-environmental problems.

CO3: Reflect critically about their roles and identities as citizens, consumers and environmental actors in a complex, interconnected world.

CO4: Identify the ethical underpinnings of socio-environmental issues in general.

Unit 1

State of Environment and Unsustainability, Need for Sustainable Development, Traditional conservation systems in India, People in Environment, Need for an attitudinal change and ethics, Need for Environmental Education, Overview of International Treaties and Conventions, Overview of Legal and Regulatory
Frameworks.

Environment: Abiotic and biotic factors, Segments of the Environment, Biogeochemical Cycles, Ecosystems (associations, community adaptations, ecological succession, Food webs, Food chain, ecological pyramids), Types of Ecosystems – Terrestrial ecosystems, Ecosystem Services, Economic value of ecosystem services, Threats to ecosystems and conservation strategies.

Biodiversity: Species, Genetic & Ecosystem Diversity, Origin of life and significance of biodiversity, Value of Biodiversity, Biodiversity at Global, National and Local Levels, India as a Mega-Diversity Nation (Hotspots) & Protected Area Network, Community Biodiversity Registers. Threats to Biodiversity, Red Data book, Rare, Endangered and Endemic Species of India. Conservation of Biodiversity. People's action. Impacts, causes, effects, control measures, international, legal and regulatory frameworks of: Climate Change, Ozone depletion, Air pollution, Water pollution, Noise pollution, Soil/ land degradation/ pollution

Unit 2

Linear vs. cyclical resource management systems, need for systems thinking and design of cyclical systems, circular economy, industrial ecology, green technology. Specifically apply these concepts to: Water Resources, Energy Resources, Food Resources, Land & Forests, Waste management.

Discuss the interrelation of environmental issues with social issues such as: Population, Illiteracy, Poverty, Gender equality, Class discrimination, Social impacts of development on the poor and tribal communities, Conservation movements: people's movements and activism, Indigenous knowledge systems and traditions of conservation.

Unit 3

Common goods and public goods, natural capital/ tragedy of commons, Cost benefit analysis of development projects, Environment Impact Assessment (EIA), Environment Management Plan (EMP), Green business, Eco-labelling, Problems and solutions with case studies.

Global and national state of housing and shelter, Urbanization, Effects of unplanned development case studies, Impacts of the building and road construction industry on the environment, Eco-homes/ Green buildings, Sustainable communities, Sustainable Cities.

Ethical issues related to resource consumption, Intergenerational ethics, Need for investigation and resolution of the root cause of unsustainability, Traditional value systems of India, Significance of holistic value-based education for true sustainability.

TEXTBOOKS/ REFERENCES:
1. R. Rajagopalan, Environmental Studies: From Crisis to Cure. Oxford University Press, 2011, 358 pages. ISBN: 9780198072089.
2. Daniel D. Chiras, Environmental Science. Jones & Bartlett Publishers, 01-Feb-2012, 669 pages. ISBN: 9781449645311.
3. Andy Jones, Michel Pimbert and Janice Jiggins, 2011. Virtuous Circles: Values, Systems, Sustainability. IIED and IUCN CEESP, London. URL:http://pubs.iied.org/pdfs/G03177.pdf
4. Annenberg Learner, The Habitable Planet, Annenberg Foundation 2015.
URL: http://www.learner.org/courses/envsci/unit/pdfs/textbook.pdf.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

Life Skills

18SSK201	**LIFE SKILLS I**	**1 0 2 2**

Course Outcomes: After successful completion of the course, students

CO1: will have develop self-confidence and positive attitude necessary to compete and challenge themselves, analyse and manage their emotions to face real life situations (Soft Skill)

CO2: will have honed their presentation skills by understanding the nuances of content creation, effective delivery, use of appropriate body language and the art of overcoming nervousness to create an impact in the minds of a target audience. (Soft Skill)

CO3: will have acquired the ability to analyse, understand and classify questions under arithmetic, algebra and logical reasoning and solve them employing the most suitable methods; will be able to analyse, compare and arrive at conclusions for data analysis questions. (Aptitude)

CO4: will have the ability to dissect polysyllabic words, infer the meaning, inspect, classify, contextualise and use them effectively (Verbal).

CO5: will have the ability to understand the nuances of English grammar and apply them effectively (Verbal).

CO6: will have the ability to identify, analyse and interpret relationship between words and use the process of elimination to arrive at the answer (Verbal).

Contents:

Soft skills and its importance: Pleasure and pains of transition from an academic environment to work-environment. Need for change. Fears, stress and competition in the professional world. Importance of positive attitude, self-motivation and continuous knowledge upgradation.

Self Confidence: Characteristics of the person perceived, characteristics of the situation, Characteristics of the Perceiver. Attitude, Values, Motivation, Emotion Management, Steps to like yourself, Positive Mental Attitude, Assertiveness.

Presentations: Preparations, Outlining, Hints for efficient practice, Last minute tasks, means of effective presentation, language, Gestures, Posture, Facial expressions, Professional attire.

Vocabulary building: A brief introduction into the methods and practices of learning vocabulary. Learning how to face questions on antonyms, synonyms, spelling error, analogy etc. Faulty comparison, wrong form of words and confused words like understanding the nuances of spelling changes and wrong use of words.

Listening Skills: The importance of listening in communication and how to listen actively.

Prepositions and Articles: A experiential method of learning the uses of articles and prepositions in sentences is provided.

Problem solving; Number System; LCM &HCF; Divisibility Test; Surds and Indices; Logarithms; Ratio, Proportions and Variations; Partnership; Time speed and distance; work time problems;

Data Interpretation: Numerical Data Tables; Line Graphs; Bar Charts and Pie charts; Caselet Forms; Mix Diagrams; Geometrical Diagrams and other forms of Data Representation.

Logical Reasoning: Family Tree; Linear Arrangements; Circular and Complex Arrangement; Conditionalities and Grouping; Sequencing and Scheduling; Selections; Networks; Codes; Cubes; Venn Diagram in Logical Reasoning.

TEXTBOOKS:

1. A Communicative Grammar of English: Geoffrey Leech and Jan Svartvik. Longman, London.
2. Adair J (1986) - "Effective Team Building: How to make a winning team", London, U.K: Pan Books.
3. Gulati S (2006) - "Corporate Soft Skills", New Delhi, India: Rupa& Co.
4. The Hard Truth about Soft Skills, by Amazone Publication.

REFERENCES:

1. Quantitative Aptitude, by R S Aggarwal, S Chand Publ.
2. Verbal and Non-verbal Reasoning, R S Aggarwal, S Chand Publ.
3. Data Interpretation, R S Aggarwal, S Chand Publ.
5. Nova GRE, KAPAL GRE, Barrons GRE books;
2. Quantitative Aptitude, The Institute of Chartered Accountants of India.
3. More Games Teams Play, by Leslie Bendaly, McGraw-Hill Ryerson.
4. The BBC and British Council online resources
5. Owl Purdue University online teaching resources
6. www.thegrammarbook.com online teaching resources
7. www.englishpage.com online teaching resources and other useful websites.

Skills: Recognizing transition from an academic environment to work-environment, in class hands on practice sessions, tutorials, help development of self confidence, skills of giving presentations, expanding listening and comminication skills, problem solving, data interpretation, and logical reasoning. Employability: Any work environment.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18SSK211	**LIFE SKILLS II**	**1 0 2 2**

Course Outcomes: After successful completion of the course, students will be able to

1) communicate convincingly and negotiate diplomatically while working in a team to arrive at a win-win situation, would further develop their inter-personal and leadership skills (Soft Skill).

2) examine the context of a Group Discussion topic and develop new perspectives and ideas through brainstorming and arrive at a consensus (Soft Skills).
3) identify, recall and arrive at appropriate strategies to solve questions on geometry; will be able to investigate, interpret and select suitable methods to solve questions on arithmetic, probability and combinatorics (Aptitude).
4) relate, choose, conclude and determine the usage of right vocabulary (Verbal).
5) utilise prior knowledge of grammar to recognise structural instabilities and modify them (Verbal).
6) comprehend, interpret, deduce and logically categorise words, phrases and sentences; will also have the ability to theorise, discuss, elaborate, criticise and defend their ideas (Verbal).

Contents:
Professional Grooming and Practices: Basics of Corporate culture, Key pillars of Business Etiquette. Basics of Etiquette: Etiquette – Socially acceptable ways of behaviour, Personal hygiene, Professional attire, Cultural Adaptability. Introductions and Greetings: Rules of the handshake, Earning respect, Business manners. Telephone Etiquette: activities during the conversation, Conclude the call, To take a message. Body Language: Components, Undesirable body language, Desirable body language. Adapting to Corporate life: Dealing with people.

Group Discussions: Advantages of Group Discussions, Structured GD – Roles, Negative roles to be avoided, Personality traits to do well in a GD, Initiation techniques, How to perform in a group discussion, Summarization techniques.

Listening Comprehension advanced: Exercise on improving listening skills, Grammar basics: Topics like clauses, punctuation, capitalization, number agreement, pronouns, tenses etc.

Reading Comprehension advanced: A course on how to approach middle level reading comprehension passages.

Problem solving – Money Related problems; Mixtures; Symbol Based problems; Clocks and Calendars; Simple, Linear, Quadratic and Polynomial Equations; Special Equations; Inequalities; Functions and Graphs; Sequence and Series; Set Theory; Permutations and Combinations; Probability; Statistics.

Data Sufficiency: Concepts and Problem Solving.

Non-Verbal Reasoning and Simple Engineering Aptitude: Mirror Image; Water Image; Paper Folding; Paper Cutting; Grouping Of Figures; Figure Formation and Analysis; Completion of Incomplete Pattern; Figure Matrix; Miscellaneous.

Special Aptitude: Cloth, Leather, 2D and 3D Objects, Coin, Match Sticks, Stubs, Chalk, Chess Board, Land and geodesic problems etc., Related Problems

TEXTBOOKS:
1. A Communicative Grammar of English: Geoffrey Leech and Jan Svartvik. Longman, London.
2. Adair J (1986) - "Effective Team Building: How to make a winning team", London, U.K: Pan Books.
3. Gulati S (2006) - "Corporate Soft Skills", New Delhi, India: Rupa& Co.
4. The Hard Truth about Soft Skills, by Amazone Publication.

REFERENCES:

1. Quantitative Aptitude, by R S Aggarwal, S Chand Publ.
2. Verbal and Non-verbal Reasoning, R S Aggarwal, S Chand Publ.
3. Quantitative Aptitude by AbjithGuha, Tata McGraw hill Publ.
5. More Games Teams Play, by Leslie Bendaly, McGraw-Hill Ryerson.
6. The BBC and British Council online resources
7. Owl Purdue University online teaching resources
8. www.thegrammarbook.com online teaching resources
9. www.englishpage.com online teaching resources and other useful websites.

Skills: In class hands on practice sessions and tutorials help development of Professional Grooming and Practices, group discussions, advanced reading, listening and comprehension, non-verbal reasoning and engineering aptitute, and problem solving skills.

Employability: Any work environment.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18SSK301	**LIFE SKILLS III**	**(1 0 2 2)**

Course Outcomes: After successful completion of the course, students will be able to

1) prepare a suitable resume (including video resume), present themselves confidently, introduce themselves and face interviews in a sure-footed manner (Soft Skills).
2) analyse every question asked by the interviewer, compose correct responses and respond in the right manner to justify and convince the interviewer of one's right candidature through displaying etiquette, positive attitude and courteous communication (Soft Skills).
3) interpret, critically analyse and solve logical reasoning questions; manage time while applying methods to solve questions on arithmetic, algebra, logical reasoning, and statistics and data analysis and arrive at appropriate conclusions (Aptitude).
4) understand and use words, idioms and phrases, interpret the meaning of standard expressions and compose sentences using the same (Verbal).
5) decide, conclude, identify and choose the right grammatical construction (Verbal)..
6) examine, interpret and investigate arguments, use inductive and deductive reasoning to support, defend, prove or disprove them; create, generate and relate facts / ideas / opinions and share / express the same convincingly to the audience / recipient using their communication skills in English (Verbal).

Contents:

Team Work: value of team work in organisations, definition of a team, why team, elements of leadership, disadvantages of a team, stages of team formation. group development activities: orientation, internal problem solving, growth and productivity, evaluation and control. effective team building: basics of team building, teamwork parameters, roles, empowerment, communication, effective team working, team effectiveness criteria, common characteristics of effective teams, factors affecting team effectiveness, personal characteristics of members, team structure, team process, team outcomes.

Facing an Interview: foundation in core subject, industry orientation/knowledge about the company, professional personality, communication skills, activities before interview, upon entering interview room, during the interview and at the end; mock interviews.

Advanced Grammar: Topics like parallel construction, dangling modifiers, active and passive voices, etc.

Syllogisms, Critical reasoning: a course on verbal reasoning. listening comprehension advanced: an exercise on improving listening skills.

Reading Comprehension advanced: A course on how to approach advanced level of reading, comprehension passages. Exercises on competitive exam questions.

Specific Training: solving campus recruitment papers, national level and state level competitive examination papers; speed mathematics; tackling aptitude problems asked in interview; techniques to remember (in mathematics). lateral thinking problems. quick checking of answers techniques; techniques on elimination of options, estimating and predicting correct answer; time management in aptitude tests; test taking strategies.

TEXTBOOKS:

1. A Communicative Grammar of English: Geoffrey Leech and Jan Svartvik. Longman, London.
2. Adair J (1986) - "Effective Team Building: How to make a winning team", London, U.K: Pan Books.
3. Gulati S (2006) - "Corporate Soft Skills", New Delhi, India: Rupa & Co.
4. The Hard Truth about Soft Skills, by Amazon Publication.

REFERENCES:

1. Speed Mathematics, Secrets of Lightning Mental Calculations, by Bill Handley, Master Mind books;
2. The Trachtenberg Speed System of Basic Mathematics, Rupa & Co., Publishers;
3. Vedic Mathematics, by Jagadguru Swami Sri Bharati Krsna Tirthayi Maharaja, Motilal Banarsidass Publ.;
4. How to Ace the Brainteaser Interview, by John Kador, Mc Graw Hill Publishers.
5. Quick Arithmetics, by Ashish Agarwal, S Chand Publ.;
6. Quicker Maths, by M tyra & K Kundan, BSC Publishing Co. Pvt. Ltd., Delhi;
7. More Games Teams Play, by Leslie Bendaly, McGraw-Hill Ryerson.
8. The BBC and British Council online resources
9. Owl Purdue University online teaching resources
10. www.the grammarbook.com online teaching resources
11. www.englishpage.com online teaching resources and other useful websites.

Skills: In class hands on practice sessions and tutorials help development of aptitude of team work spirit, facing interviews, advanced reading, listening and language skills, specific training involving solving campus recruitment papers for preparedness.

Employability: Preparedness for any future employment.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

Chemistry Courses

18CHY103	**CHEMISTRY I**	**(3 0 0 3)**

Course Outcomes:

CO-1 Gain an understanding and describe basic aspects of various chemical bonding.

CO-2 Gain an understanding of basics of thermochemistry and apply to solve problems in chemical reactions, apply them solve problems.

CO-3 Gain an understanding of concepts of chemical kinetics, reaction rates, to explain the rates of certain reactions and how to control their rates, apply them to solve problems.

CO-4 Gain an understanding of mechanisms in electrochemical reactions, electrolytes, associated fundamentals and theories and apply them solve problems.

CO-5 Gain an understanding of law of photochemistry and apply them to explain photochemical processes, including fluorescence, phosphorescence, chemiluminescence.

Unit 1 Chemical Bonding

Review of orbital concept and electronic configuration, electrovalency and ionic bond formation, ionic compounds and their properties, lattice energy, solvation enthalpy and solubility of ionic compounds, covalent bond, covalency, orbital theory of covalency - sigma and pi bonds - formation of covalent compounds and their properties Hybridization and geometry of covalent molecules - VSEPR theory - polar and non-polar covalent bonds, polarization of covalent bond - polarizing power, polarisability of ions and Fajan’s rule, dipole moment, percentage ionic character from dipole moment, dipole moment and structure of molecules -, co-ordinate covalent compounds and their characteristics, molecular orbital theory for H_2, N_2, O_2 and CO, metallic bond - free electron, valence bond and band theories, weak chemical bonds – inter and intra molecular hydrogen bond - van der Waals forces.

Unit 2 Thermodynamic Parameters

Stoichiometry - mole concept, significance of balanced chemical equation - simple calculations - Conditions for occurrence of chemical reactions - enthapy, entropy and free changes – spontaneity – Thermochemistry - heats of reactions - (formation, combustion, neutralization) - specific heats - variation of enthalpy change with temperature - Kirchhoff’ relation (integrated form) - bond enthalpy and bond order - Problems based on the above.

Unit 3 Kinetics

Review of molecularity and order of a reaction, rate law expression and rate constant - first, second, third and zero order reactions, pseudo-first order reactions (pseudo-unimolecular reactions) - complex reactions - equilibrium and steady state approximations -mechanism of these reactions - effect of temperature on reaction rates - Arrhenius equation and its significance, Michaelis Menden kinetics-enzyme catalysis.

Unit 3 Electrochemistry

Electrolytes - strong and weak, dilution law, Debye-Huckel theory, faraday’s laws, origin of potential, single electrode potential, electrochemical series, electrochemical cells, Nernst equation and its application, reference electrodes- SHE, Ag/AgCl, Calomel.

Unit 5 Photochemistry

Photochemistry, laws of photochemistry - Stark-Eistein law, Beer-Lamberts law, quantum efficiency-determination, photochemical processes - Jablonsky diagram, internal conversion, inter-system crossing, fluorescence, phosphorescence, chemiluminescence and photo sensitization, photopolymerization**.**

Reference Books

1. Principles of Physical Chemistry, B.R. Puri, L.R. Sharma & M.S. Pathania , Vishal Publications, 46^{th}, 2013.

2. Principles of Inorganic Chemistry, B R. Puri, L. R. Sharma, Vishal Publications, 2008

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18CHY114	**CHEMISTRY II**	**(3 1 0 4)**

Course Outcomes:

CO-1 Gain an understanding and explain ionic equilibrium in electrolytes, electrical conductance in dilute solutions, concepts related to pH, apply them to solve problems.

CO-2 Gain an understanding of concepts in chemical equilibria, law of mass action, temperature dependence, Le-Chatelier's principle and its application.

CO-3 Gain familiarity with concepts in organic chemistry, organic compounds, their dominant physical and chemical characteristics and describe them.

CO-4 Gain an understanding of acids, bases, and non-aqueous solvents, describe their general physical and chemical characteristics with examples.

CO-5 Gain an understanding of concepts in coordination chemistry, Weiner's theory, coordination numbers, ligands, nomenclature, isomerism, use of such compounds in qualitative and quantitative analysis, theory of boding in coordination.

Unit 1 Ionic equilibria

Electrolytes, strong and weak – specific, equivalent and molar conductances, equivalent conductance at infinite dilution and their measurement - Kohlrausch's law and its applications - calculation of equivalent conductance at infinite dilution for weak Electrolytes and solubility of sparingly soluble salts - applications of conductivity measurement - conductometric titrations - acid-base precipitation and complexometric titrations, Common ion effect and its application, concept of pH, indicators, theories of indicators – buffers and their pH - Henderson equation.

Unit 2 Chemical equilibria

Law of mass action - equilibrium constant – Relation between K_p and K_c - Temperature dependence – The van 'tHoffs equation – Pressure dependence of the equilibrium constant K_p and K_c – Factors that change the state of equilibrium - Le-Chatelier's principle and its application to chemical equilibria.

Unit 3 Basic concepts in Organic Chemistry

Composition of organic compounds – detection and estimation of elements- carbon – hydrogen -nitrogen, oxygen, sulphur, phosphorous, halogens – Calculation of empirical and molecular formula - determination of molecular weights – physical and chemical methods – Classification and Nomenclature of organic compounds. Organic reactions and their mechanisms: Electron displacement effects – inductive, electromeric, mesomeric and hyperconjugative. Reactive intermediates – carbocations, carbanions, free radicals and carbenes.

Unit 4 Acids, Bases and Non-aqueous solvents

Concepts of acids and bases – hard and soft acids and bases - Pearson's concept, HSAB principle and its application - basis for hard-hard and soft-soft interactions - non-aqueous solvents - general characteristics of non-aqueous solvent - melting point, boiling point, latent heat of fusion and vaporization, and dielectric constant - reactions such as complex formation, redox, precipitation and acid base type in non-aqueous solvents like liquid ammonia, liquid SO_2 and liquid HF.

Unit 5 Coordination chemistry
Werner's theory – Electronic interpretation of co-ordination compounds - EAN rule – types of ligands – Nomenclature, isomerism – stability of complexes – factors influencing stability – Application of coordination compounds in qualitative and quantitative analysis. Theories of bonding in coordination.

TEXTBOOKS:

1. Puri, Sharma & Pathania, 'Priniciples of Physical Chemistry', 42nd edition, Vishal Publishing Co, Delhi, 2007.
2. Morrison and R. N. Boyd, 'Organic Chemistry', 6th Edition, Prentice Hall, 1992.
3. Puri BR, Sharma LR, KaliaKK., 'Principles of Inorganic Chemistry', 23rd Edition, ShobanLalNagin Chand & Co, New Delhi, 1993.

References:

1. S. F. A. Kettle, 'Physical Inorganic Chemistry', Spectrum, 1996
2. J. Clayden, N. Greeves, S. Warren and P. Wothers, 'Organic Chemistry', 2nd edition, Oxford University Press, 2012.
3. R.Stephen Berry, Stuart A. Rice & John Ross, 'Physical Chemistry', 2nd edition,Oxford University press, 2000.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18CHY182	**CHEMISTRY LAB**	**(0 0 2 1)**

Course Outcomes:

CO1: To develop knowledge about safety requirements and to make them able to perform experiments as and analyse the results of experiments.

CO2: Explain the concept of various volumetric analysis including acid base titrations, permanganometric titrations, complexometric and conductometric titrations.

CO3: Determine the transition temperature of the given salt hydrate

CO4: Understand the measurement of viscosity by Ostwald Viscometer

CO5: Understand the measurement of surface tension by Stalagmometer

CO6: Identify the concentration of an unknown solution by photocolorimetry

Experiments:

1. Estimation of sodium hydroxide using A.R sodium carbonate
2. Estimation of oxalic acid
3. Estimation of Total, Permanent and Temporary Hardness of Water
4. Determination of transition temperature and cryoscopic constant of the given salt hydrate
5. Acid Base titration by conductance measurement
6. Viscosity measurement
7. Determination of surface tension
8. Determination of unknown concentration of copper sulphate solution using photocolorimetric method

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

Mathematics Courses

18MAT107	**Single Variable Calculus**	**(3-1-0-4)**

Course Outcome:

CO1: Understand the elementary functions and concepts of limit, continuity, derivative and integral

CO2: Study techniques of differentiation and use it in optimisation problems and curve sketching

CO3: Defining Integral as a sum and review integration techniques

CO4: Use of integrals for the computation of areas, volumes and arc length

CO5: Discuss some basic concepts in the theory of infinite series with some insight to Power series.

Unit 1

Functions – domain, range, graphs of elementary functions, limits - left limit, right limit, continuity, definition of derivative, derivative as rate of change, implicit differentiation.

Unit 2

Extreme values of functions, critical points, graphing with y' and y'', asymptotes, optimization problems, linearization and differentials, L'Hospital's Rule. Riemann sums and definite integrals (just some elementary examples, not the proof), Area, Fundamental theorem of Calculus.

Unit 3

Area between curves, Volumes of solids of revolution – washer method and cylindrical shell method, Length of plane curves, Areas of surfaces of revolution, Moments and centres of Mass.

Unit 4

Sequences, Infinite series as a limit of sequence, Integral test, Comparison tests, Ratio and Root tests, Alternating Series, Absolute and Conditional convergence.

Unit 5

Power series, Taylor and Maclaurin Series, Error estimates, Applications of Power Series, Fourier Series.

Textbook:

Thomas and Finney, *Calculus and Analytic Geometry*, 11th edition, Pearson.

References:

N. Piskunov, *Differential and Integral Calculus Vol. I and II*, CBS Publishers.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18MAT108 Vectors and Geometry (3-1-0-4)

Course Outcome:

CO1: Understand the parametric equations of curves and surfaces ,find the vector equations of the lines and planes.

CO2: Understand to describe the velocity and acceleration associated with a vector-valued function Use vector-valued function to analyze projectile motion

CO3 Understand to Set up and evaluate definite integrals in two dimensions using polar coordinates. Change from polar to rectangular coordinates and vice versa

CO4: Understand to find a unit tangent vector at a point on a space curve ,the tangential and normal components of acceleration, arc length of a space curve the curve at a point on the curvature .

CO5:Understand to use cylindrical and spherical coordinates to represent surfaces in space

Unit 1
Review of Conic Sections, Eccentricity, Quadratic Equations and Rotations, Parametrization of plane curves, Polar coordinates, Graphing in polar coordinates, Areas and Lengths in polar coordinates, Conic Sections in Polar Coordinates.

Unit 2
Review of vectors (Dot product, Cross product, Unit vector), Lines and Planes in Space, Cylinders and Quadric Surfaces, level curves.

Unit 3
Vector Functions, Modelling projectile motion, Arc length, Unit Tangent Vector, Curvature and Unit Normal Vector.

Unit 4
Double integrals, Areas, Moments and Centers of mass, Double integrals in polar form, Triple integrals in Rectangular Coordinates.

Unit 5
Applications, Triple integrals in cylindrical and spherical coordinates, Change of variables.

Textbook:
Thomas and Finney, *Calculus and Analytic Geometry*, 11th edition, Pearson.

References:
N. Piskunov, *Differential and Integral Calculus Vol. I and II*, CBS Publishers.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18MAT116	Multivariable Calculus	(3-1-0-4)

Course Outcomes:

CO1: Understand the basic concepts of vector valued functions,limits ,derivatives and it's geometrical interpretations.

CO2: Understand the concept of scalar and vector field

CO3: Understand the concept of Line integrals and it's independence of path

CO4: Understand and apply the concepts of double integrals to various problems including Green's theorem for plane

CO5: Understand the concepts of surface integrals, divergence theorem and Stokes theorem.

Unit 1
Limits and continuity of Functions of Severable Variables, Partial derivatives, Differentiability of Functions, Chain rule.

Unit 2
Directional derivatives, Gradient and tangent planes, Extreme values and saddle points, Lagrange multipliers.

Unit 3
Line integrals, Vector fields, Circulation and Flux, Path independence, Potential Functions and Conservative Fields. Green's theorem in a Plane.

Unit 4
Parameterized Surfaces, Surface Areas and Surface Integrals, Orientation of Surfaces

Unit 5
Stoke's Theorem and Divergence Theorem (no proof just applications).

Textbook:
Thomas and Finney, *Calculus and Analytic Geometry*, 11^{th} edition, Pearson.

References:
N. Piskunov, *Differential and Integral Calculus Vol. I and II*, CBS Publishers.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18MAT117	Introduction to Differential Equations	(3-1-0-4)

Course Outcome:

CO1: Ability to recognize and solve linear, separable and exact first-order differential equations.

CO2: understand the use of differential equations in modelling engineering problems

CO3 Ability to recognize and solve first-order and higher order differential equations, analyze trajectories, and comment on the stability of critical points

CO4 Understand to determine the Laplace transforms for basic functions, derivatives, integrals and periodic functions and find inverse transforms

CO5 Ability to use Laplace transforms to solve initial value problems, integral equations .

Unit 1
First order ODEs, Modelling, Direction Fields, Separable ODEs, Exact ODEs and Integrating Factors, Linear ODEs and Modelling. (Sections: 1.1 to 1.5)

Unit 2
Second Order Differential Equations: Homogeneous and non-homogeneous linear differential equations of second order, Modelling a Spring-Mass System, Euler-Cauchy Equations, Existence and Uniqueness of solutions (statement), Wronskian, Solution by Undetermined Coefficients and Variation of Parameters, Modelling. (Sections 2.1, 2.2, 2.4 to 2.10)

Unit 3
Homogeneous and non-homogeneous Higher Order Linear ODEs, Systems of ODEs, Wronskian, Constant-Coefficient Systems, Phase plane method, Criteria for Critical points and Stability. (Sections 3.1, 3.2, 3.3, 4.0 to 4.4)

Unit 4
Laplace Transforms: Linearity, first and Second Shifting theorems, Dirac delta functions, Convolution and Integral Equations. (Sections 6.1 to 6.5)

Unit 5
Differentiation and Integration of Transforms, ODEs with Variable Coefficients, Systems of ODEs. (Sections 6.6 to 6.9)

Textbook:
Erwin Kreyszig, *Advanced Engineering Mathematics*, 10^{th} edition, Wiley.
References:
W.E. Boyce and R.C. DiPrima, *Elementary Differential Equations and Boundary Value Problems*, 7^{th} edition, Wiley.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18MAT210	**Transforms and PDE**	**(3-1-0-4)**

Course Outcomes:
CO1: Ability to understand the series solution of certain differential equations give rise to special functions
CO2: Ability to understand the basic concepts of Fourier series for periodic functions .
CO3:Model mathematically One and Two Dimensional Wave and Heat Equations and solve using Fourier series

CO4: Ability to understand the general principle in boundary value problems for PDEs to choose coordinates that make the formula for the boundary as simple as possible
CO5: Ability to solve the boundary value problems in Polar, Cylindrical and Sperical co-ordinates.

Unit 1
Series Solutions of ODEs: Power Series method, Legendre's equation and Legendre Polynomials, Extended Power Series method – Frobenius method. (Sections 5.1 to 5.3)

Unit 2
Bessel's equation and Bessel Functions, General Solution, Fourier Series—Even and Odd functions, Half range expansions, Approximation by Trigonometric Polynomials. (Sections 5.4, 5.5, 11.1 to 11.4)

Unit 3
Sturm-Liouville problems, Generalised Fourier Series, Fourier Integral and Fourier transforms. (Sections 11.5 to 11.10)

Unit 4
Basic concepts of PDEs, Solution by Separating Variables, D'Alembert's Solution of the Wave Equation, Heat Equation, Solution By Fourier Series, 2D Heat Equation and Dirichlet Problem, Heat equation for long bars, Solution by Fourier Integrals and Transforms. (Sections 12.1 to 12.7)

Unit 5
Two Dimensional Wave Equation, Laplacian in Polar Coordinates, Fourier Bessel Series, Laplace's equation in Cylindrical and Spherical Coordinates, Solution of PDEs by Laplace Transforms. (Sections 12.8 to 12.12)

Textbook:
Erwin Kreyszig, *Advanced Engineering Mathematics*, 10th edition, Wiley.

References:
W.E. Boyce and R.C. DiPrima, *Elementary Differential Equations and Boundary Value Problems*, 7th edition, Wiley.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18MAT220	**Introduction to Linear Algebra**	**(3-1-0-4)**

Course Outcomes:
CO1: Understand the basic arithmetic operations on vectors and matrices, including inversion and determinants, using technology where appropriate;
CO2: Abllity to solve systems of linear equations, using technology to facilitate row reduction
CO3: Ability to understand the basic terminology of linear algebra in Euclidean spaces,

including linear independence, spanning, basis, rank, nullity, subspace, and linear transformation.
CO4: Ability to understand and. find eigen values and eigenvectors of a matrix or a linear transformation, and using them to diagonalize a matrix
CO5: Ability to understand Orthogonally diagonalise symmetric matrices and quadratic forms

Unit 1
Matrices, Operations on Matrices-Addition, Multiplication, Transpose, Special types of matrices. systems of linear equations.

Unit 2
Gaussian elimination and row operations, Echelon form of a matrix, Elementary matrices and rank of a matrix, Existence of solution of AX=B.

Unit 3
Properties of determinants, Cofactor expansion, Inverse of a matrix. Vector spaces, Subspaces.

Unit 4
Span and linear independence, Basis and dimension, Row and column space of a matrix, Change of Basis. Linear transformations, Range space and rank, null space and nullity, Matrix representation, Isomorphism.

Unit 5
Eigenvalues and Eigenvectors, Diagonalization and Similar Matrices, Real Quadratic Forms.

Textbook:
David C. Lay, *Linear Algebra and its Applications*, Pearson.

References:
Gilbert Strang, *Linear Algebra and its Applications*, Cengage.
Derek Robinson, *A Course in Linear Algebra with Applications*, Allied publishers.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18MAT225	**Numerical Methods**	**(3-1-0-4)**

Course Outcome
CO-1: Understand the basic concepts of root finding methods, system of equations and their solutions.
CO-2: Understand the concepts of interpolation and construction of polynomials.
CO-3: Application of numerical methods to understand the concept of Calculus (Differentiation and Integration).
CO-4: Application of numerical concepts to solve ODEs and PDEs.
CO-5: Usage of software tools to solve various problems numerically.

Unit 1
Solution of Nonlinear Equations: Bisection and False position Methods, Newton Raphson and Secant Methods, Rate of Convergence.

Unit 2
Solution of Linear Systems AX=B and Eigen value problems (12 hours): Direct methods, Gaussian Elimination, Gauss Jordan method, LU Factorisation, Jacobi & Gauss Seidel iterative Methods.

Unit 3
Interpolation, Curve Fitting (12 hours): Taylor's Series calculation of Functions, Lagrange's Polynomial Approximation and Interpolation, Newton Polynomial Approximation using divided differences and Interpolation, Error, Newton-Gregory forward and backward difference interpolation, Hermite interpolation, Piecewise and Spline interpolation, Polynomial approximation and Weierstrass theorem, Principle of Least Squares.

Unit 4
Numerical Differentiation and Integration (10 hours):Numerical Differentiation using Lagrange, Finite difference interpolation and Undetermined coefficient method, Numerical Integration using Newton-Cotes method, Gauss-Legendre Integration method, Trapezoidal and Simpson method, Quadrature, Composite Trapezoidal and Simpson's Rule, Romberg Integration, Orthogonal polynomials and Gaussian integration.

Unit 5
Solution of Ordinary Differential Equations (10 hours): Euler method, Modified-Euler, midpoint method, Taylor series method, Runge-Kutta methods, Error analysis.

Textbook:
Jain M.K., Iyengar S.R.K. and Jain R.K., *Numerical Methods for Engineering and Scientific Computation*, 3rd edition, New Age International (P), New Delhi, 1995.

References:
1. John H. Mathews, Kurtis D. Fink, *Numerical Methods Using Matlab*, 4E, Prentice-Hall.
2. Rudra Pratap, *Getting Started with MATLAB 7: A Quick Introduction for Scientists and Engineers*, Oxford University Press, 2005.

Skills: In class practice sessions, tutorials and assignments help build foundations and develops computational thinking and programming skills leading to industrial computing and engineering software applications in industries and research labs.
Employability: Scientific computing applications.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18MAT541	**Probability and Statistics with R**	**(3-1-0-4)**

Course Outcomes:

CO1: Able to understand the basic statistical concepts and measures

CO2; Able to understand the basic knowledge on fundamental probability concepts, including random variable, probability of an event, additive rules and conditional probability and Bayes' theorem

CO3: Able to understand several well-known distributions, including Binomial, Geometrical, Negative Binomial, Pascal, Normal and Exponential Distribution

CO4:A good understanding of the basic concepts of statistical inference

CO5:A good understanding of the Central Limit Theorem and its applications

CO6: Develop skills to use R software to apply to statistics problems.

Unit 1
Probability Concepts: random experiment, trial, sample space, mutually exclusive events, mathematical and stochastic approaches, axiomatic definition of probability, laws of addition, multiplication, conditional probabilities, Bayes theorem.

Unit 2
Random variable and distributions: Uniform, Binomial, Poisson, geometric, exponential, Gamma and Normal Distributions; functions of random variables; mathematical expectations, variance, moments, moment generating functions - Characteristic function, Chebyshev's Inequality.

Unit 3
Two and higher dimensional random variables: joint, marginal and conditional probability distributions for discrete and continuous cases, stochastic independence; transformation of random variables, sequences of random variables, law of large numbers, central limit theorem.

Unit 4
Correlation and Regression: Principle of least squares, scatter plots, curve fitting, simple regression, regression lines, correlation coefficient, estimation of correlation coefficients. Theory of Estimation: population and sample, sampling distributions, sample mean and sample variance, determination of sample size, student's-t, F and Chi-square distributions; Estimation: Point and interval estimation methods, Testing of Hypothesis, Large and Small Sample Tests for Mean, Variance and Proportion, Goodness of Fit, Testing of Independence and Homogeneity.

Unit 5
Problem solving with R: Introduction to programming in R, exercises and projects using R.

Textbooks:

1. S. M. Ross, Introduction to Probability and Statistics for Engineers and Scientists, 4E, Elsevier, 2009
2. Michael W. Trosset, An Introduction to Statistical Inference and Its Applications with R, CRC, 2009

References

3. P.L. Meyer, Introductory Probability and statistical Applications, Oxford & IBH Publishing Ltd.
4. R.V.Hogg and E.A.Tanis, Probability and Statistical inference, 6th edition, Pearson.

Skills: In class practice sessions, tutorials and assignments help build foundations and develops computational thinking and programming skills leading to industrial computing and engineering software applications in industries and research labs.
Employability: Statistical computing involving R is used in data science applications.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18MAT542	**Optimization Methods**	**(3-1-0-4)**

CO-1 Understand different types of Optimization Techniques in engineering problems. Learn Optimization methods such as Bracketing methods, Region elimination methods,Point estimation methods.

CO-2 Learn gradient based Optimizations Techniques in single variables as well as multi-variables (non-linear).

CO-3 Understand the Optimality criteria for functions in several variables and learn to apply OT methods like Unidirectional search and Direct search methods.

CO-4 Learn constrained optimization techniques. Learn to verify Kuhn-Tucker conditions and Lagrangian Method.

Unit I

Introduction to Optimization, Historical Development, Applications of Optimization, Statement of an Optimization Problem, Classification of Optimization Problems, Optimization Techniques.

Unit 2

Classical Optimization Techniques-Single-Variable Optimization, Multivariable Optimization with no constraints, Multivariable Optimization with Equality Constraints, Solution by Direct Substitution, Solution by the Method of Constrained Variation, Solution by the Method of Lagrange Multipliers, Multivariable Optimization with Inequality Constraints, Kuhn–Tucker Conditions, Constraint Qualification, Convex Programming Problem.

Unit 3

Single Variable Optimization- Optimality criteria, bracketing methods-exhaustive search method, bounding phase method- region elimination methods- interval halving, Fibonacci search, golden section search, point estimation-successive quadratic search, gradient based methods.

Unit 4

Multivariable Optimization, optimality criteria, unconstrained optimization-solution by direct substitution, unidirectional search-direct search methods, evolutionary search method, simplex search method, Hook-Jeeves pattern search method, gradient based methods-steepest descent, Cauchy's steepest descent method, Newton's method, conjugate gradient method- constrained optimization.

Suggested Books for Reading

1. S.S Rao (2009) Engineering Optimization: Theory and Practice, John Wiley & Sons, Inc.
2. Kalyanmoy Deb (2004) Optimization for engineering design algorithms and examples, Prentice hall of India, New Delhi
3. Edwin K.P.Chong and Stanislaw H.Zak (2004), An introduction to optimization, 2nd Ed, Wiley Inter-science
4. M. Asghar Bhatti(2000), Practical optimization methods, Springer-Verlag

   Skills: In class practice sessions, tutorials and assignments help build foundations and develops computational thinking and programming skills leading to industrial computing and engineering software applications in industries and research labs.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

Computer Science Courses

18CSA102 Introduction to Programming I (3-0-2-4)

Course Outcomes: On successful completion, students will be able to
CO1: Understand the foundation concepts of information and information processing in computer systems, data representation, coding systems.
CO2: Understand programming language syntax and its definition by example of Python.
CO3: Adequately use standard programming constructs: repetition, selection, functions, composition, modules, aggregated data (arrays, lists, etc.)
CO4: Identify and repair coding errors in a python program
CO5: Use library software for (e.g.) building a graphical user interface, or mathematical software.
CO6: Understand function concept and how to deal with function arguments and parameters.

Unit 1

Introduction to Computers and Programming: Hardware and software; binary representation of numbers, working of a program, high-level languages, compilers and interpreters; Installing python, editors, integrated development environment, writing and running programs.

Introduction to programming: Designing a program: development cycle, pseudocode, flowcharts and algorithm development; variables, numerical data types and literals, strings, assignment and reassignment, input/output, formatted output, reading numbers and strings from keyboard; performing calculations: floating point and integer division, converting math formulas to programming statements, standard mathematical functions, mixed-type expressions and data type conversions.

Unit 2

Program Decision and Control Structures: Boolean expressions, relational expressions, logical operators, Boolean variables; if, if-else, if-elif-else, inline-if statements, nested structures, and flowcharts; use of temporary variables, application: arranging a few numbers in increasing or non-decreasing, decreasing or non-increasing orders, etc.

Unit 3

Repeated calculations and Looping: condition-controlled and count-controlled loops, while-loop (condition-controlled), infinite loops; for-loop (count-controlled), applications: calculating summation of series, Taylor expansion of mathematical functions, etc; nested loops.

Unit 4

Functions: void and value returning functions, defining and calling functions,
local and global variables and constants, scope, returning one or more values, Math module, use of standard math libraries and functions, passing functions as arguments, the Main program, Lambda functions, example: numerical integration, testing and test functions; Measuring CPU time and efficiency assessment; examples.

Unit 5

Arrays, Lists and Tuples: lists, index, iterating over a list with for-loop, operations with lists, built-in functions, finding index, sorting, etc., processing lists; Arrays: vectors and tuples, vector arithmetic, arrays, Numerical Python arrays – Numpy, curve plotting: matplotlib, SciTools, making animations and videos; Higher-dimensional arrays: two and three dimensional arrays, matrix objects and matrix operations: inverse, determinant, solving linear systems using standard libraries.

Lab Exercises to be done along with the course:

1. Using computer: Hardware: input/output devices, ports, memory units; Software: Operating systems, File system, application software; Word processor: formatting, including tables, pictures, drawing in a canvas, equations; Spreadsheet program: rapidly calculating with formulas and filling columns, etc, plotting; Presentation tools (2 weeks)
2. Start programming: keyboard input, assigning and printing variables – numbers, strings, names, etc.; Converting formulas into programming statements: examples of conversion from one unit to another unit, Calculating distances, areas and volumes; Formatted output, scientific notation; Program to (a) find the roots of a quadratic equation (both real and imaginary root), (b) make tables of mathematical functions like sin x, tan x, exp(x), etc. (3 weeks)
3. Control, Looping and Functions: Programs to illustrate logical expressions, arranging a few numbers in a given order; looping statements: summing numbers from keyboard input, calculating summation of power series of functions, error estimation; Defining custom functions: examples; returning multiple values, passing functions as arguments. (3 weeks)
4. Introducing Sage or equivalent Computer Algebra System: using it as calculator, symbolic mathematics, derivatives and integrals, solving linear system of equations, summing series, plotting functions, surfaces, Arrays, vectors and matrix operations. (2 weeks)
5. Programs for vector and matrix operations: Define arrays, dot product and cross product of vectors; sum, product, and other operations of two $n \times n$ matrices; Sorting numbers, searching the index of a sorted set of numbers; Programs to plot mathematical and user defined functions. (2 weeks)

Textbooks/References

1. Tony Gaddis, Starting Out with Python, 3E, Pearson, 2015.Book contains flowcharting and pedagogical program development in an introductory Python book. Ch. 1 to 5, Ch 7.
2. Hans Petter Langtangen, A Primer on Scientific Programming with Python, 5E, Springer, 2016. Ch. 1 to 3, Ch. 4 (carefully selected material appropriate for first year students)
3. Christian Hill, Learning Scientific Programming with Python, 2016(carefully selected material appropriate for first year students)
4. Zed A Shaw, Learn Python the Hard Way, 3E, Pearson, 2017
5. Mark Newman, Computational Physics, Ch. 1 to 3.
6. One material and tutorials: www.python.org ; https://www.learnpython.org; www.vpython.org.

Skills: Entire course contents with tutorials and lab exercises help build foundations and develops computational thinking and programming skills leading to scientific computing and software applications in research labs.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18CSA112 Introduction to Programming II (3-0-2-4)

Course Outcomes:

CO1: Understand defensive programming concept. Ability to handle possible errors during program execution

CO2: Write code in Python to perform mathematical calculations and scientific simulations.

CO3: Understand the concepts of object-oriented programming as used in Python: classes, subclasses, properties, inheritance, and overriding.

CO4: Have knowledge of basic searching and sorting algorithms. Have knowledge of the basics of vector computation

CO5:Understand the concept of recursion and solve problems using recursion.

CO6: Implement a given algorithm as a computer program (in Python)

Unit 1

Review of basics (2 hours); Files: reading from a command-line, option-value pairs, file input and output, filenames and file objects, opening and writing / appending /reading data to a file, writing and reading numerical data, loop operations and file processing; Handling errors and exceptions: try, except, finally statements and catching exceptions; Making modules, example: bisection and root finding.

Unit 2

More about Strings: basic string operations, slicing, testing, searching, manipulating;
Dictionaries: creating dictionaries, retrieving values, using for-loop to iterate over a dictionary, etc.; Sets: creation and operations on a set.

Unit 3

Classes: Introduction to procedural and object-oriented programming, definition, attributes, methods, examples, instances, accessor and mutator methods, passing objects as arguments;

function classes for mathematical computations, complex number class, static methods and attributes.

Unit 4

Object-Oriented Programming: Inheritance: generalization and specialization, examples; Polymorphism: definition, general examples, mathematical examples, Inheritance and class hierarchies; classes for numerical differentiation and integration; subclasses.

Unit 5

Recursion: Introduction and problem solving with recursion, examples: factorials, Fibonacci series, Euclid's algorithm of gcd calculation, recursion versus looping; A couple of sorting and searching algorithms; Glimpses of advanced data structures, GUI programming.

Lab Exercises to be done along with the course:

1. More about Computer Algebra System: Problem solving, multiple integrals, vector calculus (3 weeks)
2. Programs: (3 weeks)
    a. To fit a straight line through the given set of data points using least square fitting algorithm.
    b. To sort a given list containing the name of students and their total marks and print the rank list.
    c. To search a sorted list and print the details of the sought item.
3. Program to (a) integrate a given function using Simpson's rule and Trapezoidal rules, (b) determine derivative table of a smooth function. (3 weeks)
4. Program to solve elementary differential equations: (3 weeks)
    a. To compute the trajectory of the projectile thrown at various angles.
    b. To compute position and velocity of a spherical body in a viscous fluid, e.g., falling of rain drop, terminal velocity.
    c. To study the motion of a body under a central force field: planetary motion - elementary approach.

Textbooks/References

1. Tony Gaddis, Starting Out with Python, 3E, Pearson, 2015.Book contains flowcharting and pedagogical program development in an introductory Python book. Ch. 6, Ch. 8 to 12. (text)
2. Hans Petter Langtangen, A Primer on Scientific Programming with Python, 5E, Springer, 2016. Ch. 4, 6, 7, 9 (text)
3. Christian Hill, Learning Scientific Programming with Python, 2016 (carefully selected material appropriate for first year students)
4. Zed A Shaw, Learn Python the Hard Way, 3E, Pearson, 2017
5. Mark Newman, Computational Physics, 3E, Ch. 1 to 3.
6. One material and tutorials: www.python.org; https://www.learnpython.org; www.vpython.org.

Skills: Entire course contents with tutorials and lab exercises help build foundations and develops computational thinking and programming skills leading to scientific computing and software applications in research labs.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18CSA209	Data Structures and Algorithms	(3-1-0-4)

Course Outcomes:

1) develop knowledge of basic data structures for storage and retrieval of ordered or unordered data. Data structures include: arrays, linked lists, binary trees, heaps, and hash tables.
2) develop knowledge of applications of data structures including the ability to implement algorithms for the creation, insertion, deletion, searching, and sorting of each data structure.
3) analyze and compare algorithms for efficiency using Big-O notation.
4) Program examples requiring the implementation of the above data structures.
5) develop knowledge of basic data structures for storage and retrieval of ordered or unordered data. Data structures include: arrays, linked lists, binary trees, heaps, and hash tables.
6) develop knowledge of applications of data structures including the ability to implement algorithms for the creation, insertion, deletion, searching, and sorting of each data structure.
7) analyze and compare algorithms for efficiency using Big-O notation.

Unit 1

Introduction: Overview of Data Structures – A Philosophy of Data Structures - The Need for Data Structures – Cost and Benefits - Abstract Data Types and Data Structures - Principles, and Patterns. Basic complexity analysis – Best, Worst, and Average Cases - Asymptotic Analysis - Analysing Programs – Space Bounds. Recurrence Relations: Analysis using Recurrence Tree based Method.

Unit 2

Arrays. Linked Lists : Using Arrays - Lists - Array based List Implementation – Linked Lists – LL ADT – Singly Linked List – Doubly Linked List – Circular Linked List. Stacks and Queues: Stack ADT - Array based Stacks, Linked Stacks – Implementing Recursion using Stacks, Queues - ADT, Array based Queue, Linked Queue, Double-ended queue, Circular queue.

Unit 3

Trees: Tree Definition and Properties – Tree ADT - Basic tree traversals - Binary tree - Data structure for representing trees – Linked Structure for Binary Tree – Array based implementation. Graphs: ADT- Data structure for graphs - Graph traversal - Transitive Closure - Directed Acyclic graphs - Weighted graphs – Shortest Paths - Minimum spanning tree.

Unit 4

Sorting and Searching. Bubble sort, Insertion sort, Heap Sort - Merge Sort - Quick Sort. Binary search. Divide and Conquer Strategy.

Unit 5

Greedy Method. Elements of Greedy Method. Fractional knapsack problem, scheduling problem. Applications of greedy method. Introduction to Cryptography, efficiency of algorithms.

Textbook:
Goodrich M T, Tamassia R and Michael H. Goldwasser*, "Data Structures and Algorithms in Python",* Wiley publication, 2016.

References:

1. Clifford A. Shaffer, *"Data Structures and Algorithm Analysis",* Third Edition, Dover Publications, 2012.
2. Tremblay J P and Sorenson P G*, "An Introduction to Data Structures with Applications",* Second Edition, Tata McGraw-Hill, 2002.

Skills: Entire course contents with tutorials and assignments help build foundations and develops computational thinking and programming skills leading to scientific computing and software applications in research labs.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18CSA308	**Machine Learning I**	**(3-1-0-4)**

Course Outcomes:

CO1: Understand the domain of machine learning with respect to the regression and classification and its huge potential for providing solutions to real-life problems.

CO2: Have a good understanding of the fundamental issues and challenges in basic machine learning algorithms in terms of data, model selection, and complexity.

CO3: Understand the problem of Curse of Dimensionality and different methods to tackle it.

CO4: Understand the mathematical framework for machine learning (both supervised and un-supervised learning) and methods to tackle under fitting & overfitting.

CO5: Learn the motivation and theory behind learning an artificial neural networks for machine learning applications.

CO6: Be able to design and implement right machine learning algorithm for a given real-world problem.

Unit 1
Introduction, Simple Linear regression, Multiple linear regression, Extensions of the linear model, Classification: overview, Logistic regression, Linear discriminant analysis, comparison of classification methods.

Unit 2
Resampling methods: Cross validation and the bootstrap, Linear model selection and Regularization: Subset selection, Shrinkage methods, Dimension reduction methods, Considerations in high dimensions.

Unit 3
Polynomial regression, step functions, basis functions, regression splines, smoothing splines, local regression, generalised additive models for regression and classification problems, Regression trees, Classification trees, comparison of trees and linear models, Bagging,

Random Forests, Boosting.

Unit 4

Support Vector Machines: Hyperplane, Maximum Margin Classifier, Support Vector Classifiers, Support Vector Machines, One vs One Classification and One vs All Classification, Relationship to Logistic Regression. Unsupervised Learning: Principal Component Analysis and its applications, K-Means Clustering and Hierarchical Clustering.

Unit 5

Neural Networks: Introduction, Projection Pursuit Regression, Neural Networks, Fitting Neural Networks, Some issues in Training Neural Networks-Starting Values, Overfitting, Scaling of the Inputs, Number of Hidden Units and Layers, Multiple Minima.

Textbooks:

G. James, R. Tibshirani, *An Introduction to Statistical Learning: with applications in R*, Springer.

T. Hastie, R. Tibshirani, *Elements of Statistical Learning: Data mining, Inference and Predicton*, Springer.

References:

Kevin Murphy, *Machine Learning: A Probabilistic Perspective*, MIT Press.

Skills: Entire course contents with tutorials and assignments help build foundations and develops computational thinking and programming skills leading to scientific computing and software applications in research labs.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18CSA316	**Machine Learning II**	**(3-1-0-4)**

Course Outcomes:

CO1: To understand the computing capacity of single layer neural networks, and the need for multi-layer neural networks.

CO2: Learn to tackle the under-fitting, overfitting, and getting into local optimal solutions when learning an artificial neural network.

CO3: Learn about the deep neural networks, CNN to understand how it differ from a deep traditional FFN both in terms of the number of parameters to be learned and in terms of the learning by back-propagation.

CO4: Learn to design and use CNN both as a stand-alone classifier and in transfer learning settings.

CO5: Learn the necessary theory behind different recurrent neural networks and its applications to sequential data analysis.

Unit 1

Machine learning Basics and introduction, Capacity, Overfitting and underfitting, Hyperparameters, Estimator, Bias and Variance, Maximum likelihood estimation, Stochastic Gradient descent

Unit 2
Deep feedforward networks, Learning XOR, Hidden units, Architecture design, Backpropagation

Unit 3
Regularization, L1 and L2 regularization, Noise robustness, Semi supervised learning, Parameter typing and sharing, Sparse representation, Dropout

Unit 4
Optimization, Challenges in neural network optimization, Parameter initialization strategy, Adaptive learning rates, Optimization algorithms

Unit 5
Convolution operator, Pooling, Structured outputs, Efficient convolution algorithms, Unsupervised features, Convolution Neural networks, Recurrent Neural Networks, Encoder-decoder, LSTM and memory architectures, Optimization for long term dependency.

Textbooks:
Ian Goodfellow, Yoshua Bengio and Aaron Courville, *Deep Learning*, MIT Press. (Chapters 5-10).

Skills: Entire course contents with tutorials and assignments help build foundations and develops computational thinking and programming skills leading to scientific computing and software applications in research labs.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

Physics Courses (Semester-wise)

Semester 1

18PHY105	Introduction to Mechanics	3 1 0 4

Description: This course is the most fundamental and singularly important course that introduces students to fundamental concepts and mechanics and initiates students to college level problem solving in physics. This course sets the learning paradigm and lays foundation for rest of physics.

Course Outcomes: After successful completion of the course, students will be able to

CO1: apply to the concepts of measurements, estimating order of magnitudes, vectors, kinematics in one dimension, projectile and circular, and relative motions.

CO2: apply Newton’s law of motion to solve, with the help of a free-body diagram, for forces of equilibrium or acceleration, under contact forces, uniform gravity, for rectilinear and circular motions.

CO3: apply the concepts of kinetic energy, work – dot product of force and displacement, work-kinetic energy theorem, power, potential energy and relation to conservative forces, conservation energy, identify types of equilibrium.

CO4: apply Newton's law for center of mass motion, linear momentum and its conservation for collision problems.

CO5: apply concepts of rotation – angle, angular velocity, angular acceleration, torque, inertia, angular oscillations, angular momentum and its conservation, describe gyroscope motion.

CO6: apply Hooke's law, simple harmonic motion, free, damped and forced oscillations, resonance, describe aspects of wave motion, speed, wave equation, traveling waves, interference, standing waves, resonance.

Contents:

Unit 1 Measurement: standards of mass, length and time, dimensional analysis, estimation and order of magnitude calculations.
Kinematics: Motion in one dimension; Vectors; Motion in 2D: vectors of displacement, velocity and acceleration, projectile and uniform circular motion; relative motion, relative velocity and relative acceleration.

Unit 2 Laws of motion: concepts of force and mass, Newton's laws, reference frames, gravitational force, free body diagram analysis for simple applications, friction and contact forces; drag force and terminal speed, uniform circular motion.

Unit 3 Work and kinetic energy: scalar product of two vectors, kinetic energy and work-kinetic energy theorem, work done by gravitational and spring forces, power; Work and potential energy, conservative and non-conservative forces, conservative forces from potential energy, energy diagrams and equilibrium; Conservation of energy: examples without and with friction, power.

Unit 4 Linear momentum and Conservation: linear momentum and conservation in an isolated system of two particles, impulse, elastic and inelastic collisions in 1D; basic ideas (simple exercises only) on the concepts of centre of mass and dynamics of system of particles.
Rotational motion about fixed axis: Rotational variables, linear and angular variables, rotational kinetic energy and inertia, torque, Newton's law for rotation, work; rolling – combined translation and rotation; elementary discussions on angular momentum and its conservation.

Unit 5 Oscillations: simple harmonic motion, linear spring and Hooke's law, motion of mass on a spring, angular frequency, period, phase, angular oscillations and pendulums, small angle (linear) approximation, connection with uniform circular motion, average kinetic and potential energies, friction and damping, damped and forced oscillations, resonance, power absorption, Q-value, superposition principle.
Introduction to wave motion (selected topics and simple exercises only): propagation of disturbance, traveling wave on string, speed, reflection and transmission, energy transfer, linear wave equation; Sound: Basic description of sound as travelling wave of pressure variations, elementary discussions on superposition and interference, boundary conditions, standing waves and quantization of frequency, sonometer, resonance in sonometer.

Textbook/References

1. Serway and Jewett, Physics for Scientists and Engineers, 9E, Cengage Learning, 2013. Ch. 1 – 8, Ch. 9, 10 (lightly), Ch. 15, topics culled from Ch. 16 – 18.
2. C. Kittel et al, Mechanics – Berkeley Physics Course Vol. 1, 2E, Ch. 1 – 7, McGraw-Hill
3. D. Halliday, R. Resnick and J. Walker, Fundamentals of Physics, 10E, Ch. 2 – 11, 15 – 17.
4. Halliday, Resnick, and Krane, Physics, Vol. 1, 5th Ed., Wiley Indian Reprint, 2007
5. Feynman, Leighton and Sands, The Feynman Lectures on Physics, Vol.1, Narosa, 2008.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

Semester 2

18PHY115	**Electricity and Magnetism**	**3 1 0 4**

Description: This course is the second one in the foundational series. It introduces to the students a part of basic electricity and Magnetism at an elementary level and introduces to students to problem solving in this topic.

Course Outcomes: By the end of the course students will be able to develop an understanding, and

CO1: describe and apply electrostatic forces laws in vector form, superposition of forces, calculate electric fields, potentials, potential energies for basic charge distributions, electric flux, apply Gauss' law for symmetric charge distributions, electric potential from electric field and vice-versa, dipoles, work and potential energy.

CO2: describe Gauss' law and divergence, curl and rotation, gradient of potentials, capacitors, conductors, electric current, electrical resistance and Ohm's law, capacitor, resistor networks, RC circuit concepts, apply for problems therein.

CO3: describe magnetism, magnetic fields, determine forces due to magnetic field on moving charges and current carrying wires and their consequences, determine magnetic field due to current distributions, solenoids.

CO4: apply Faraday's laws for induced emf, induced electric field, describe laws in induction in integral form, mutual and self-induction, inductors and LRC ac-circuits, resonance and tuning.

CO5: describe displacement current and Maxwell's equation, Maxwell's equation and electromagnetic waves in vacuum, electric polarization, dipoles, and fields in dielectric media, magnetic fields in matter, magnetic dipoles.

Unit 1 Electric forces and Fields: Coulomb law in vector form, superposition of electric forces; electric fields, calculation of electric fields of static discrete and continuous charge distributions; Gauss' law and determination of electric fields of simple symmetric charge distributions: spherical distribution, line charge, infinite flat sheet of charge, energy associated with electric field. Electric potential: work, potential energy, and potential, line integral of electric field, potential difference and potential function, electric field as gradient of potential, potential of simple distributions of charges, dipoles; potential energy of system of point charges.

Unit 2 Vector calculus of fields: Divergence of a vector function and physical meaning, differential form of Gauss's law, Laplacian and Laplace's equation, calculating electric field from potential; Curl of a vector function, Stoke's theorem, physical meaning of curl.
Conductors and Capacitors: elementary discussions of electric field around charged conductors, potential of a charged conductor; capacitors, energy stored in a capacitor. Electric currents RC circuits: electric current, current density, charge conservation and continuity equation, electrical conductivity and Ohm's law, elementary theory of conductivity, conduction in metals and semiconductors, electrical circuits, energy dissipation, voltage sources, resistor networks with voltage sources, RC circuit, charging and discharging.

UNIT 3 Magnetostatics: Force due to magnetic fields, magnetic force on a current carrying wire, elementary discussions of Hall-effect, circular and helical orbits; Biot-Savart and Ampere's laws, magnetic field due to static current distributions; solenoid and toroid. Divergence of magnetic field, magnetic vector potential, vector potential for simple current distributions, and magnetic dipole (no derivation).

UNIT 4 Changing magnetic fields: Electromagnetic induction, Faraday's law, induced EMF, AC generator, moving field sources, universal law of induction, induced electric field, Faraday's law in integral and differential forms, mutual and self-inductance, LR circuit, energy stored in a magnetic field. AC Circuits: AC Circuits, Resonant RLC circuit, Q-value, LR, RC and RLC circuits driven by AC, complex impedances, power and energy in AC circuits.

UNIT 5 Maxwell's equations and Electromagnetic waves: displacement current, Maxwell's equations in integral and differential forms, plane electromagnetic waves. Elementary discussions on dielectrics: dipoles in electric fields, Gauss's law for dielectrics; capacitor with dielectrics, energy stored in a dielectric; Elementary discussions on magnetism in matter: current loop and magnetic dipole, magnetic dipole moment, torque and force on a magnetic dipole; currents in atoms, spin and magnetic moment, magnetization, magnetic fields in matter, magnetic susceptibility, magnetic and auxiliary fields, ferromagnetism.

Textbook

1. Edward Purcell, Electricity and Magnetism, 2e (SI edition), Tata-McGraw Hill, 2011.
(Ch. 1, 3; elementary discussions of Ch. 3;Ch. 6 – 9; elementary discussions of Ch. 10, 11; Some sections may be taken from Halliday, Resnick and Walker for simpler presentation. This syllabus has been designed for students who take vector calculus math course in the same semester.)
2. Halliday, Resnick, and Walker, Fundamentals of Physics, 10th Ed., Wiley Indian Reprint, 2008, Chapters 21-32.

References

1. Halliday, Resnick, and Krane, Physics, Vol. 2, 5th Ed., Wiley Indian Reprint, 2007
2. Feynman, Leighton and Sands, The Feynman Lectures on Physics, Vol.2, Narosa, 2008.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY184	**Physics Lab I**	**0 0 2 1**

Suggested list of experiments are given. Equivalent experiments may be considered.

Course Outcomes: After successful complete of the course, students will be able to

CO1: perform basic experiments in physics

CO2: apply the measurement techniques and analyze data and infer physics

CO3: apply the basic classical physics theories

CO4: calculate errors in measurements

CO5: through experiments infer basic material properties such as elasticity moduli, fluid properties and some topics from heat and thermodynamics, optics and rigid body.

Experiments:

1. Karter's AND/OR compound pendulum
2. Moment of inertia (MI) of irregular body – (MI table)
3. Young's modulus – using Uniform bending OR Non-uniform bending OR by Cantilever (any one)
4. Rigidity modulus – Torsion pendulum OR Maxwell's vibration needle method
5. Surface Tension – Capillary rise
6. Viscosity – Stoke's method
7. Flow of liquid through capillary tube
8. Newton's law of cooling – Convective heat transfer – Specific heat capacity of a liquid
9. Sonometer – String under tension
10. Newton's rings – wavelength of sodium light

Skills: Lab sessions and experimentation help develop intuition for lab equipment and builds practical knowledge of using lab instruments, measurement techniques and experimental techniques needed for work involving communication of science such as lab instructor/ demonstrator, educator in schools, colleges and universities, technical staff and scientist in research labs, and builds skills needed for higher studies.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

Semester 3

18PHY206	**Intermediate Mechanics I**	**3 1 0 4**

Description: This course is the first part of the two courses that introduces advanced problem solving in mechanics covering topics from an intermediate level book on mechanics.

Course Outcomes: After successful completion of this course, students shall be able to

1) Set up vector relations for most kinematic systems and identify the appropriate vector system for the problem at hand.

2) Distinguish between inertial and non-inertial frames, and successfully solve important dynamical problems using Fictitious forces.
3) Define and describe the significance of the Least action principle, and set up Lagrangians and Hamiltonians for simple systems, and solve them.
4) Distinguish what dynamical problems are more easily solved by the Work-Energy theorem than by Newtons laws and apply them successfully to obtain solutions.
5) Apply appropriate conservation laws for elastic and inelastic collisions.
6) Resolve the general motion of a rigid body system into translational and rotational motion; apply the ideas of central force motion and solve basic problems in planetary systems.
7) Set up differential equations for various types of oscillations and solve them; use the results to explain the observed oscillatory phenomena in nature.

Unit 1 Vector kinematics: displacement, velocity and acceleration from trajectories, vector form of uniform circular motion, formal solutions of kinematic equations, examples, motion in polar coordinates.
Dynamics: Newton's laws, the notion of mass, inertial systems and fictitious forces, applications, gravity, electric, contact, friction, spring, viscous and drag forces; Introduction to Lagrangian and Hamiltonian and qualitative ideas on least action principle.

Unit 2 Energy: First integral of equation of motion and work-energy theorem in 1D and 3D, examples of work, path dependence of work, potential energy, force from potential energy, stability of systems, energy diagrams, small oscillations in bound systems and harmonic approximation, molecular vibrations, non-conservative forces, general law conservation of energy, power; Irrotational and conservative forces, force as a gradient of potential energy and related mathematical theorems.

Unit 3 Momentum: Dynamics of system of particles, centre of mass, centre of mass motion, conservation of momentum, centre of mass and relative coordinates, impulse forces, mass flow and momentum, rockets, momentum transport by collision of particles and fluids. Conservation laws for particle collisions: elastic and inelastic collisions, collisions in 1D; Collisions in lab and centre of mass frames, collisions in 2D, scattering angle.

Unit 4 Rotation and Angular momentum: angular momentum and torque on a particle and system of particles, angular momentum in central forces; review and problems on dynamics of rotation about an axis and motion involving both translation and rotation.
Central force motion: Gravitation, general properties, two-body problem, energy equation and diagrams, first integrals and constants of motion, planetary orbits, Kepler's laws.

Unit 5 Oscillatory motion: Review of free oscillations and simple harmonic motion of mechanical and electrical systems; Damped oscillations: over damped and critically damped systems, decay and relaxation time, Q-value; Damped and driven systems: electrical and mechanical impedance, transient and steady state behaviour, frequency dependence of phase lag, resonance, Q-value, absorption bandwidth, amplification, linearity and superposition principle; Coupled oscillations of two masses; Introduction to transverse waves on a string: wave equation, boundary conditions, travelling and stationary solutions, momentum and energy transport.

References:

1. Kleppner and Kolenkov, Introduction to Mechanics, 2E (Ch. 1 – 7.)
2. C. Kittel et al, Mechanics – Berkeley Physics Course Vol. 1, 2E, McGraw-Hill. Ch. 1 – 7.
3. Patrick Hamill, Intermediate Dynamics, Jones and Bartlett Publishers
4. David Morin, Introduction to Classical Mechanics, CUP, Ch. 1 – 7.
5. R.P. Feynman et al, Feynman Lectures in Physics, Narosa publications.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY207	Introduction to Thermal & Modern Physics	3 1 0 4

Description: This course aims to gradually introduce basic concepts in thermodynamics, invite students to special relativity and quantum physics.

Course Outcomes: By the end of the course students will be able to develop an understanding, and be able to

CO1: apply concepts in temperature, thermal expansion, ideal gas laws, heat, conduction, convection, and radiation.

CO2: calculate work by thermodynamic systems, energy change, apply first law of thermodynamics, describe and apply kinetic theory, molecular speed distributions, apply to heat capacities, isothermal and adiabatic processes.

CO3: apply concepts of efficiency of heat engines, Carnot engine, describe irreversible processes and entropy property, identify distribution of energies from molecular speeds, and statistical connection of all thermodynamic properties.

CO4: describe and apply postulates of relativity, calculate length contraction, time dilation, relativistic Doppler-effect, relativistic momentum and energy, apply to relativistic collisions.

CO5: Describe a few quantum phenomena, need for quantum model, wave packets and explain uncertainties, wave-particle duality.

CO6: Describe and explain wave function, Schrodinger equation, probabilities, and basic principles of quantum mechanics, stationary states, application to simple one-potentials, quantized energy levels, barrier and tunnelling.

Unit 1 Temperature: Thermodynamic systems, temperature and the Zeroth law, temperature scales and thermometers, PT-100 and thermocouples, thermal expansion, ideal gases. The first law of thermodynamics: Heat and internal energy function, specific heat and calorimetry, heat capacities of ideal gases, latent heat, thermodynamic processes, applications; Energy transfer mechanisms: conduction, convection, and radiation. Elementary Kinetic Theory of Gases: Molecular model of ideal gases, kinetic calculation of pressure, kinetic interpretation of temperature, equipartition of energy, molar specific heat, isothermal and adiabatic processes.

Unit 2 The second law of thermodynamics: Heat engines, heat pumps, refrigerators, efficiencies, reversible and irreversible processes, loss of useful work, the Carnot, gasoline and Diesel engines, Clausius inequality, entropy function, entropy and the second law, entropy changes in reversible and irreversible processes. Invitation to statistical mechanics:

mean free path, distribution of molecular speeds, distribution of energies, Boltzmann distribution.

Unit 3 Invitation to Relativity: Galilean relativity, Michelson-Morley experiment, consequences of special theory of relativity: time-dilation, length-contraction, Lorentz transformations, relativistic velocity addition, relativistic momentum and energy.
Introduction to quantum physics: Blackbody radiation and Planck's hypothesis, photoelectric and Compton effects, particle nature of electromagnetic waves, electron diffraction, wave nature of particles, de Broglie quantum model of a particle, double slit experiment for particles and uncertainty principle, wave packets.

Unit 4 Quantum Physics: Schrödinger, equation, statistical interpretation, probability, normalization momentum, the uncertainty principle, postulates of quantum mechanics – an elementary approach.

Unit 5 Time independent Schrodinger equation, stationary states, infinite square well, harmonic oscillator, free particles, wave packets, finite square well, tunnelling through a potential energy barrier, alpha decay rate, simple harmonic oscillator (energy levels and basic discussions).

Textbooks/References
1. Serway and Jewett, Physics for Scientists and Engineers, 9e, Cengage Learning, 2013 (text for thermodynamics, relativity)
2. Arthur Beiser, Modern Physics, 6E. (origins of quantum physics)
3. D. Griffiths, Quantum Mechanics, 2E, Person (text)
4. Wolfgang Demtroder, Atoms, Molecules, Photons, Springer, 2006 (text)
5. Halliday, Resnick and Krane, Physics, Vol. 1, 4th Ed., Ch. 22 – 26, 21.
6. Halliday, Resnick and Krane, Physics, Vol. 1, 4th Ext. Ed., Ch. 49 – 56.
7. Wichmann, Quantum Physics – Berkeley Physics Course Vol 4, McGraw-Hill.

18PHY281	**Physics Lab II**	**0 0 3 1**

Suggested list of experiments are given. Equivalent experiments may be considered.

Course Outcomes: After successful complete of the course, students will be able to

CO1: perform basic experiments in electrical measurements in physics
CO2: apply measurement techniques, collect data, analyze data and draw interferences.
CO3: apply the basic electricity laws in physics and different circuit theories, bridges etc. and their applications
CO4: calculate errors in measurements
CO5: infer specified the basic electrical properties of matter and applications through experiments.
CO6: gain skills in using basic electrical instruments such as ammeter, voltmeter and galvanometer, etc., for various measurements.

1. Potentiometer – Measurement of resistance
2. Maximum power transfer theorem
3. Spot Galvanometer: determination of High Resistance
4. High resistance by leakage – RC circuit
5. Field along the axis of a circular coil with magnetic needle: Biot-Savart's law, Earth's magnetic field
6. Helmholtz coil (Field along the axis, Biot-Savart's law)
7. LCR circuit (Series and Parallel): frequency response
8. AC Bridges Anderson, Maxwell, DeSauty, Owen
9. Electric Field of metal sphere
10. Capacitance measurement and Dipole Moment of Organic Molecule and polar molecules.
11. Fourier Analysis using resonance circuit.

Skills: Lab sessions and experimentation help develop intuition for lab equipment and builds practical knowledge of using lab instruments, measurement techniques and experimental techniques needed for work involving communication of science such as lab instructor/ demonstrator, educator in schools, colleges and universities, technical staff and scientist in research labs, and builds skills needed for higher studies.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

Semester 4

18PHY211	**Intermediate Mechanics II**	**3 1 0 4**

Description: In continuation with part I, the following topics are covered: rotational motion and motion in accelerated frames, special theory of relativity, and elements of continuum mechanics.

Course Outcomes: By the end of the course students will be able to develop an understanding, and be able to
CO1: Describe Galilean transformation, apply to Michelson-Morley experiment, describe postulates of relativity, simultaneity of time, Lorentz transformation, apply to velocity addition, and few relativistic effects.
CO2: Describe relativistic momentum, mass-energy equivalence, conservation laws, four-vectors, Minkowski space, describe equivalence principle, apply to collisions and other relativistic effects.
CO3: Describe motion in linearly accelerating and rotating frames, Foucault pendulum, cyclones.
CO4: Describe rigid body motion, calculate angular momentum, kinetic energy, moments of inertia, apply Euler's equation for torque free wobble, calculate precession frequency of spinning top and gyroscopes.
CO5: Describe elastic properties of solids, deformations, stress, strain, their tensor nature,

elastic constants, equations of elasticity, strain energy, apply to compression, elongation, shear, torsion, and bending.
CO6: Describe fluid properties, fluid statistics, floating bodies, dynamics of fluid flow, laminar and turbulent flows, incompressible, irrotational flows, ideal and viscous flows, circulation and vorticity, Bernoulli's, and Navier-Stokes' equations, apply to simple cases: force on a dam, lift, flow through ducts, etc.

Unit 1 Special theory of relativity: Moving reference frames, Galilean transformation and consequences; Michelson-Morley experiment, postulates, relativity of simultaneity, time, and space, Lorentz transformations, time-dilation and length contraction, velocity addition, relativistic Doppler and a few other relativistic effects.

Unit 2 Relativistic dynamics: collisions, momentum, energy, conservation of energy, mass-energy equivalence, four-vectors, introduction to Minkowski space, invariant intervals, space-time diagrams; equivalence principle.

Unit 3 Accelerated frames: Linearly accelerated systems, pseudo-forces; rotating coordinate systems: velocity and acceleration, pseudo forces: centrifugal, Coriolis and Euler forces, weather systems and Foucault pendulum; Rigid body dynamics: angular velocity, angular momentum, kinetic energy, inertia tensor, principal axes, principal moments of inertia, Euler's equation, torque-free motion, gyroscope, precession of equinoxes.

Unit 4 Elements of solid mechanics: the concept of an elastic body, forces and deformations, elastic properties, internal forces: tension, compression, torsion; longitudinal and shear stresses and strains; General stresses, stress tensor, small deformations and strain tensor, equations of elasticity, elastic constants, Young's and Rigidity moduli and Poisson's ratio, strain energy, simple cases of compression, elongation, shear, torsion, and bending, wave equation in elastic solids.

Unit 5 Elements of fluid mechanics: fluid statics: fluid pressure, pressure distribution, basic ideas of equilibrium of floating bodies. Fluid motion: continuity equation, dynamics of a particle of an ideal fluid, vorticity and circulation, irrotational flow, Bernoulli's equation for stationary flow of an incompressible fluid and applications, rotating fluid; Viscosity and viscous flow, elementary discussion of Navier-Stokes equation and flow through a circular tube – results, elementary discussions of laminar flow and turbulence.

References:

1. Kleppner and Kolenkov, Introduction to Mechanics, 2E, Ch. 7 – 9, 12 – 13.
2. Patrick & Hamill, Intermediate Mechanics, Jones & Bartlett Learning.
3. C. Kittel et al, Mechanics – Berkeley Physics Course Vol. 1, 2E, Ch. 8 – 14, McGraw-Hill. Wheeler and Taylor, Space-time Physics.
4. J.R. Taylor, Classical Mechanics, University Science Books, (Especially for Ch. 16 on elastic solid and fluid mechanics)
5. David Morin, Introduction to Classical Mechanics, CUP, Ch. 8 – 14.
6. Marion and Thornton, Classical Dynamics of Particles and Systems, 5E.
7. Feynman Lectures in Physics, Vol 2, Ch. 31, 38 – 41.
8. Rana and Joag, Classical Mechanics, McGraw-Hill. Ch. 13, 14.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY212	Thermal and Materials Physics	3 1 0 4

Description: Continuing from previous introductory course on thermal and modern physics, this course aims to introduce more advanced concepts in thermodynamics, statistical mechanics and its application to properties of materials.

Course Outcomes: By the end of the course students will be able to develop an understanding, and be able to

CO1: Describe and apply equilibrium properties, equations of state, independent variables, differentials of properties of thermodynamic systems from more abstract point of view, distinguish between boundary energy transfer mechanisms (heat & work) and internal energy – system property, 1st law for differential and cyclic processes, heat capacities.

CO2: Describe and apply reversible and irreversible processes, Carnot theorem, thermodynamic temperature scale, Clausius inequality, entropy function, 2nd law inequality, principles of maximum of entropy and minimum of thermodynamic potentials, entropy changes, thermodynamic relations, apply for response functions, explain P-T diagram of phase transitions.

CO3: Describe and apply postulates of statistical mechanics, microstates – counting states, density of states and probabilities, counting quantum states of many identical particles, use Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics to explain properties of ideal gas, black-body radiation, specific heats of atoms, molecules, solids, and electrons in metals.

CO4: Describe, illustrate, identify Bravais lattices and crystal systems, crystal planes, determine cell volume, packing fraction, density, Miller indices, reciprocal lattices, Brillouin zones, conditions for X-ray diffraction, structure factors for cubic lattices, diffraction angles and identification of crystals.

CO5: Argue and visualize Drude and Sommerfeld models of electrons in metals, and Bloch electrons in crystals, calculate carrier densities and Fermi energy, apply motion in external fields, find effective mass and hole properties, electron transport, distinguish between metals, semiconductors, insulators, and semi-metals, Hall and thermoelectric coefficients.

CO6: Describe basic dielectric, optical, magnetic and superconducting properties of solids, apply principles to calculate some basic parameters of the theories.

Unit 1

Review of thermodynamics: equations of state for hydrostatic systems; Heat, work and change of state, process path, path dependence of work, first law, internal energy function, first law in the differential form, heat capacities; Reversible and irreversible processes, Carnot theorem, thermodynamic temperature scale (statement only), Clausius inequality, entropy function, differential form of the second law, entropy change of simple reversible and irreversible processes, principle of increase of entropy. Thermodynamic potentials: TdS relations, examples of response functions, enthalpy, Helmholtz and Gibbs free energies. Introduction to open systems and multiple components: chemical potential; basic ideas on maximum entropy & minimum energy principles and equilibrium, homogeneous systems and Gibbs-Duhem relation; Liquid-gas phase transition, phase diagrams, conditions for phase coexistence, Clapeyron equation.

Unit 2

Statistical physics: Ensembles and rules of Statistical Mechanics, Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac statistics; Ideal Maxwell-Boltzmann gas, ideal Fermi gas, ideal Bose gas and blackbody radiation.

Unit 3

Crystal structure: Fourteen Bravais lattices and seven crystal systems, crystal directions, crystal planes, Miller indices, simple crystal structures; basic ideas on interatomic forces and bonding; X-ray, electron and neutron diffractions, Bragg's law, X-ray diffraction of cubic lattices, structure factor.

Unit 4

Conduction in Metals: free electron gas model, density of states, Fermi surface, elementary theory of specific heat, DC electrical conductivity, temperature dependence of resistivity, thermal conductivity, Hall effect and magneto-resistance; DC electrical conductivity, Hall effect, ac-conductivity, and optical properties, failures of free electron model.
Basic band theory of electrons in crystalline solids: Bloch theorem, Kronig-Penny model, construction of Brillouin zones; conductors, semiconductors and insulators, energy spectrum near band edges, concepts of effective mass and hole.

Unit 5

Dielectric and optical properties: dielectric constant, polarizability, local field, dipolar polarizability, polarization, piezoelectricity, ferroelectricity, some optical properties of solids.
Magnetic properties: auxiliary field, magnetic susceptibility, classification, Larmor diamagnetism, Langevin Paramagnetism, Curie-Weiss law; Basic ideas on magnetism in metals, ferromagnetism, antiferromagnetism; ferro-magnetic domains, B-H curve.
Superconductivity: Zero-resistance, perfect diamagnetism, Meissner effect, critical field, intermediate state, type I & II superconductors; elementary ideas on electrodynamics of superconductors and theories of superconductivity, Josephson effect.

References

1. Zemansky & Dittmann, Heat & Thermodynamics, 8E, McGraw-Hill, 2017
2. Kerson Huang, Introduction to Statistical Physics, 2E, CRC Press (Indian Reprint), 2010.
3. M. Ali Omar, Elementary Solid-State Physics - Principles and Applications, Addison-Wesley, 1975 (text, for solid state physics)
4. C. Kittel, Solid State Physics, 8E, Wiley. (crystal structure, electrons, Kronig-Penny model, electron transport properties)
5. Ashcroft and Mermin, Solid State Physics (for elementary discussion on X-ray diffraction).
6. R.P. Feynman, Physics, Vol 2, Statistical thermodynamics of magnetic and dielectric properties.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY213   Atomic, Molecular And Nuclear Physics   3 1 0 4

Course Outcomes:

CO1: Review hydrogen atom to discuss its spectral outputs.

CO2: Explain the observed dependence of atomic spectral lines on externally applied electric and magnetic fields

CO3: State and justify the selection rules for various optical spectroscopy in terms of the symmetries of molecular vibrations

CO4: Discuss modern spectroscopic instruments with theoretical support. CO5: Describe basis nuclear properties.

CO6: Classify elementary particles and describe standard model.

CO7: Study Cosmic ray phenomenon and describe methods of investigations.

Contents:

Unit 1 Hydrogen atom: angular momentum, wave functions, atomic spectra, quantum numbers, vector atom model; intrinsic spin, magnetic dipole moment, basic ideas of addition of angular momenta, Landé g-factor, anomalous and normal Zeeman Effects, spin-orbit coupling and fine structure, hyperfine structure, Stark and Paschen-Back effect; Many-electron systems, Pauli's exclusion principle, Helium atom – singlet and triplet states.

Unit 2 Periodic table, Hund's rules, spectroscopic notation; X-rays: Production of X-rays, Auger effect, characteristics X-ray spectrum, Bremsstrahlung, Moseley's law, absorption of X-rays. Molecules: Hydrogen molecule, molecular binding – ionic and covalent bonds, bonding and anti-bonding orbitals, hybridized orbitals.

Unit 3 Molecular Spectra: electronic, vibrational levels, IR spectroscopy, rotational levels, microwave spectroscopy, Franck-Condon principle, Raman effect & spectroscopy,
Resonance Spectroscopy: NMR principle, resonance condition, chemical shift, indirect spin-spin interaction, applications of NMR spectroscopy; ESR: principle, resonance condition, hyperfine interaction, applications of ESR spectroscopy; Mossbauer spectroscopy: principle, isomer shift.

Unit 4 Structure and properties of atomic nucleus: nuclear charge, binding energy, angular momentum of the nucleus, magnetic moment, nuclear quadrupole moment, nuclear stability, models of nuclear structure, the liquid drop model, shell model, collective model; Radioactivity: alpha, beta, gamma rays, decay, half-life, radio isotopes and applications; Nuclear reactions: resonance, Q-value of a nuclear reaction, nuclear fission and fusion, nuclear reactors, breeder reactors, fusion reactors, ITER.

Unit 5 Cosmic rays: Discovery, latitude effect, altitude effect, primary cosmic rays, secondary cosmic rays, cosmic showers, origin of cosmic rays.
Particle physics: fundamental interactions in nature, classification of elementary particles, conservation laws, lepton and baryon conservation, strangeness, isospin, hyper-charge, resonance particles, the quark model.

Textbooks/References

1. Arther Beiser, Concepts of Modern Physics, TMH, 6E, 2006 (text)
2. Wolfgang Demtroder, Atoms, Molecules, Photons, Springer, 2006 (text)
3. Kenneth Krane, Modern Physics, Wiley-India, 2E 2006
4. Bemstein, Fishbane and Gasiorowic, Modern Physics, 1E, Pearson-India, 2003
5. Eisberg and Resnick, Quantum Physics of Atoms, molecules, solids, Nuclei and particles, Wiley-India,2E, 2006

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY219	Waves and Optics	3 1 0 4

Description: Wave phenomena is the foundation of development of modern communication technology as well as quantum physics; This course introduces theory of wave phenomena in matter, electromagnetic waves and light, interaction of light with matter, and elementary discussions of geometric optics, wave phenomena.

Course Outcomes: After successful completion of the course, students will be able to

1) Describe and apply concepts in oscillations in 1D and 2D, polarization, many coupled oscillations, mechanical and electrical filters,
2) Describe concepts of wave motion and apply to transverse wave motion on a string, describe and deduce phase velocity, dispersion, energy transport, characteristic impedance in forces oscillations, superposition, interference, reflection and transmission at a boundary, apply boundary conditions to deduce standing waves and quantized frequencies; Describe wave packets, phase and group velocities, understand bandwidth theorem for wave packets.
3) Describe basic ideas of waves in 2D and 3D, wave vector, cylindrical and spherical waves.
4) Describe concepts in sound waves and apply to explain Doppler effect, characterize intensities with decibels, shock waves.
5) electromagnetic waves and its origin from Maxwell's equation, energy and momentum transport, radiation pressure; Describe propagation of electromagnetic waves in dielectric media, dispersion relations, refractive index, reflection and transmission at boundary, concepts in polarization, method of polarizing a light and applications.
6) Describe and apply concepts in interference, multi-beam interference for Fabry-Perot interferometer.
7) Describe and apply concepts in (Fraunhofer) diffraction to single and double slits, gratings, Raleigh criterion and resolution of images, basic ideas on Fresnel diffraction.
8) Describe and apply basics of optics to fiber optics and holography.

Unit 1

Recap of concepts in oscillations: Summary of results of free, damped and driven oscillations in mechanical and electrical systems in 1D, linearity and superposition principle, Impedance in electrical and mechanical systems. Two degree of freedom systems: 2D harmonic oscillator, Lissajou's figures and the concept of polarization; oscillations in two and many coupled pendulums, normal modes; basic ideas on mechanical and electrical filters.

Transverse modes of a continuous string: wave equation, dispersion relation, phase velocity, energy flux, characteristic impedance in a forced oscillation, transmitter output power, energy transport.

Unit 2

Reflection and transmission at a boundary, matching impedances; standing waves, boundary conditions, quantized frequencies; wave and group velocity, band-width theorem (statement and application); Sound waves in gases, standard sound intensities – decibel, Doppler effect, shock waves; Basic ideas on plane waves in three dimensions, wave vector and wavelength, cylindrical and spherical waves.

Unit 3

Maxwell's equations and electromagnetic waves in vacuum, energy and momentum transport, radiation pressure; Basics of dispersion of light in dielectric media: index refraction, Cauchy's and Hartmann dispersion formula, anomalous dispersion, boundary conditions, reflection and transmission, Brewster angle; Polarization: linear and circular polarizations, dichroism, birefringence, polarization by specular reflection, Malus's law; polarizing devices & applications, optical activity.

Unit 4

Interference and Diffraction: coherent sources, division of wave-front and amplitude, Young's double slit experiment, intensity, interference from thin films, Michelson interferometer, Fabry-Perot interferometer – multi-beam interference; Diffraction by single and double slits, diffraction gratings, Raleigh criterion.

Unit 5

Introduction to Fiber Optics: numerical aperture, coherent bundle, pulse dispersion in step index fiber, graded index fiber, single mode fiber, multimode fiber, fiber optic sensors (qualitative), fiber optic communication (qualitative) and its advantages. Introduction to Holography: principles, recording of holograms, reconstruction of images (theory not needed), an application of holography, different types of holograms, transmission and reflection types.

Textbooks/References

1. H J Pain, Physics of Vibrations and Waves, 6E, Ch. 1 – 7, 9, 11.
2. E. Hecht and A.R. Ganesan, Optics, 4E, Pearson
3. Ajoy Ghatak, Optics, 4E, TMH, 2009
4. Halliday, Resnick and Krane, Physics, Vol. 1, 4th Ed., Ch. 15, 18, 19.
5. Halliday, Resnick and Krane, Physics, Vol. 2 Ext. 4th Ed., Ch. 40 – 47.
6. Frank S. Crawford, Waves – Berkeley Physics Vol 3 (SIE), Ch. 1 – 7. (RLC circuit oscillations and LC-transmission lines may be skipped).
7. Halliday, Resnick and Walker, Fundamentals of Physics, 10E, Ch. 15, 16, 17, 33, 35, 36.
8. A.P. French, Vibrations and Waves, Introductory MIT Physics Series, CBS

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY282	Physics Lab III	0 0 3 1

Suggested list of experiments are given. Equivalent experiments may be considered.

Course Outcomes: After successful complete of the course, students will be able to

CO1: perform basic experiments in optical measurements in physics

CO2: apply measurement techniques, gather data, and develop skills and analyze data, and draw inferences.

CO3: apply the basic wave theories in physics and their dependence with different mediums or properties of matter

CO4: calculate errors in measurements

CO5: infer specified the basic properties of laser, light and sound waves through different experimental phenomena associated in optics

CO6: gain skills to use basic electrical instruments such as spectrometer, grating, light sources etc.

Experiments:

1. Spectrometer – Prism, Sodium lamp:
(a) determination of refractive index (by measurement of angle of min. deviation.)
(b) dispersive power of prism
2. Spectrometer – Grating, Mercury vapour lamp: determination of prominent spectral line of Mercury using transmission grating
3. Laser diffraction: reflection grating determination of spacing between CD tracks and mm ruling of meter of scale
4. Laser diffraction: single and double slits, circular opening, wire, cross, wire mesh.
5. Polarization of light
(a) Brewster's angle
(b) Malus law of polarization
6. (a) Screen Based Apparatus for Ultrasonic Diffraction
(b) Resonance based Ultrasonic Interferometer
7. Velocity of sound using Kundt's Tube
8. Young's modulus by resonance of flexural vibrations of a steel bar
9. Rigidity modulus of a brass wire by resonance of torsional oscillations
10. Young's modulus and Poisson's ratio by Cornu's interference apparatus

Skills: Lab sessions and experimentation help develop intuition for lab equipment and builds practical knowledge of using lab instruments, measurement techniques and experimental techniques needed for work involving communication of science such as lab instructor/ demonstrator, educator in schools, colleges and universities, technical staff and scientist in research labs, and builds skills needed for higher studies.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

Semester 5

18PHY301	Classical Mechanics	3 1 0 4

Description: Building on the earlier two courses on intermediate mechanics, this course provides a survey of variational formalism of solving mechanics problems. This is a foundational course for post-graduate physics courses.

Course Outcomes: After successful completion of the course, students will be able to develop an understanding, and be able to

CO1: describe the fundamental concept of dynamics of a system of particles.

CO2: apply the Lagrangian and the Hamiltonian formalism for solving the equations of motion for any reasonable mechanical system.

CO3: describe basic ideas of motion in central potential, small oscillations, kinematics and dynamics of rigid bodies, and charged particles in magnetic field, relativistic particles, solve problems of reasonable complexity.

CO4: Describe and apply Poisson-bracket formalism, derive various Poisson brackets and equations of motion.

CO5: State and derive conditions for Canonical transformations, apply them to symmetry transformations, deduce invariants.

CO6: describe and explain Hamilton-Jacobi and Action-Angle formalisms, apply them for 1D oscillators, describe motion for other important problems in this formalism.

Unit 1

Review of Mechanics of a system of particles in vector form; Degrees of freedom, generalized coordinates, velocities, Principle of virtual work, d'Alembert's principle, generalized forces, Euler-Lagrange equations, Lagrangian, dissipation function, applications; transformations, symmetries, invariance, and conservation theorems; canonical momentum, cyclic coordinates, energy function and conservation of energy.

Unit 2

Variational method: Hamilton's variational principle, derivation Euler-Lagrange equations; Lagrangian formalism to systems with constraints.

Hamiltonian formalism: Legendre transformations, Hamiltonian, Hamilton's equations, applications, phase space and trajectories, charged particle in electromagnetic field, cyclic coordinates and conservation theorems; derivation of Hamilton's equations from variational principle in phase space, phase trajectories, applications; Introduction to Lagrangian and Hamiltonian formalism to relativistic particles.

Unit 3

Central force motion: two-body problem – reduction to equivalent one-body problem, first integrals of motion, equivalent 1D problem, classification of orbits, virial theorem, results for power-law potentials, conditions for closed of orbits (statement only), Kepler problem; Scattering orbits: scattering angle and cross section of Coulomb field.

Unit 4

Oscillations: An example of coupled oscillations and normal modes and coordinates, normal modes of infinite chain of coupled masses. Rigid body motion: rotations, Euler angles; Euler equation for rigid body, Lagrangian and Hamiltonian for heavy symmetric top – elementary discussions.

Poisson brackets: formalism and properties, fundamental and angular momentum Poisson brackets, Jacobi identity; Poisson brackets involving position, momentum, angular momentum, and Hamiltonian.

Unit 5

Canonical transformations: Point transformations in coordinate space and invariance of Euler-Lagrange equations; general transformations in phase space, conditions for invariance of Hamilton's equations, generating functions; infinitesimal canonical transformations, generators, invariance transformations, and conserved quantities; spatial translations, rotations, and time evolution as canonical transformations; Phase space, basic ideas (statements) on integral invariants and Liouville's theorem.

Introduction to Hamilton-Jacobi (H-J) theory: Hamilton's principal and characteristic functions, Harmonic oscillator as an example, separation of variables; action-angle variables: application to harmonic and quartic oscillators in 1D, results and discussion for Kepler problem.

References

1. H. Goldstein, C.P. Poole Jr, and J.L. Safko, Classical Mechanics, 3E, Pearson.
2. Rana and Joag, Classical Mechanics, McGraw-Hill Education.
3. M.G. Calkin, Lagrangian and Hamiltonian Mechanics, Word Scientific
4. Thornton and Marion, Classical Mechanics of Particles and Systems, 5E, Brooks/Cole.
5. L.D. Landau & E,M. Lifshitz, Mechanics – Course in Theoretical Physics Vol.1, 3E, Elsevier.
6. R. Shankar, Principles of Quantum Mechanics, 2E (revised), Springer. (A chapter on Summary of Classical Mechanics)
7. M. Tabor, Chaos and Integrability in Nonlinear Dynamics.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY302	**Mathematical Physics I**	**4 1 0 4**

Description: The course aims to develop student skill set in applying a variety of mathematical tools that are essential for solving a range of problems in different branches of physics like quantum mechanics, electrodynamics, statistical mechanics and other fields of theoretical physics.

Course Outcomes: After successful completion of the course, students will be able to develop an understanding, and be able to

1) recall vector analysis and apply to electrostatics, magnetostatics, and other applications.
2) solve problems involving vector and function spaces
3) tackle problems involving eigenvalue, change of basis, transformations, diagonalization and spectral decompositions of matrices
4) formulate elementary physical phenomena as Ordinary Differential Equations up to 2nd order and solve them
5) Use curvilinear coordinates to solve problems in electrodynamics
6) describe physical problems in hydrodynamics, material science and general theory of relativity using tensors

7) Solve problems in acoustics and other branches of physics using Fourier techniques
8) Review probability concepts and apply them to a few physics applications.

Contents:

Unit 1

Preliminaries: some special integrals using of Leibnitz theorem; summation notation, Kronecker delta, Dirac-delta function.

Review of vector calculus: scalar and vector fields and functions, differential operations: gradient, divergence and curl and their physical significance; Taylor series and extrema in one and many dimensions, integration: line, surface and volume integrals and theorems; curvilinear coordinates; applications to electrodynamics.

Introduction to tensors: index notation, rotation matrices in R3, Cartesian tensors, tensor operations, inertia and other important tensors in physics, transformation of tensors, Kronecker delta and Levi-Civita tensors; Laplacian expansion of determinants and vector cross product using Levi-Civita tensor, related identities, isotropic tensors, Pseudo-vectors and pseudo-tensors, curvilinear coordinates, non-Cartesian tensors, Covariant and Contra-variant tensors, metric tensor.

Unit 2

Review of linear algebra: vector spaces, inner product, orthonormality and completeness, Dirac notation, transformations and linear operators, matrices of transformations, change of basis and transformation of matrices, special matrices, Pauli and Dirac matrices, direct sum and product of matrices, block matrices: basic operations, eigenvalue problem, diagonalization of matrices, spectral decomposition of Hermitian matrices, simultaneous diagonalization of two commuting matrices.

Unit 3

Function spaces: linear independence of functions and Wronskian, linear vector space of square summable sequences and square integrable functions, inner product, Hilbert space, orthogonal functions, orthogonal expansions; Fourier series as orthogonal expansion; Bessel inequality, convergence in the mean, completeness (statement and application only); expansions of Dirac-delta function; Construction of orthogonal polynomials, Rodrigues formula (results only); Fourier transform as orthogonal expansion; Linear operators in function spaces: examples, commutators, inverse and adjoint of operators, basis expansion of operators and matrix representation, Hermitian and unitary operators, change of basis.

Unit 4

Brief review of ordinary differential equations and power series solutions to second order ODEs; Review of Sturm-Liouville problems: Legendre, Hermite, Laguerre polynomials, and Bessel functions– Rodrigues formulas, orthogonality and completeness (statement and application), generating functions and integral representations, series expansions.

Unit 5

Probability theory: Counting in MB, FD and BE statistics, random variables, probability distributions and probability densities, standard discrete and continuous probability distributions, moments and generating functions, central limit theorem (statement and applications);Poisson process.

References

1. Arfken & Weber, Mathematical Methods for Physicists, 7E
2. Mathews and Walker, Mathematical Methods in Physics, 2E,
3. Hobson, Riley and Bence, Mathematical Methods for Physics and Engineering, 3E, CUP.
4. Mary L Boas, Mathematical Methods in Physical Sciences, 3E, Wiley India
5. R. Shankar, Principles of Quantum Mechanics, 2E, (Ch 1), Springer India
6. Dennery and Krzywicki, Mathematical Methods for Physicists (Advanced text)
7. E. Keyszig, Advanced Engineering Mathematics, 10E, Wiley India.
8. Sean Mauch's Lecture notes on "Advanced Mathematical Methods for Scientists and Engineers, 2001 (Online)

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY303	**Electrodynamics I**	**3 1 0 4**

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

1. Become proficient in Mathematical techniques (notation, definitions, identities, theorems and transformations) that play an important role in the study of Electromagnetism.

2. Gain understanding of Electrostatics and demonstrate its application – Summation and boundary value problems, and calculation of electric field associated with various charge distributions – mainly summation problems. Student will also learn about Rot and Div of electrostatic electric field, their Integral and Differential forms & role of symmetry in computing fields, besides matching conditions for the field.

3. Gain understanding of analytic methods to solve Laplace and Poisson's problems, Uniqueness of Poisson's equation in spaces (vacuum or linear dielectric) bound by conductors, and Image problems. Student will also learn about Laplace equation, discussion of solutions with varying symmetry, besides the electric multipoles and multipole expansion as a systematic approximation for the potential

4. Conceptual understanding of conducting matter, electrostatic induction and dielectric matter. Learn about Polarization, its physical meaning and the field produced. Understand concepts behind total and auxiliary fields, Dielectric responses and energy

5. Gain understanding of Magnetostatics – Concept of vector current density, Lorentz force and the important point that different types of currents produce magnetic fields – electric and magnetization, besides the comparison of magneto- and electrostatic equations and understanding the fact that their differences helps in building physical intuition and calculation skill. Student will also learn about Rot and Div of magnetostatic magnetic field, their Integral and Differential forms & role of symmetry in computing fields, besides matching conditions for the field

6. Learn the concepts behind magnetic scalar and vector potentials, and magnetic field produced by various current distributions involving symmetry. Understand the concept of magnetic multipoles and the systematic scheme of magnetic multipole expansion

7. Physical meaning behind magnetic matter – response of matter to static magnetic field, magnetization, Field produced by magnetized matter, Total and auxiliary fields, and energy

Unit 1

Electrostatics: Electrostatic fields of charge distributions, electric flux, divergence of electric fields and Gauss law and applications; Curl of electric fields, line integral, potentials and its gradient, work and energy, conductors.

Unit 2

Calculation of potentials: Laplace's and Poisson's equation, boundary-value problems in electrostatics, metal sphere in uniform external field, method of images, multipole expansion, and Green's functions.

Unit 3

Electrostatic fields in matter: Dielectrics, induced dipoles, polarization, field of a polarized object, bound and surface charges, filed inside a dielectric, electric displacement, linear dielectrics, boundary value problems, dielectric sphere in uniform external field, spherical cavity in a dielectric solid.

Unit 4

Magnetostatics: Lorentz force and elementary applications; Biot-Savart and Ampere law and application to simple current distributions, the divergence and curl of B, magnetic vector potential.

Unit 5

Magnetostatic fields in matter: summary of magnetic properties of matter, torques and forces on dipoles, dipole-dipole interaction; Magnetization, the field of a magnetized object, bound currents, magnetic field B inside matter and the auxiliary field H, fields in linear media, susceptibility.

Textbooks/References

1. D. Griffiths, Electrodynamics, 2E, Ch. 2 – 6.
2. Purcell, E.M., and Morin, D.J., Electricity and Magnetism (Berkeley Physics Series Vol.2), 3E, McGraw-Hill.
3. A. Zangwill, Modern Electrodynamics, CUP (2013).
4. J.D. Jackson, Classical Electrodynamics, 3E, Wiley India.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY304	Electronics I	3 1 0 4

Description: To provide an overview of the design principles of electronic circuits, involving diodes, transistors, amplification and feedback. By the end of this course, students are expected to be able to understand simple circuits, and design new circuits on their own.

Course Outcomes: After successful completion of the course, students will be able to develop an understanding, and be able to

1) Describe basic concepts regarding semiconductor p-n junction devices and identify their unique properties for device applications.

2) solve different electrical networks based on theorems
3) To develop the knowledge regarding the use of transistors and diodes for different scientific and household applications
4) To analyse and troubleshoot an amplifier circuit.

Contents:

Unit 1: Basic concepts of semiconductors: conduction and doping, PN junction, diode characteristics, forward bias, reverse bias, static and dynamic resistance, junction capacitance, Diode approximations, equivalent circuit, Zener and avalanche breakdown, Heterojunction; Thevenin and Norton's theorems, Voltage and current source; Diode circuits - Rectifiers half wave and full wave efficiency and ripple factor, Voltage multiplier, clipper and clamper circuits. Filters: Capacitor, RC and LC filters; Special purpose diodes Zener, Schottky diode, Varactor, Tunnel diode.

Unit 2: Bipolar Junction transistor: the transistor action, transistor current components, Modes of operation, common base, common emitter and common collector configurations, Current voltage characteristics of CB, CE, CC configuration, current gain, Early effect, DC load line, Q-point, saturation and cut-off regions; Transistor biasing: Base bias, Emitter bias, transistor switch, voltage divider bias, self-bias, collector feedback bias, stability factor.

Unit 3: AC Models: ac resistance of the emitter diode, ac input impedance, ac load-line, ac-equivalent circuits - T-model, Pi-model, Transistor hybrid model- determination of h-parameters from characteristics, analysis of a transistor amplifier using h-parameters, comparison of amplifier configurations, simplified h-model; Voltage amplifiers voltage gain, DC, RC, transformer coupled amplifiers, frequency response of RC coupled amplifiers, cascading CE & CC amplifiers, Darlington pair.

Unit 4: Feedback circuits: Positive and negative feedback-advantages of negative feedback-input and output resistances-voltage series and current series feedback-frequency response of amplifiers with and without feedback.

Unit 5: Power amplifiers: Class A, Class B, Class C amplifiers, Push pull amplifiers; Oscillators: Wien bridge oscillator, Colpitts oscillator, phase shift oscillator, resonant circuit oscillators, crystal oscillator, square wave and triangle wave generators, Schmitt trigger, 555, multivibrators.

Textbooks/References

1. A. Malvino and D. J. Bates, Electronic Principles, 8E, McGraw-Hill, 2015
2. J. Millman, C. C. Halkias and S. Jit, Electronic Devices and Circuits, Tata McGraw Hill, 2007.
3. S. M. Sze, Semiconductor Devices, Physics and Technology (2nd Ed.), Wiley India, 2008.
4. T. L. Floyd and R. P. Jain, Digital Fundamentals (8th Ed.), Pearson Education, 2005.
5. R.L. Boylestad, Introductory Circuit Analysis, 12E, Pearson
6. R.L. Boylestad and L Nashelsky, Electronic Devices and Circuit Theory, 11E, Pearson

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY386	**Physics Lab IV**	**0 0 3 1**

Suggested list of experiments are given. Equivalent experiments may be considered. Experiments may include error analysis.

Course Outcomes: After successful complete of the course, students will be able to

CO1: perform basic experiments in modern physics.

CO2: apply measurement techniques, efficiently collect data, develop skills and analyze, and draw inferences.

CO3: infer specified properties from standard and fundamental heat and thermodynamic related experiments in different forms of matter.

CO4: calculate errors in measurements.

CO5: get exposed to and familiarized with some of the fundamental path breaking experiments in modern physics such as photo electric effect, Thomson model, Millikan's oil drop experiments.

CO6: perform some of the advanced level experiments to strengthen students' caliber towards research and development for e.g. solar cell characterization etc.

Experiments:

1. Heat capacity of gases
2. Thermal diffusivity of brass
3. Calibration of thermometers: Thermocouple & Si-Diode
4. Temp. Coefficient of Resistance of Copper
5. Thermal Relaxation of Bulb
6. Stefan's Constant
7. Franck-Hertz experiment
8. Photo electric effect, Verification of inverse square law of radiation using photoelectric cell
9. Solar cell characterization
10. (a) e/m measurement using Millikan Oil drop (force on a charge in E field, gravity)
    (b) e/m measurement by Thomson's method (Lorentz force, motion in magnetic field)

Skills: Lab sessions and experimentation help develop intuition for lab equipment and builds practical knowledge of using lab instruments, measurement techniques and experimental techniques needed for work involving communication of science such as lab instructor/ demonstrator, educator in schools, colleges and universities, technical staff and scientist in research labs, and builds skills needed for higher studies.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY387	**Physics Lab V**	**0 0 3 1**

A minimum of 10 experiments from suggested list of experiments can be chosen. Equivalent experiments may be considered.

Course Outcomes: After successful completion of the course, students will be able to

1) perform the experiments using different p-n junction devices and its analysis
2) identify the characteristics of transistor and operational amplifiers.
3) design circuits using transistors for different applications and its analysis
4) develop basic skill in using op-amp, apply, design circuits for different applications

Experiments:

1. Diode Characteristics & Gates using Diodes
2. Diode Rectifiers
3. Zener Diode Voltage Regulator
4. Photo-diode Characteristics (Intensity vs. Photo current, dark resistance of photo diode)
5. Transistor Characteristics (CE and CB)
6. Transistor as a Switch and Amplifier
7. Phase-shift &Wein-bridge Oscillators (Transistor)
8. Multivibrator (Transistor) Astable, Monostable and Bistable - Using Op Amp
9. FET Characteristics and Amplifier using FET
10. SCR, Triac, Diac Characteristics
11. Experiments based on operational amplifier (741) all the basic circuits.
12. Op-Amp Inverting and Non-inverting amplifiers (Frequency Response)
13. Op-Amp Mathematical Tools (Addition, Integration, Differentiation)
14. Voltage Amplifier with coupling capacitor with feedback
15. Power amplifier Push-pull class A type
16. Square, Triangular & Saw-tooth wave generators using Op-amp

Skills: Lab sessions and experimentation help develop intuition for lab equipment and builds practical knowledge of using lab instruments, measurement techniques and experimental techniques needed for work involving communication of science such as lab instructor/ demonstrator, educator in schools, colleges and universities, technical staff and scientist in research labs, and builds skills needed for higher studies.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

Semester 6

18PHY311	**Mathematical Physics II**	**3 1 0 4**

Description: This the second course aims to develop student's in-depth understanding of the advanced topics and a skill set in applying a variety of mathematical tools that are essential for solving a range of problems in different branches of physics like quantum mechanics, electrodynamics, statistical mechanics and other fields of theoretical physics.

Course Outcomes: After successful completion of the course, students will be able to develop an understanding, and be able to

1) To impart in Mathematics with a view to apply them to solve the problems in physics.
2) Apply techniques of complex analysis like the concept of singularity, Cauchy's theorem, multiple value functions, branch points etc. to solve problems in contour integration.

3) Solve problems related applications in Fourier and Laplace transforms, convolution and other theorems.
4) Solve problems in vector and function and Hilbert spaces, including Parseval's theorem, Bessel inequality etc.
5) Recognize how physical phenomena are modelled using PDEs and solve problems related to PDEs using methods of separation of variables, transforms, eigenfunction expansions.
6) Apply concepts in group theory like discrete groups and continuous (Lie) groups, rotation group in 2-D and 3-D, U(1) and SU(2), SO(3) identify their use in physics.

Unit 1

Complex analysis: review of complex numbers, examples of functions of complex variables, analytic functions, contour integration, Cauchy's theorem, singularities, multiple valued functions and branch point and branch-cuts.

Unit 2

Complex power series, convergence, radius of convergence; Taylor & Laurent series, analytical continuation; Residue theorem, evaluation of definite integrals, Principal value, summation of series; Gamma and Beta functions, Sterling approximation.

Unit 3

Integral transforms: Fourier and Laplace transforms, inverse transforms using complex integration, Parseval's theorem, Convolution theorem, applications.

Calculus of Variations: Functionals, natural boundary conditions, Lagrange multipliers, Rayleigh-Ritz method.

Unit 4

PDE: Laplace, Poisson, diffusion, wave, Helmholtz equations, method of separation of variables, method of eigenfunction expansions, summary of results in various geometries; solution using Laplace and Fourier transform techniques. Green's functions: Green's functions for harmonic oscillator, Laplace, Helmholtz, and wave equations.

Unit 5

Group theory: Elements of group theory; discrete groups with examples; continuous groups (Lie groups), rotation group in 2 and 3 dimensions, U(1) and SU(2), SO(3), generators; (If time permits: Representations, Character tables for some point groups and the orthogonality theorem).

References:

1. Arfken& Weber, Mathematical Methods for Physicists, 7E
2. Mary L Boas, Mathematical Methods in Physical Science, 3E, Wiley India
3. Mathews and Walker, Mathematical Methods in Physics, 2E, Pearson
4. K.F. Riley, M.P. Hobson, S.J. Bence, Mathematical methods for physics and engineering, 3ed., CUP, 2006.
5. Sean Mauch's Lecture notes on "Advanced Mathematical Methods for Scientists and Engineers, 2001

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY312	**Electrodynamics II**	**3 1 0 4**

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

1. Explain concepts of electrodynamics, and write down Maxwell's equations in linear, isotropic, homogeneous, and magnetic & dielectric media
2. Derive electromagnetic wave solutions and propagation in vacuum, dielectric and other media. Explain transport of energy, Poynting vector and momentum and Maxwell stress tensor, radiation pressure.
3. Show laws of geometric optics originate with Maxwell's equations at dielectric boundaries. Calculate reflection and transmission coefficients for waves at dielectric boundaries
4. Explain gauge invariance of Maxwell's equations, solve for retarded potentials and electric and magnetic fields for simple problems involving time-dependent charge-current distributions
5. Explain the term radiation zone and derive angular distribution of and power emitted by a dipole.
6. Derive fully covariant forms of Maxwell equations, Lorentz gauge condition and continuity equation. Obtain Lorentz transformations for electric and magnetic fields and apply to simple cases
7. Derive Lienard-Wiechert potentials for a moving point charge and also corresponding electric and magnetic fields. Show that acceleration of the charge gives electromagnetic radiation. Apply to cases of charges – slowly accelerating at low velocities, undergoing acceleration collinear with velocity; and in a circular orbit (synchrotron radiation)

Unit 1

Electrodynamics: electromotive force, motional emf; electromagnetic induction: Faraday's law, induced electric field, inductance and mutual inductance, energy in magnetic fields; changing electric fields, Maxwell's equations in vacuum and matter, boundary conditions.

Unit 2:

Conservation laws: Poynting vector and continuity equation, conservation of electro-mechanical energy, momentum and angular momentum, Maxwell stress tensor.

Recap of concepts in waves; Electromagnetic waves: wave equation for electric and magnetic fields, plane waves, polarization, energy and momentum; Propagation in linear media, reflection and transmission, Fresnel's equation, total internal reflection and evanescent waves and tunnelling; Absorption and Dispersion: electromagnetic waves in conductors: skin depth, reflection at a conducting surface; EM waves in dielectrics: frequency dependence of permittivity, dispersion, complex susceptibility and complex permittivity, absorption, anomalous dispersion, Cauchy's formula.

Unit 3

Guided waves: propagation EM waves in wave guides, TE, TM and TEM waves, TE and TM waves in rectangular waves; Coaxial transmission lines, resonant cavity.

Potentials and Fields: gauge transformations, Coulomb and Lorentz gauges, wave equations for potential form; Fields of a moving charges: retarded and advanced potentials, Jefimenko equations, Lienard-Wiechert potentials, fields of moving point charges.

Unit 4

Radiation: Electric and magnetic dipole radiations, radiation from arbitrary sources, radiation by a point charge accelerating linearly and in circular motions, radiation reaction.

Review of special theory of relativity: Lorentz transformation, 4-vector notation, Minkowski metric, space-time and energy-momentum 4-vectors.

Unit 5

Relativistic Electrodynamics: particle under constant electric and magnetic fields; Relativistic electrodynamics: magnetism as relativistic phenomena, transformation of fields; Electrodynamics in tensor notation, relativistic four-potentials, field tensor, gauge invariance, Maxwell's equations, and invariance under Lorentz transformations; Introduction to Lagrangian and Hamiltonian formalism in electrodynamics of particles and fields.

References

1. D. Griffiths, Electrodynamics, 4E. (Ch. 7 – 12).
2. A. Zangwill, Modern Electrodynamics, CUP (2013).
3. J.D. Jackson, Classical Electrodynamics, 3E, Wiley India.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY313	Statistical Mechanics	3 1 0 4

Description: This is a basic course for students of physics. It provides an introduction to the microscopic understanding of thermodynamic systems via the laws of statistical mechanics and applies this to various ideal and non-ideal systems.

Course Outcomes: After successful completion of the course students will be able to develop an understanding, and be able to

1) describe and apply principles of macroscopic thermodynamic properties of systems.
2) summarize and apply laws of probability for random walk, density fluctuations in gas.
3) describe micro and macro states and fundamental postulates, statistical approach to thermodynamics – statistical mechanics, apply to ideal gas and other systems.
4) describe and apply the formalism to systems that can exchange energy and particles, and systems containing identical particles to explain from more advanced perspective electrons in metals, black-body radiation, specific heat of atoms, molecules, electrons in solids.
5) describe interacting statistical mechanics of interacting spins and phase transitions, and phenomenology of liquid-gas transitions and universality, apply to estimate parameters of the theory.

Unit 1

Foundations: macroscopic vs. microscopic descriptions, a basic summary of thermodynamics, open systems, thermodynamic potentials, minimum & maximum principles, homogeneity principle and Gibbs-Duhem relation, response functions, phase transition and Clapeyron equation; Review of probability: random variables, probability distributions, statement of central limit theorem, relative fluctuation in large systems; Examples: random walk on a 1-d lattice, continuum limit, Brownian motion, diffusion equation, density fluctuations in gases.

Unit 2

Statistical description: specification of states, micro and macrostates in quantum and classical systems, phase space, trajectories, density of states; time and ensemble averages, Liouville theorem, ergodicity and the fundamental postulate; Ensembles, microcanonical ensemble – postulate of equal a priori probabilities – connection with thermodynamics, probability calculations with spin system, classical ideal gas, entropy of mixing and Gibb's paradox.

Unit 3

Canonical and grand canonical ensembles of quantum and classical systems: systems in equilibrium with energy and particle exchanges, partition functions, connection with thermodynamics and calculation of thermodynamic quantities, energy and density fluctuations; examples: classical and quantized systems of ideal gases, magnetic or spin systems, harmonic oscillator; density and velocity distributions, equipartition of energy, specific heat and chemical potential of classical ideal gases.

Unit 4

Statistics of indistinguishable particles: Maxwell-Boltzmann, Fermi-Dirac and Bose Einstein statistics, properties of ideal Bose and Fermi gases, degenerate Fermi gases, Planck's distribution law of black-body radiation, Bose-Einstein condensation.

Unit 5

Interacting systems and phase transitions: thermodynamics of magnetic systems, paramagnetism; Ising model – exact solution in one dimension, mean field theory of ferromagnetic transition; Phenomenology of liquid-gas system: Van der Wall's equation of state, liquid-gas transition, first & second order phase transitions, order parameter, critical exponents, comparison with magnetic system, scaling, universality.

Textbooks/References:

1. Silvio Salinas, Introduction to Statistical Physics, Springer Indian, 2006.
2. F Reif, Statistical Physics, Berkeley Physics Vol 5, TMH
3. F Reif, Foundations of Statistical and Thermal Physics, TMH, 1E, 2011.
4. Tobochnik and Gould, Thermal and Statistical Physics, Princeton University Press, 2010
5. Kerson Huang, Introduction to Statistical Physics, 2E, CRC Press (Indian Reprint), 2010. (Ch.1-4, 10)
6. Zemansky & Dittmann, Heat & Thermodynamics, 8E, Ch. 1 – 10, selected parts of Ch.12 and 13.
7. R.K. Pathria, Statistical Mechanics, 3E, Elsevier India.
8. Kerson Huang, Statistical Mechanics, 2E, Wiley India, 1987.
9. Landau and Lifshitz, Statistical Physics, Pergamon Press.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY314 Quantum Mechanics I 3 1 0 4

Description: This course is a foundational pre-requisite for many advanced courses in physics and chemistry, and is indispensable for understanding the behaviour of molecules, atoms and elementary particles.

Course Outcomes: After successful completion of the course students will be able

CO1: identify inadequacy of classical mechanics and need for quantum model, wave function, Schrodinger equation, probabilities, apply probability conservation, describe classical-quantum correspondence, wave-packets, uncertainty relations.

CO2: apply Schrodinger equation for simple one-dimensional potentials to obtain energy spectrum, identify scattering and bound states, calculate reflection, transmission coefficients of steps and barriers.

CO3: describe and apply of concepts of vector spaces, Hilbert spaces, inner products, orthogonality, completeness.

CO4: describe postulates of QM, precisely describe quantum states, observables and operators, commutators, eigenvalues, measurements, uncertainties, orthonormal bases and representations, matrices.

CO5: describe quantum dynamics, propagator and unitary transformation, operator methods, apply them two and many level systems.

CO6: apply Schrodinger equation to three-dimensional rectangular and spherical infinite potential wells, Coulomb potential, angular momentum eigenvalue problems, apply properties of special functions for wave functions, identify and characterize simultaneous eigenstates of L_z, L^2, and H with respective quantum numbers.

CO7: describe many particle systems, symmetry of wave functions, Pauli's principle and statistics of identical particles, and write down wave functions and product states for simple cases.

Unit 1

Foundations: Electron diffraction, Wave-particle duality, and transition from classical to quantum mechanics, wave function, Schrodinger equation, probability, probability currents, continuity equation for probability; elementary discussion of expectation values, operators, measurement, uncertainty relations. Stationary states: eigenstates and energy eigenvalues of Hamiltonian and elementary discussions on interpretation of eigenvalues, eigenfunctions, and eigenfunction expansions and coefficients; conditions on wave functions.

Unit 2

Particle in one-dimensional potentials: energy spectrum and related properties of eigenstates of particle in a box and circular ring; Free particles states, wave packet, and spread of a wave packet; step and barrier potentials.

Unit 3

Mathematical Foundations and Postulates: Review of vector and Hilbert spaces; Postulates, quantum state and wave function, superposition principle; observables, Hermitian operators, eigenvalue problem – discrete and continuous spectrum; measurement and probabilities, expectation values, collapse of wave function; incompatible observables and uncertainty relations; compatible observables, commuting operators, simultaneous eigenstates.

Unit 4
Quantum Dynamics: time evolution, Ehrenfest theorem, connection with classical Poisson bracket formalism; position, momentum and energy bases and representations. Harmonic oscillator: operator and algebraic methods, coherent states.

Unit 5
Commutation relations, angular momentum eigenstates – spherical harmonics – eigenvalues.
Central force potentials: radial equation, 3D spherical square well potential, Hydrogen atom.
Introduction to many-particle systems: two-particle and many-particle product states, separable and interacting potentials, identical particles: spin and statistics, symmetric and anti-symmetric wave functions.

Textbooks:

1. R. Shankar, Principles of Quantum Mechanics, Pearson India (LPE), 2E 2005
2. David Griffiths, Introduction to Quantum Mechanics, Pearson India (LPE), 2E, 2005

Reference Books:

1. L I Schiff, Quantum Mechanics, TMH, 3E, 2010
2. J.S. Townsend, A Modern Approach to Quantum Mechanics, 1E, Viva Books, 2010
3. JJ Sakurai, Modern Quantum Mechanics, Pearson, 1E, 1994
4. S Gasiorowicz, Quantum Physics, Wiley India, 2E

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY315	**Electronics II**	**3 1 0 4**

Description: Building on the first course, this course focuses on advanced topics in electronics op-amps, waveform generators, digital electronic circuits.

Course Outcomes: After successful completion of the course, students will be able to develop an understanding, and be able to

1) Explain the basic concepts and workings of Field-Effect-Transistors and operational amplifiers and identify their properties for applications.
2) Design op-amp based circuits for different applications.
3) Describe and apply the digital electronic and logic gate circuits.
4) Analyse digital logic gate circuits and write its truth table for design of digital circuits.
5) Describe analog to digital conversion and memory devices and identify areas of applications.

Unit 1 FETS, characteristics, small signal model, common source and common drain amplifiers, biasing; MOSFET; Silicon controlled rectifiers, SCS, Diac, Triac, characteristics and applications.

Unit 2 Operational amplifiers: actual circuits of operational amplifiers, uses as amplifiers, analog circuits: adding, integration and differentiation circuits, comparators, waveform generators, logarithmic generators.

Unit 3 Binary number systems, binary-decimal conversions, hexadecimal and Octal numbers, BCD, Gray code, ASCII code; Boolean algebra, Laws of Boolean algebra, De Morgan's theorem, Simplification of Boolean expressions, Karnaugh Map; Logic gates; Combinational logic circuits, deriving the truth table, designing combinational logic from truth table; NAND and NOR gates.

Unit 4 Half adder, full adder, look-ahead-carry implementation, magnitude comparators, decoders, encoders, multiplexers, demultiplexers; Flip-flops - RS, D, JK flip-flops, multivibrators; Registers, Shift registers, different types, shift register applications; Counters; Synchronous and asynchronous counters, counter applications; D/A and A/D conversions.

Unit 5 Memories ROM, PROM and EPROM, RAM, special memories and applications; Integrated CMOS, PMOS and NMOS; Microprocessors architecture, addressing modes, 8085, 8086 microprocessors, peripheral devices, microcontrollers.

TEXTBOOKS/REFERENCES

1. A. Malvino and D. J. Bates, Electronic principles, McGraw-Hill, 2006.
2. J. Millman, C. C. Halkias and S. Jit, Electronic devices and circuits, Tata McGraw Hill, 2007.
3. J. Millman, C. C. Halkias and C.D. Parikh, Integrated electronics, 2E, Tata McGraw Hill, 2009.
4. S. M. Sze, Semiconductor Devices, Physics and Technology (2nd Ed.), Wiley India, 2008.
5. T. L. Floyd and R. P. Jain, Digital Fundamentals (8th Ed.), Pearson Education, 2005.
6. M. Morris Mano and M. D. Ciletty, Digital Design (5th Ed.), Pearson Education, 2013.
7. R. S. Gaonkar, Microprocessor architecture, programming, and applications with 8085, Prentice Hall, 2002.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY383	**Physics Lab VI**	**0 0 3 1**

(A minimum of 10 experiments from suggested list of experiments can be chosen. Equivalent experiments may be considered.)

Course Outcomes: After successful completion of the course, students will be able to

1) Study an oscillator circuit and analyse its performance using transistor and 555-timer
2) draw the frequency response curve of different fitter circuits
3) perform basic experiments using differentia amplifier and logic gates
4) demonstrate skills in the basic of microprocessor programming

Experiments:

1. Voltage Controlled Oscillator (Transistor): Variation in frequency with control voltage; Voltage Controlled Oscillator (555 timer): Variation in frequency with control voltage
2. Colpitts& Hartley Oscillators (Transistor)
3. Low-pass, High-pass, Signal Filter, Band Pass and Band Reject Filters (First and Second

Order) Frequency Response
4. Differential Amplifier using transistor CMRR, Frequency responses (Common and Diff. Modes)
5. Bridge rectifier and regulator circuits using DSO
6. Amplitude modulation: modulation index for different amplitudes of audio signal.
7. AND, OR, NOT, NAND, NOR, XOR Verification, Boolean Algebra verification of DeMorgan's theorem
8. Combination of gate universal building blocks NAND, NOR
9. Encoders and Decoders 4 bits
10. Half adder, Subtractor, Full adder IC 7483s
11. Counters 4 bits; Registers 4 bits
12. Multiplexing and de-multiplexing
13. SR & JK Flip-flops
14. Decade Counters with seven segment Display
15. A/D and D/A Converters
16. Microprocessor programming: multiplication / bubble sorting
17. Microprocessor programming: A/D Converter
18. Microprocessor programming : Stepper Motor

Skills: Lab sessions and experimentation help develop intuition for lab equipment and builds practical knowledge of using lab instruments, measurement techniques and experimental techniques needed for work involving communication of science such as lab instructor/ demonstrator, educator in schools, colleges and universities, technical staff and scientist in research labs, and builds skills needed for higher studies.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

Semester 7

18PHY505	Condensed Matter Physics I	3 1 0 4

Description: This course builds on the elementary treatment of the subject at the undergraduate level. The objective is to understand the properties of solids based on the principles of quantum and statistical physics at an advanced level. A basic background in Classical Mechanics, Quantum Mechanics I, and Statistical Mechanics courses, and basic mathematical methods are essential. This is an important foundational course for physics of materials and solid-state devices.

Course Outcomes: After successful completion of the course students will be able to develop an understanding, and be able to

1) apply the concepts of Bravais lattices and crystal symmetry and classification, periodic functions in crystals, reciprocal lattices, crystal planes, X-ray diffraction to identify crystals, relate lattice plane and reciprocal lattices, find structure factor, and scattering angles.
2) describe and apply classical and quantum models of free electrons in crystals to calculate

density of states and thermal, electric and other transport coefficients.

3) describe and apply electrons in periodic potential, Bloch theorem for calculations in Kronig-Penny model, nearly free electron and tight-binding approximations, Fermi energy, Fermi surface, density of states.
4) describe semiclassical equations and limits of validity and apply them to explain band insulators, effective mass, holes, cyclotron resonance, classical & quantum Hall, and dHVA effects, measuring Fermi surface parameters.
5) describe and apply concepts in semiconductor physics: direct and indirect gap semiconductors, impurity levels, carrier densities, majority carriers, drift, diffusion, recombination and Einstein's relation in inhomogeneous semiconductors.

Unit 1 Concepts in crystal symmetry and structure, Bravais lattice, basis, symmetry and crystal systems; Fourier expansion of periodic functions in crystal lattice, reciprocal lattices and reciprocal lattice vectors, crystal planes, Miller indices; X-ray diffraction: Bragg's law and Laue conditions, Bragg plane and Brillouin zone, structure factor, methods of determination of crystal structure.

Unit 2 Theory of free electrons: Drude and Sommerfeld models, specific heat of electrons, elementary transport theory of electrons in external fields, temperature gradient and subject to collisions, Ohms law and Hall-effect, thermal conductivity and thermopower.

Unit 3 Electrons in in periodic potentials: Bloch theorem, energy bands, nearly free electron approximation, Wannier functions, tight-binding approximations, Fermi surface; metals insulators and semiconductors; density of states calculations.

Unit 4 Bloch electrons in external fields: Semiclassical equations of motion, current in filled band, Bloch oscillations, concepts of effective mass and holes, cyclotron motion and cyclotron effective mass in semiconductors; Hall effect and magneto-resistance in semiconductors; Landau levels, de-Hass-van-Alphen effect, introduction to quantum Hall effect.
Elements of Boltzmann transport theory: relaxation time approximation electrical and thermal conductivities, transport coefficients.

Unit 5 Introduction to semiconductors: model and band diagrams, determination band gap and effective mass: photo-absorption, cyclotron resonance, indirect-gap and phonon assisted absorption; intrinsic and extrinsic semiconductors, carrier density in equilibrium; Elements of ideal Schottky diode, surface states, 2DEG; Introduction to inhomogeneous semiconductors: drift, diffusion, recombination, steady state and Einstein's relation.

References

1. Ashcroft and Mermin, Solid State Physics, 1E, Cengage India
2. Kittel, Solid State Physics, 8E, Wiley India
3. M. Marder, Condensed Matter Physics
4. Ibach and Luth, Solid State Physics, 3E, Springer
5. J. Singleton, Band Theory and Electronic Properties of Solids, OUP
6. S. Simon, Solid State Basics, OUP

7. J.J. Quinn and K. Yi, Solid State Physics, Springer

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY506	Computational Physics I	3 0 1 4

Course Outcomes:

CO-1 Familiarize with the basics of computer programming using Python/MATLAB.

CO-2 Solve ordinary differential equations using numerical methods. Utilize the concepts of numerical stability and convergence to analyze each of the methods.

CO-3 Utilize Python/MATLAB codes to solve nonlinear equations.

CO-4 Learn how to numerically approximate functions as well as data.

CO-5 Approximate function derivatives and estimate integrals using numerical methods.

CO-6 Apply numerical methods to solve a system of linear equations.

CO-7 Understand the concepts of optimization.

CO-8 Apply finite difference and finite element methods to approximate boundary value problems

Unit 1

Preliminaries: Programming, Basic elements of Python (mathematical operations, control, flow, branching, iteration, arrays, structures, functions, classes, input/output, visualization, and animation), standard libraries for scientific computations; Representation of numbers, Round-off errors, accuracy and speed; Applications: basic numerical differentiation and integration, interpolation and approximations.

Unit 2

Ordinary Differential Equations: Euler method, numerical errors and instabilities; Runge-Kutta methods: fixed step RK4, adaptive methods: adaptive-step RK4; Advanced methods; Applications: simple, double, and coupled pendulums, planetary motion.

Unit 3

Systems of Equations: Linear Systems, matrix inverse, eigenvalue problems, standard libraries; non-linear systems: Newton-Raphson and bisection methods; Fourier transforms: fast Fourier transform; maxima and minima of functions.

Unit 4

Partial Differential Equations: boundary value problems and the relaxation method, faster methods, over-relaxation, Gauss-Seidel method, initial value problems, FTCS, numerical stability, implicit and Crank–Nicolson methods, spectral methods, selected applications.

Unit 5

Introduction to Stochastic methods: Random number generators, Gaussian and other nonuniform random numbers, Monte Carlo integration: mean value method, integrals in many dimensions, importance sampling; Basic ideas on Monte Carlo simulation: Importance sampling and statistical mechanics, Markov chain method, simulated annealing; Introduction to semi-definite programming (for maximizing functions over convex sets).

References

1. Mark Newman, Computational Physics, CreateSpace Independent Publishing Platform, 2012
2. Alejandro L. Garcia, Numerical Methods for Physicists (Python Ed.), 2E, Addison Wesley, 2000
3. Fitzpatrick, Lecture notes on Computational Physics, University of Texas at Austin http://farside.ph.utexas.edu/teaching/329/329.pdf
4. Nicholas J. Giordano, Computational Physics, 2E, Pearson, 2005
5. Paul Devries, A First Course in Computational Physics, 2E, Jones and Bartlett , 2010

Skills: Entire course contents with tutorials and assignments help build foundations and develops computational thinking and programming skills leading to industrial computing and engineering software applications in industries and research labs. Employability: Design and implementation of Applications in Scientific Computing.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY507	Quantum Mechanics II	3 1 0 4

Description: The course is the 2nd part of the two-part course and will cover but relatively advanced topics that are required for every physicist.

Course Outcomes: After successful completion of the course students will be able to

CO1: describe the effect of transformations on wave functions and observables, symmetry-invariance connection, behaviour of generators, apply to symmetric potentials.

CO2: deduce angular momentum spectrum by algebraic method, describe Stern-Gerlach experiment, spin states and operators, apply to spin dynamics in magnetic fields.

CO3: Describe and calculate Clebsch-Gordan coefficients for addition of angular momenta in simple cases.

CO4: apply time-dependent perturbation theory to obtain approximate energy system of complex problems, Hydrogen atom under various approximations.

CO5: Apply variational methods to estimate ground state and 1st excited states.

CO6: Apply WKB method to obtain energy spectrum and tunnelling properties.

CO7: apply time-dependent perturbation theory to describe level transitions, calculate transition rates and radiation characteristics.

CO8: describe scattering process, apply scattering theory and Born approximation to calculate scattering cross-section for simple potentials.

CO9: Apply Dirac equation to describe phenomena at the relativistic speeds, like particle creation, etc.

Unit 1

Symmetries and consequences: spatial and time translations, rotations; infinitesimal and finite transformations, associated generators of transformations (momentum, Hamiltonian, angular momentum), unitary operators of finite transformations of states, consequences of

invariance; parity, time reversal.
Angular momentum algebra and eigenvalue spectrum by algebraic method; Spin: commutation relations, Pauli's spin matrices, spin states, rotational transformation in spin space; Spin dynamics: orbital and spin magnetic moments, spin in magnetic field; orbital and spin degrees of freedom, Stern-Gerlach experiment; Addition of angular momenta: Clebsch-Gordan Coefficients.

Unit 2
Time independent perturbation theory: non-degenerate and degenerate cases, application to simple systems; corrections to energy levels of Hydrogen atom: fine and hyperfine structures; Zeeman and Stark effects, selection rules.

Unit 3
Variational and WKB methods: Variational estimate of ground state energies in simple systems; WKB (semiclassical) approximation of wave functions, tunnelling amplitudes, bound states and Bohr-Sommerfeld quantization rule.

Unit 4
Time-dependent perturbation theory: first order correction, constant, sudden, adiabatic and sinusoidal perturbations; transition rates & Fermi golden rule, lifetime of an excited state, electromagnetic interaction, semiclassical radiation theory.

Unit 5
Scattering theory: scattering amplitude and cross section, Integral equation and Greens functions, Born approximation and its validity, partial wave analysis, optical theorem, calculation of phase shifts, scattering by hard sphere and Coulomb potentials, introduction to resonances and Breit-Wigner distribution. Elements of relativistic quantum mechanics: Dirac equation, Dirac equation in EM fields – nonrelativistic limit and spin; free particle solutions, negative energy states.

Textbooks:
1. R Shankar, Principles of Quantum Mechanics, 2E, Springer
2. David Griffiths, Introduction to Quantum Mechanics, 2E, Pearson, 2005
3. L I Schiff, Quantum Mechanics, TMH, 3E, 2010
4. E. Merzbacher, Quantum Mechanics, 3E, Wiley India.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY584	**Physics Lab VII**	**0 0 6 2**

(Suggested list of experiments are given. Equivalent experiments may be considered.)

Course Outcomes: After successful completion of the course, students will be able to

CO1: perform some advanced experiments in physics

CO2: apply the measurement techniques and develop skill and analyze data, and draw inferences

CO3: infer some specified properties standard atomic and molecular physics related experiments based on electromagnetic absorptions

CO4: use skillfully modern equipment such as Michelson and Fraby-Pero interferometers

CO5: link some of the modern concepts and advanced experiments in electrical, dielectric and magnetic properties of matter and their applications

CO6: perform some of the advanced level experiments to strengthen students' caliber towards research and development

Experiments:

1. Hydrogen spectra Balmer lines, calibration using Mercury lines
2. Absorption Spectrum $KMnO_4$ or Iodine
3. Four Probe Band gap of a semiconductor
4. Magnetic susceptibility - Quincke's/Gouy Method
5. B - H Curve (Ferromagnet)
6. Michelson Interferometer
   (a) Wavelength of a laser
   (b) Thickness of a glass plate
   (c) Dependence of refractive index air on pressure
7. Fraby-Perot Interferometer
8. (a) Lorentz Number for Copper

(b) conductivity of poor conductor

(c) k/e using transistor

9. (a) Dielectric constant of polymer & ceramic capacitors, verification of Curie-Weiss Law

(b) Ferroelectric transition of $BaTiO_3$

Skills: Lab sessions and experimentation help develop intuition for lab equipment and builds practical knowledge of using lab instruments, measurement techniques and experimental techniques needed for work involving communication of science such as lab instructor/ demonstrator, educator in schools, colleges and universities, technical staff and scientist in research labs, and builds skills needed for higher studies.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

Semester 8

18PHY516	Condensed Matter Physics I	3 1 0 4

Description: This is course in a continuation of the part I of the course and introduces students to topics more topics.

Course Outcomes: After successful completion of the course students will be able to develop an understanding, and be able to

CO1: describe theory of formation of different types of solids, calculate cohesion energy in inert gas and ionic crystals.

CO2: Describe elastic waves, modes, calculate dispersion, elastic constants, lattice specific heat, thermal expansion.

CO3: describe basics of electron-electron screening, Hartree-Fock equations, density

functional and Thomas-Fermi theories.
CO4: describe dielectric properties, Drude's model of ac-conductivity, dielectric permittivity, susceptibility, dielectric functions various cases, describe optical properties of metals, semiconductors and insulators, and calculate parameters of the theories.
CO5: describe dia-, para-, ferro-magnetism, Pauli paramagnetism, exchange interaction, NMR, explain the behaviour of magnetic susceptibilities, line-widths in NMR.
CO6: describe superconducting properties, BCS and GL theories, explain thermal properties, Meisner, Josephson, flux quantum effects, bound state of a Cooper pair.

Unit 1
Elementary theory of binding in solids, inert gas and ionic crystals; Elastic waves in crystals: acoustic and optic modes, dispersion, phonon spectrum, elastic constants, lattice specific heat, anharmonic effects.

Unit 2
Electron-electron interaction and screening: Variational formulation, Hartree-Fock equations, application to free electrons; Introduction to density functional and Thomas-Fermi theories.
Dielectric properties: Drude's model of ac-conductivity, Maxwell's equations, electrical permittivity; dielectric function of insulators, Kramers-Kronig relations, sum rules; Kubo-Greenwood formula (statement only); susceptibility, Lindhard dielectric function.

Unit 3
Dielectric and Optical properties of insulators: macroscopic polarization, dielectric constant, Clausius-Mossotti relation, optical modes in ionic crystals, F and M centers, Franck-Condon effect, optical absorption.
Optical properties of Metals: Drude model of plasma oscillations, transparency condition; low frequency response, plasmon dispersion, inter-band transitions; basic ideas on Raman and Brillouin scattering, photoemission, work function, ARPES.
Optical properties of semiconductors: excitons – Mott-Wannier and Frenkel excitons.

Unit 4
Magnetism: dia-, para-, Van-Vleck and Pauli Paramagnetism; Exchange coupling and origins of ferromagnetism, review of mean field theory of ferromagnetism and anti-ferromagnetism, susceptibility; introduction to NMR, Bloch equations, and line-widths.

Unit 5
Introduction to superconductors: Thermal properties and London's equation, basic ideas on Ginzburg-Landau and BCS theories, Josephson tunnelling and SQUID; basic ideas in superfluidity.

References:
1. Ashcroft and Mermin, Solid State Physics, 1E, Cengage India
2. Kittel, Solid State Physics, 8E, Wiley India
3. M. Marder, Condensed Matter Physics
4. Ibach and Luth, Solid State Physics, 3E, Springer
5. J. Singleton, Band Theory and Electronic Properties of Solids, OUP
6. S. Simon, Solid State Basics, OUP

7. J.J. Quinn and K. Yi, Solid State Physics, Springer

Skills: Entire course contents with tutorials and assignments help build foundations and develops computational thinking and programming skills leading to industrial computing and engineering software applications in industries and research labs. Employability: Design and implementation of Applications in Scientific Computing.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY517	Atomic and Molecular Spectroscopy	3 0 1 4

Description: The course introduces students to the basic physics of atoms, molecules, their spectra and the interaction of light with matter.

Course Outcomes: After successful completion of the course, students will be able to
1) Justify and deduce wave functions of H-atom from Rodrigues formulas, write down energy levels, degeneracies, formulate and derive perturbation corrections.
2) Describe models for helium and multielectron atoms, and their electronic spectra, and distinguish various angular momentum coupling schemes and their consequences.
3) Apply time-dependent perturbation theory to analyse emission and absorption spectra of atoms, transition probabilities, apply selection rules to explain electronic spectra of atoms and their line-widths, describe and classify basic laser types and their operation principles.
4) Describe models, Franck-Condon principle, and analyse consequences to explain electronic, rotational, and vibrational spectra of diatomic molecules, explain IR spectroscopy.
5) Describe and apply the models of polyatomic molecules to explain electronic, vibrational and rotational levels, classical and quantum theory of Raman effect and spectroscopy, calculate parameters of interest.

Unit1
One-electron atoms: H-atom, quantum numbers, wavefunctions, relativistic corrections; electron spin, Einstein–de Haas effect, spin-orbit coupling and fine-structure, Normal and anomalous Zeeman effects, hyperfine structure, complete description of the Hydrogen atom, Lamb shift, correspondence principle; Stark effect in Hydrogen, weak field and strong field effect.

Unit 2
Helium and multi electron atoms: Approximation models, Pauli principle and symmetry of wavefunctions, Helium spectrum, building-up principle of the electron shell for larger atoms, model of electron shells, periodic system of the elements, alkali atoms, coupling schemes for electronic angular momenta, Rydberg states.

Unit 3
Electronic transitions and selection rules: emission and absorption of electromagnetic radiation by atoms, transition probabilities, Einstein coefficients; parity selection rules,

selection rules for spontaneous emission, induced absorption and emission, selection rules for the magnetic and spin quantum numbers; lifetimes of excited states, line profiles of spectral lines, natural line width and broadening mechanisms.
Introduction to Lasers: Threshold condition, generation of population inversion; Optical resonators: quality factor, open resonators, modes, diffraction losses, frequency spectrum; Single mode lasers; Basic ideas on solid-state, semiconductor, dye and gas lasers.

Unit 4
Diatomic molecules: spectra of diatomic molecules, structure of electronic transitions, rotational structure, vibrational structure and the Franck–Condon Principle, continuous spectra, IR spectroscopy.

Unit 5
Polyatomic molecules: electronic states of polyatomic molecules CO_2 molecule, rotation and vibration of polyatomic molecules, spectra of polyatomic molecules, Raman spectroscopy, classical and quantum theory of Raman effect, Stokes and anti-Stokes Raman lines.

References:
1. Atoms, Molecules and Photons, 2E: W. Demtroder Springer (Text)
2. Physics of Atoms and Quanta: H. Haken and H.C. Wolf, Springer (2005)
3. Physics of Atoms and Molecules: B.H. Bransden and C.J. Joachain, Pearson India (2003)
12. Molecular spectroscopy, 4E: Banwell, Tata McGraw Hill, 1995

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY585 Physics Lab VIII 0 0 6 2

Suggested list of experiments are given. Equivalent experiments may be considered.

Course Outcomes: After successful completion of the course, students will be able to

CO1: perform some more advanced experiments in modern physics viz. Zeeman Effect, Pocket effect, Faraday Effect etc.

CO2: apply measurement techniques and develop skills for efficient data collection, data and error analyzing skills, and draw inferences

CO3: perform standard spectroscopy related experiments

CO4: use modern equipment such as XRD

CO5: understand and analyze some of the basic as well as advanced concepts of properties of matter and electronics related topics

CO6: perform some of the advanced level experiments to strengthen students' caliber towards research and development

Experiments:

1. Phase sensitive detection and Lock-in amplifier

(a) Calibration of lock-in amplifier
(b) determination of mutual inductance of a pair of coils using this technique

2. Hall Effect & Magneto resistance

3. Pockel Effect
4. Faraday Effect
5. Anomalous and Normal Zeeman Effects
6. ESR spectrometer
7. GM Counter
8. X-ray investigation of cubic crystal structures/Debye-Scherrer powder method

Skills: Lab sessions and experimentation help develop intuition for lab equipment and builds practical knowledge of using lab instruments, measurement techniques and experimental techniques needed for work involving communication of science such as lab instructor/ demonstrator, educator in schools, colleges and universities, technical staff and scientist in research labs, and builds skills needed for higher studies.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY590	Research Methods and Physics Seminar	1 0 1 2

Description: This course introduces the basic ideas to begin research career, methods and tools of research activity, elements of typesetting and scientific reporting and presentation.

Course Outcomes:

CO-1 Familiarize methods of research, purpose, choice of method, construction of models.

CO-2 Study hypothesis testing and measurement and sampling, investigate errors in sampled data, describe safety and ethical aspects.

CO-3 Apply probability and statistical techniques to analyse measured data and arrive at dependency on parameters of the problem.

CO-4 Explore suitable mathematical models to describe phenomena.

CO-5 Familiarize methods and tools of scientific communications, experience writing short scientific reports and present in a classroom.

Unit 1

Research methods in science: hypothesis driven research; experimental research – measure a value, measure a function or relationship; theoretical sciences - construct a model; observational and exploratory research, improve a product or process – industrial and applied research, allied research.

Hypothesis drive experiments: Null and alternative hypotheses, error, time, money, solution possibilities, error analysis, types of error, precision, accuracy, propagation; improving experiments, measurement values, sampling and surveys, safety and ethics.

Unit 2

Statistics: measurement error, distributed quantities, means, averages, histograms, standard deviation, probability distributions, discrete and continuous distributions, connecting data and probability distributions, central limit theorem, uses of normal distribution, Z-test and interpretations, confidence intervals, comparing other experiments, t-test: comparing two measurements, Chi-square test.

Unit 3

Mathematical Model: ingredients of modelling, setting up problems, sketching and naming, functions, estimation, dimensional analysis, linear regression, matching arbitrary functions to data.

Unit 4

Scientific information and Communication: writing proposal and scientific proposals, title, abstract, procedures, analysis, scientific figures, charts, plots, scientific presentations, searching information, obtaining and reading articles. Other tools: Spread-sheet programs, Latex typesetting, word processors, image manipulation and graphics open source and free software.

Unit 5

Project and Presentations.

Textbook/References

1. Michael P Marder, Research Methods for Science, CUP (2011).
2. Online resources on LaTeX, and other tools.

Skill: Tutorials, assignments and a project prepares students as a science communicator, physics consultant in journalism and administrative services, instructor/researcher in schools, colleges and Universities, research labs, in while building foundations in physics and gain experience in documentation and presentation methods.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

Semester 9

18PHY603	**Nuclear and Particle Physics**	**3 1 0 4**

Description: This course introduces the fundamental constituents of matter and their interactions.

Course Outcomes: After successful completion of the course, students will be able to

1) Describe basic nuclear properties based on size, shape, charge, spin, parity, binding energy, and nuclear models
2) Describe nature of nuclear forces and interactions, shell structure and models, explain rotational spectra
3) Describe ideas in nuclear radiations, apply selection rules, fusion and fissions, nuclear reaction mechanisms.
4) Investigate the properties of nuclear forces and scattering processes.
5) Classify elementary particles, fundamental forces, quantum numbers, apply invariance and conservation laws in nuclear reactions, describe quark models.
6) Apply symmetry arguments in particle reactions, parity non-conservation in weak interactions, and outline arguments leading to model of phenomenology of weak interactions, outline standard model.

Unit 1

Basic nuclear properties: size, shape and charge distribution, spin and parity; Binding energy, semi-empirical mass formula, liquid drop model;

Unit 2
Nature of the nuclear force, form of nucleon-nucleon potential, charge-independence and charge-symmetry of nuclear forces; Deuteron problem; Evidence of shell structure, single-particle shell model, its validity and limitations; Rotational spectra;

Unit 3
Elementary ideas of alpha, beta and gamma decays and their selection rules; Fission and fusion; Nuclear reactions, reaction mechanism, compound nuclei and direct reactions.

Unit 4
Elementary particles: Classification of fundamental forces, Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.), Gellmann-Nishijima formula, Quark model, baryons and mesons, conservation laws.

Unit 5
C, P, and T invariance; Application of symmetry arguments to particle reactions; Parity non-conservation in weak interaction, introduction to the phenomenology of weak interaction and the standard model.

References:
8. Kenneth S. Krane, Introductory Nuclear Physics, Wiley 1988
9. Cottingham and Greenwood, An Introduction to Nuclear Physics, 2E, CUP
10. D. Griffiths, Introduction to Elementary Particles, 2E, Wiley-VCH
11. B. R. Martin, Nuclear and Particle Physics – An Introduction, 2E, Wiley India
12. Povh et al; Particles and Nuclei: An Introduction to the Physical Concepts, 5E, Springer.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY691	**MINIPROJECT**	**(6 credits)**

The aim of the project work is to give more detailed exposure to the student for research methodology. This can include literature survey, review, data collection, and theoretical/experimental work on small parts of research in area chosen by the faculty guiding the project work. If the project is carried out at other institutions / research laboratories, the experts from these institutions are to be associated in choosing the research topic and its execution.

Course Outcomes: After successful completion of the project, students will be able to
1) Gain deeper insights into the chosen areas of research.
2) Gain experience in research methodologies in the chosen area.
3) Develop theoretical/experimental/computational skills in helping explore the research goals.

4) Communicate one's efforts in the form of a well reference scientific report with illustrations, tables, equations, organization conforming to current publication standards.

Skills: Training during the course of the project work help develop theoretical/ experimental/ computational skills and help communicate one's efforts in the form of a well referenced scientific report.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

Semester 10

18PHY699	**THESIS**	**(15 credits)**

The aim of the project work is to give more detailed exposure to the student for research methodology. This can include literature survey, review, data collection, and theoretical/experimental work on small parts of research in area chosen by the faculty guiding the project work. If the project is carried out at other institutions / research laboratories, the experts from these institutions are to be associated in choosing the research topic and its execution. This project work is done in continuation from the miniproject carried out in the previous semester.

Course Outcomes: After successful completion of the project, students will be able to
1) Gain deeper insights into the chosen areas of research.
2) Gain experience in research methodologies in the chosen area.
3) Develop theoretical/experimental/computational skills in helping explore the research goals.
4) Communicate one's efforts in the form of a well reference scientific report with illustrations, tables, equations, organization conforming to current publication standards leading to master's thesis.
5) Hone and demonstrate research and communication skills by submitting a research article to a conference or journal.

Skills: Training during the course of the project work help develop theoretical/ experimental/ computational skills and help communicate one's efforts in the form of a well referenced scientific report.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

Physics Electives

18PHY320	**Modern Optics**	**3 0 0 3**

Description: This course describes optical phenomena in nature at the graduate level, dealing mainly with wave optics.

Course Outcomes: After successful completion of the course, students will be able to

1) Summarize and apply results on interaction of electromagnetic radiation with matter, and calculate parameters in reflection, transmission, dispersion in metals and dielectrics.
2) Describe and apply concepts of polarization, relate to angular momentum, polarization using scattering and reflection, quantify using Stokes' and related parameters.
3) Describe and apply complex representations and phasors to deduce conditions for interference, apply to interferometers, thin films, coatings.
4) Describe and apply Huygens-Fresnel principle and Kirchhoff's scalar diffraction theory, Fraunhofer diffraction analysis to single and double slits and other problems.
5) Describe and apply Fourier methods in diffraction, basics of coherence theory, basic ideas in lasers and nonlinear optics.

Unit 1
Basics: Review of Maxwell's equations and electromagnetic waves, summary of results on interaction of electromagnetic waves with matter, Fresnel's equation, reflection & transmission, total internal reflection and evanescent waves, dispersion of waves in metals and dielectrics.

Unit 2
Polarization: Review of linear, circular and elliptical polarizations, angular momentum of photon picture, Malus's law, polarization by scattering and reflection, Brewster angle, selected related phenomena; Stokes parameters, Jones vector and Mueller matrices, Poincare sphere.

Unit 3
Review of Interference: Complex representation of waves, phasors, superposition principle; conditions for interference, spatial & temporal coherence, wave front & amplitude splitting; Michelson, Mach-Zehnder and Sagnac interferometers. Multiple beam interference, Fabry-Perot interferometer, antireflection coatings.

Unit 4
Diffraction: Huygens-Fresnel principle, Kirchhoff's scalar diffraction theory; Fraunhofer diffraction single slit, double & multiple slits, rectangular & circular apertures, resolution of imaging systems, diffraction grating. Fresnel's diffraction, half-period zones, circular & rectangular apertures, Cornu spiral, diffraction by slit, Babinet's principle.

Unit 5
Fourier methods in diffraction theory: Fourier view point in optics, Fraunhofer diffraction – single slit, Young's double-slit experiment; Basics of Coherence theory: visibility, mutual coherence function and degree of coherence. Introduction to Modern Optics: Review of stimulated emission, introduction lasers, optical resonant cavities, selected related effects; basic ideas on nonlinear optics.

References

1. E. Hecht and A.R., Ganesan, Optics, 4E, Pearson
2. Ajoy Ghatak, Optics, Tata McGraw-Hill, 2009.
3. Max Born and Emil Wolf, Principles of Optics, 7th Ed, CUP, 2013

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY547	Physics of the Atmosphere	3 0 03

Description: The introduces to the students the basic concepts in the physics of the Earth's atmosphere. This course should help students do projects in weather systems.

Course Outcomes: After successful completion of the course, students will be able to

1. Gain a basic understanding of the Earth's atmospheric system – its structure and composition as well as the energy transfer and general circulation within it.
2. Apply the basics of thermodynamics to the atmospheric system, explain the basics of cloud formation.
3. describe the principle of radiative transfer in the atmosphere, the basic spectroscopy as applied to the atmospheric molecules, scattering of radiation in the atmosphere through the use of a simple scattering model.
4. describe the fundamentals of fluid dynamics, apply them to the atmospheric system, derive the equations of motion in the rotating frame of reference, describe the basic dynamics of weather systems.
5. describe the basic chemical kinetics and Ozone chemistry, apply the basics of thermodynamics, dynamics and chemical reactions to explain the processes and dynamics of air pollution.
6. describe the basics of atmospheric remote sensing.
7. describe the basics of atmospheric modeling and explain a few of numerical models.
8. Describe the basics of climate change.
9. Apply the basics of dynamics/thermodynamics/numerical modeling/remote sensing and successfully finish a small project by reading and reproducing the results of a published article.

Unit 1

Earth - Atmosphere system – Introduction, Composition and structure, Radiative equilibrium, Energy budget, General circulation, Historical perspectives, Weather & Climate
Atmospheric thermodynamics – Ideal gas law, First law of thermodynamics, Atmospheric composition, Hydrostatic balance, Entropy & potential temperature, Parcel concepts, Available potential energy, Moisture in the atmosphere, Saturated adiabatic lapse rate, Tephigram, Cloud formation

Unit 2

Atmospheric radiation – Basic physical concepts, Radiative transfer equation, basic spectroscopy of molecules, Transmittance, Absorption by atmospheric gases, Heating rates, Greenhouse effect revisited, Simple scattering model

Unit 3

Basic fluid dynamics – Mass conservation, material derivative, alternative form of continuity equation, equation of state for the atmosphere, Navier-Stokes equation, Rotating frames of reference, equations of motion in coordinate form, geostrophic and hydrostatic approximation, Pressure coordinates and geopotential, Thermodynamic energy equation; Atmospheric fluid dynamics – vorticity and potential vorticity, Boussinesq approximation, Quasi-geostrophic motion, Gravity waves, Rossby waves, Boundary layers, Instability

Unit 4

Stratospheric chemistry – Thermodynamics and chemical reactions, Chemical kinetics, Bimolecular reactions, Photo-dissociation, Stratospheric ozone, Transport of chemicals, Antarctic ozone hole.

Atmospheric remote sounding – Observations, remote sounding from space and ground; Atmospheric modeling – Hierarchy of models, Numerical methods, Uses of complex numerical models, Lab models.

Unit 5

Climate change – Introduction, energy balance model, some solutions of the linearised energy balance model, Climatic feedbacks, Radiative forcing due to increase in Carbon dioxide.

Projects based on Modules 4 and 5 (Reading a journal paper & reproducing calculations, Numerical modeling and / or data analyses)

Textbooks/References

1. Andrews DG: An introduction to atmospheric physics, 2E, CUP, 2010
2. Salby ML: Physics of the Atmosphere and Climate, CUP, 2012
3. Holton JR: An introduction to Dynamic Meteorology, 4E, AP, 2004
4. Wallace JM & Hobbs PV: Atmospheric Science-An Introductory Survey, 2E, AP, 2006
5. Chandrasekar A: Basics of Atmospheric Science, PHI, 2010

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY336	**SPACE PHYSICS**	**3 0 0 3**

(Pre-requisites: Two-part course on electrodynamics, and Plasma Physics)

Course Outcomes:

1) Define what is meant by a plasma, the criteria that an ionized gas must satisfy in order to be called a plasma, different types of plasma and their classification
2) Describe the plasma environment in space, with focus on near-Earth environment, Classify the main domains where Space Physics applies and enumerate their properties, giving specific details
3) Describe and define the relevant key physical theories (particularly from plasma physics) that control the qualitative properties of different space plasma phenomena – Explain how certain important plasma populations in the solar system, e.g. the Earth's ionosphere and magnetosphere, get their basic properties, and how these properties may differ between the planets
4) Calculate the quantitative behaviour of different space physics phenomena using

plasma physics analysis methods. Make order of magnitude estimates of some properties in space plasmas and space phenomena, e.g. the power dissipated in the aurora, or the amount of current floating from Earth's Magnetosphere to Ionosphere

5) Demonstrate an understanding of how Space Physics has a practical impact on everyday life in the field of Space Weather. Identify ways in which experimental studies of Space Physics phenomena have advanced our understanding of basic plasma physics
6) Model certain Space Physics phenomena by applying basic physical laws, using simple Mathematics (e.g. model the form of the ionosphere/magnetosphere or estimate the temperature of a sunspot)
7) Describe current research within space physics and explain it to an interested layman

Unit 1 Brief history of solar-terrestrial physics – The variables Sun and the heliosphere, Earth's space environment and upper atmosphere.

Unit 2 Space plasma physics - single particle motion, plasma state, Fluid description, MHD & kinetic theory, Applications

Unit 3 Solid wind & Interplanetary Magnetic field (IMF), Shocks and Instabilities in space

Unit 4 Solar wind interactions with magnetized planets - Introduction, planetary magnetic fields, spherical harmonic expansions, geomagnetic field and its measurements, variations in Earth's field.

Unit 5 Magnetosphere - Dynamics, SW-magnetosphere interactions; Ionospheres, Currents in space and Ionosphere; Neutral atmosphere -Dynamics.

Textbooks/References:

1. Hannu E.J. Koskinen, Physics of Space Storms, Springer, 2011
2. Molwin, M., An Introduction to Space Weather, CUP, 2008
3. Kallenrode, M.B., Space Physics: An introduction to plasmas and particles in the Heliosphere and Magnetosphers, Springer, 3e, 2004
4. Baumjohann, W. & Treumann, R.A., Basic Space Plasma Physics, Imperial College Press, 1997
5. Kivelson & Russell, Introduction to Space Physics, CUP, 1995

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY342	**NONLINEAR OPTICS**	**3 0 0 3**

Course Outcomes:

CO-1 Understand sources of and propagation of optical electromagnetic waves and predict the possible optical process when nonlinearity in the optical response of a material comes into picture

CO-2 Demonstrate a detailed physical and mathematical understanding of a variety of nonlinear processes as an application of electromagnetic theory, semiclassical theory and quantum mechanics

CO-3 Apply the knowledge to identify the broad variety of ways in which materials exhibit nonlinear behavior.

Unit 1

Introduction to Nonlinear Optics: Brief review of electromagnetic waves - Wave propagation in an anisotropic crystal - Nonlinear optical effects - Polarization response of materials to light, Harmonic generation.

Unit 2

Second order effects: Second harmonic generation - Sum and difference frequency generation - Phase matching - Parametric amplification, parametric fluorescence and oscillation; Concept of quasi-phase matching; Periodically poled materials and their applications in nonlinear optical devices.

Unit 3

Third order effects: Third harmonic generation – bistability - self focusing, self-phase modulation, Temporal and spatial solitons, Cross Phase modulation, four wave mixing, Phase conjugation.

Unit 4

Multiphoton Processes: Two photon process - Theory and experiment - Three photon process, Parametric generation of light - Oscillator - Amplifier - Stimulated Raman scattering - Intensity dependent refractive index optical Kerr effect - photorefractive, electron optic effects.

Unit 5

Nonlinear Optical Materials: Basic requirements - Inorganics - Borates - Organics - Urea, Nitro aniline - Semi organics - Thiourea complex - X-ray diffraction FTIR, FINMR - Second harmonic generation - Laser induced surface damage threshold.

Textbooks:

1. Robert W. Boyd, Nonlinear Optics, 2nd Ed., Academic Press, 2003.
2. D.L. Mills, Nonlinear Optics – Basic Concepts, Springer, 1998.
3. B.B. Laud, Lasers and Nonlinear Optics, 2nd Ed. New Age International (P) Ltd., 1991.

References

1. A Yariv, Quantum Electronics, John Wiley, NY, 1989.
2. A Ghatak and K Thyagarajan, Optical Electronics, Cambridge Univ Press, 1989.
3. Scully and M S Zubairy, Quantum optics, Cambridge Univ. Press, 1997.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY531	**Introduction to Quantum Computing**	**3 0 0 3**

Course Outcomes: After successful completion of the course, students will be able to

1) refresh and summarize principles of quantum mechanics from a Quantum Information

computing perspective

2) describe basic formalism with mathematical structure of QM through various special types of matrices like Hermitian, unitary, density matrices with tensor products
3) apply the concept of Entanglement, quantum nonlocality leading to Bell's inequality.
4) analyze the concepts of pure and mixed states, Schmidt decomposition, non-perfect distinguishability of non-orthogonal states along with the quantum measurement theory.
5) describe the paradigm of quantum information/computation: Dense coding, quantum teleportation and Quantum cryptography.
6) solve certain problems using various quantum computing algorithms: viz. Deutsch-Jozsa, Grover search Algorithm (and extensions), Shor's algorithm (quantum Fourier transform).

, analyze Quantum circuits (classical circuits, gates)

7) apply Quantum error correction and fault tolerant quantum computing.
8) analyze classical and quantum information theory and entropy.

Contents:

Unit 1 Introduction to quantum mechanics from a QI/QC perspective: Hermitian / unitary / density matrices; taking functions of matrices; tensor products; Entanglement, quantum nonlocality, Bell's inequality; pure and mixed states; Schmidt decomposition; various no-go theorems such as no-cloning, no-signaling, non-perfect distinguishability of non-orthogonal states, etc; quantum measurement theory.

Unit 2 Invitation to quantum information/computation: Dense coding, quantum teleportation, dense-coding, Deutsch-Jozsa algorithm.

Introduction to computer science: complexity classes such as P, NP, NP-complete, BQP, BPP, PSPACE etc.

Unit 3 Quantum circuits (classical circuits, gates); Grover search algorithm (and extensions).

Unit 4 Shor's algorithm (quantum Fourier transform); Quantum error correction and fault tolerant quantum computing.

Unit 5 Classical and quantum information theory (entropy measures such as mutual information, relative entropy etc.); Quantum cryptography (BB84, Ekert, Shor-Preskill and Lo-Chau).

References:

1. David Mahon, Quantum Computing Explained, Wiley India.
2. Quantum Computation and Quantum Information: M.A. Nielsen and I.L. Chuang (2011), CUP.
3. P. Kaye, R. Laflamme, and M. Mosca, An Introduction to Quantum Computing, OUP, 2007

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY532	**Advanced Statistical Mechanics**	**3 00 3**

(Prerequisite: 18PHY Statistical Mechanics)

Description: This is an advanced course to provide an introduction to the advanced topics in statistical mechanics, including fluctuation phenomena, transport theory, interacting systems, Critical phenomena, linear response.

Course Outcomes: After successful completion of the course students will be able to develop an understanding, and be able to
CO1: describe and apply fluctuation phenomena, correlations and relate to diffusion and transport, model Brownian motion, random walk using Langevin equation, relate fluctuation and dissipation, describe Markov process, Fokker-Planck equation.
CO2: describe interacting non-ideal gases and find virial coefficients and van der Waals equation, 1^{st} and 2^{nd} order phase transitions, mean-field theories, correlations.
CO3: describe models of magnetic interaction and model critical phenomena and relate to liquid-gas system.
CO4: describe critical phenomena, scaling and universality of phase transitions, spontaneously broken symmetries, Landau theory and Ginzburg-Landau model, role of fluctuations, topological phase transitions, ideas on RG.
CO5: describe and apply linear response theory, Boltzmann transport equation, Kubo formula to find transport coefficients.

Unit 1
Introduction to fluctuations and non-equilibrium processes: fluctuations, correlations, diffusion, transport, Brownian motion, random walk, stochastic processes, Langevin equation, fluctuation -dissipation theorem, irreversibility, Markov processes, master equation, Fokker-Planck equation, normal and anomalous diffusion.

Unit 2
Introduction to non-ideal classical gas: second virial coefficient and van der Waals equation, Examples of first order and continuous phase transitions; Mean field (van der Waals and Weiss molecular field) theories; Fluid-magnet analogy; Correlations; Classical (Ornstein-Zernicke) theory.

Unit 3
Statistical mechanical models: Ising, lattice gas, Heisenberg, XV and Potts models. Transfer matrix method, illustration using the one-dimensional Ising model; Introduction to the two-dimensional Ising model.

Unit 4
Critical phenomena: long-range order, order parameter, scaling, universality, critical exponents; Peierls argument for phase transitions; Spontaneous breakdown of symmetry, Landau theory of phase transitions; Role of fluctuations, lower and upper critical dimensions; Ginzburg-Landau model; Higgs mechanism, examples; Mermin-Wagner theorem; Topological (Berezinski-Kosterlitz-Thouless) phase transition; Basic ideas of the renormalization group approach to phase transitions.

Unit 5
Introduction to Linear Response: Generalized susceptibility and structure factor, thermodynamic properties, sum rules; Mean field response: dielectric function of the electron

gas; Kubo formula; Boltzmann equation.

References

1. N.G. Van Kampen, Stochastic Processes in Physics and Chemistry, North-Holland (1985).
2. C.W. Gardiner, Handbook of Stochastic Methods, 2E, Springer-Verlag (1983).
3. C.J. Thompson, Classical Equilibrium Statistical Methods Springer-Verlag (1988).
4. H.E. Stanley, Introduction to Phase Transitions and Critical Phenomena, Clarendon Press, Oxford (1971).
5. J.M. Yeoman, Statistical Mechanics of Phase Transitions, Clarendon Press, Oxford (1992).
6. Statistical Mechanics: K. Huang (2005) 2 edition, John Wiley and Sons
7. Introduction to Modern Statistical Mechanics: D. Chandler (1979) Oxford University Press
8. M. Plischke and B. Bergersen, Equilibrium Statistical Mechanics, 3E, World Scientific, 2005
9. Elements of Non-equilibrium Statistical Mechanics: V. Balakrishnan (2009) Ane Books
10. Statistical Physics of Particles: Mehran Kardar (2007) Cambridge University Press
11. D. Stauffer, Introduction to Percolation Theory, Taylor and Francis (1985).

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY534	Epistemological Foundations of Quantum Mechanics	3 0 0 3

Description: The main objective of this course is to impart and inculcate an epistemological vision that quantum physics imply and can afford.

Course Outcomes: After successful completion of the course, students will be able to

1) Identify failure of classical mechanics and origin of QM starting from Planck to Schrodinger and later to Bell with a historic and philosophical perspective.
2) formulate quantum mechanical problems in Dirac's Ket and Bra and Hilbert space representation.
3) Analyse the concepts of reality and trajectory of a particle with the experimental paradigms using Mach-Zehnder type interferometers.
4) Distinguish between Fermions and Bosons and be able to connect it to Pauli Exclusion Principle, indistinguishability and symmetry.
5) Identify the paradoxes of QM like de Broglie, Schrödinger's cat, Wigner's friend, EPR paradox, etc. and describe measurement problem using State-vector reduction and justify the same by the concept of decoherence.
6) Analyse Bell type of inequalities (like CHSH inequality) using the notions of Entanglement, Hidden variables and the like using Mermin's Reality machine and Aspects Experiments
7) Describe a variety of interpretations of quantum mechanics like, Statistical, Copenhagen, Bohm's formulation, Transactional, Wheeler's Participatory Universe, Many World, Transactional Interpretation, Consciousness interpretation.
8) Apply the quantum concepts to some modern technological applications like, Vaidman bomb detector, Quantum teleportation, Quantum Erasing, Quantum cryptography and Quantum Computing, dense coding, Quantum Information.

Contents:

Unit 1 Historical & Epistemological Perspctive: Quick review of the failure of classical mechanics and origin of QM: Planck-Einstein, Bohr atom, de Broglie, Heisenberg's uncertainty principle, Experimental verifications – wave-particle duality and Young's double-slit experiment, polarization experiments, Stern-Gerlach experiments, Schrödinger equation - particle in a box, tunnel effect.

Unit 2 Dirac's ket and dual ket formulations and Hibert space representation, Mach-Zhender type interferometers; Reality and trajectory of a particle, Fermions and Bosons, Pauli Exclusion Principle and indistinguishability, symmetry; State-vector reduction and measurement problem, decoherence.

Unit 3 Paradoxes of QM: de Broglie paradox, Schrödinger's cat, Wigner's friend paradox, Entanglement, Hidden variables, EPR paradox, Bell-type Inequalities, Mermin's Reality machine, Aspects Experiments, CHSH inequality, Kohen-Specker theorem.

Unit 4 Various interpretations of QM: Statistical, Copenhagen, Bohm's formulation, Transactional, Wheeler's Participatory Universe, Many World, Transactional Interpretation, Consciousness interpretation – Philosophical implications.

Unit 5 Modern applications of quantum entanglement: Quantum teleportation, Quantum Erasing, Introduction to Quantum cryptography and Quantum Computing, dense coding, Quantum Information.

Reference Books:
Since the subject is rather unconventional, there are no affordable, tailor-made text book is available. Hence the following reference books are suggested for reading. Separate additional lecture notes will be provided.

Suggested Reading:
1. John von Neumann, Mathematical Foundations of Quantum Mechanics, Reprint, PUP, 1996.
2. M. Bell, K. Gottfried and M.Veltman (Eds.), John S. Bell on the Foundations of Quantum Mechanics, World Scientific, 2001.
3. George Greenstein and Arthur G. Zajonc, The Quantum Challenge: Modern Research on the Foundations of Quantum Mechanics, 2nd Ed., Jones & Bartlett Learning, 2005.
4. Bruce Rosenblum and Fred Kuttner, Quantum Enigma: Physics Encounters Consciousness, 2nd Ed., Oxford University Press, 2011.
5. Bernard D'Espagnat, Conceptual Foundations of Quantum Mechanics:, 2nd Ed., Westview Press, 1999.
6. TarjaKallio-Tamminen, Quantum Metaphysics (dissertation, e-copy), University of Helsinki, 2004 (http://ethesis.helsinki.fi/julkaisut/hum/filos/vk/kallio-tamminen/quantumm.pdf)

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY535	TOPICS IN ASTROPHYSICS	3 0 0 3

Description: The objective of this course is to give reasonable advanced introductory understanding of select brand of important topics in astrophysics.

CO1: Present a bird's eye view Stellar dynamics, types of forces on a star, star-star encounter and its application to Galaxy & star cluster.

CO2: Apply virial theorem to analyse masses of cluster of galaxies by to identify missing mass problem as a justification to the dark matter theory.

CO3: Describe and apply General Theory of Relativity and gravitational equations with Schwarzschild solution as well as geodesics of Riemannian geometry of curved space-time employing the formalism of tensors.

CO4: Apply Robertson walker equations and analyse the various cosmic models-open, critical or closed etc. through deceleration parameters and critical density.

CO5: Describe Einstein field equations in cosmology, Friedman's solution, Einstein de-sitter model, open model, particle and Event horizon.

CO6: Apply Jean's equation for instability in the expanding universe and explain the formation of structures in the Universe and describe the growth in the Post recombination era.

CO7: Analyse small angle anisotropy of CMBR and horizon problem and relate it to the Thermal History of the Universe and distribution at the time of decoupling of matter and radiation in the early universe.

Contents:

Unit 1 Stellar dynamics: types of forces on a star in the stellar system, Tidal radii, star-star encounter, time of relaxation determination of time of relaxation, application to Galaxy & star cluster. Masses of double galaxies, Masses of cluster of galaxies by virial theorem observational determination of masses, clusters of galaxies, missing mass problem.

Unit 2 Introduction to General Theory of Relativity: Space, time, and gravitation, tensors, covariant differentiation, Riemannian geometry, space-time curvature, geodesics, principle of equivalence, action principle and energy tensor, gravitational equations, Schwarzschild solution.

Unit 3 Cosmology: cosmological principle, Newtonian cosmology, deceleration parameters critical density, Robertson walker equation and its properties, solution of Robertson-Walker equations. Einstein field equation in cosmology, Energy tensor of Universe, solution of Friedman's equation, Einstein de-sitter model, open model, particle horizon, Event horizon.

Unit 4 The formation of structures in the Universe: Jean's equation derivation from fluid dynamics and General relativity; evolution of Jean mass, Growth in the Post recombination era; Einstein-do Sitter model; closed model; open model; observation constraints; small angle anisotropy, horizon problem, the scale – invariant spectrum, Hierarchy of structures, Age distribution.

Unit 5 Thermal History of the Universe, Temperature red shift relation, distribution in the early Universe, relativistic and non-relativistic limits, decoupling of matter and radiation, Cosmic microwave background radiation (CMBR), isotropy and anisotropy of CMBR.

TEXT AND References

1. Introduction to Cosmology By J.V. Narliker
2. Structure Formation in the Universe by T. Padmanabhan, Cambridge University

3. Stellar Dynamics by S.Chandersakher
4. Stellar Evolution by Kippenhahn
5. Quasars and Active Galactic Nuclei by A.K.Kembehavia & G.V. Narliker, Cambridge University Press
6. Modern Astrophysics by B.W.Carroll and D.A.Ostlie, Addison-Wesley Publishing Co.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY536	**PLASMA PHYSICS**	**3 0 0 3**

(Pre-requisite: Two-part course on Electrodynamics)

Course Outcomes: At end of the course students are expected to

1. Gain knowledge of the basic concepts of plasma physics.
2. Gain an understanding of spatial and time scales in plasmas, Debye shielding, single particle motion in different types of magnetic field variations.
3. Gain an understanding of kinetic theory of plasmas, a describe collisoinless plasmas, energy distribution.
4. Gain an understanding of two-fluid description and equations of motion of charged particles in plasmas.
5. Gain an understanding of single fluid theory of magneto-hydrodynamics in plasmas.
6. Gain basic knowledge of the propagation of electromagnetic waves in plasmas

Unit 1

Introduction – Spatial scale of an unmagnetized plasma – Debye Length, time scale - plasma period, gyroradius and gyrofrequency of magnetized plasma, single particle motion in prescribed fields - ExB, grad-B, Curvature and polarization drifts, magnetic moment, adiabatic invariants of particle motion, magnetic mirror.

Unit 2

Kinetic theory of plasmas, Boltzmann equation, Maxwell-Boltzmann distribution, Vlasov description of collisionless plasmas, Moments of the Boltzmann equation, Systems of macroscopic equations: Cold and Warm plasma models.

Unit 3

Plasmas as fluids - Two fluid description, equation of motion, Drifts perpendicular to B, parallel pressure balance.

Unit 4

Single fluid theory of plasmas: Magneto hydrodynamics (Hydromagnetic, MHD).

Unit 5

Introduction to waves in plasmas, waves in cold magnetized and unmagnetized plasma, Fourier representation, Dispersion relation, Waves in hot (magnetized) plasmas, Landau Damping, CMA diagram, Instabilities, MHD Waves, Alfven Waves, MHD discontinuities.

Textbooks/References

1. Umran S. Inan & Marek Golkowski, Principles of Plasma Physics for Engineers and Scientists, Cambridge, 2011
2. Francis F. Chen, Introduction to Plasma Physics and controlled fusion, Springer, 2006
3. D.A. Gumett & A. Bhattacharjee, Introduction to Plasma Physics, CUP, 2006
4. Boyd, T.J.M., and Sanderson, J.J.: The Physics of plasmas, CUP,2003
5. Krall, N.A, Trivelpiece, A.W., Principles of plasma physics, McGraw Hill,1973
6. Stix, T.H., Waves in plasmas, Springer, 1992

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY537	**Fluid Dynamics**	**3 0 0 3**

Description: This course will be useful for students wishing to gain an overview of the vast field of fluid dynamics. The course is aimed at imparting basic knowledge of the subject to facilitate research career in plasma physics, astrophysics, soft matter, biophysics, and computational fluid dynamics.

Course Outcomes:

CO-1 Familiarize with the basic concepts of fluid statistics.

CO-2 Describe fluid motion in Lagrangian and Eulerian perspectives. Derive the equations of fluid motion and learn about waves in fluids.

CO-3 Derive the Navier-Stokes equations pertaining to viscous fluids. Apply the concepts of stress and strain tensors to study deformation of fluids.

CO-4 Solve Navier-Stokes equation for laminar flows.

CO-5 Utilize Prandtl's formulation to understand the boundary layer flow. Learn about Non-Newtonian flows. Analyze the fluid flows using the various dimensionless numbers in fluid mechanics, like Reynold's number.

Unit 1

Basics: fluid statics; Conservation equations, equation of continuity, energy and momentum flux.

Unit 2

The Lagrangian and Eulerian description of fluid mechanics, Euler's equation of motion for Ideal flows, Potential flow and related problems, vorticity, Gravity waves.

Unit 3

Deformation of continuous media, strain rate tensor, viscous stress tensor, the equation of motion for viscous flows (Navier-Stokes equation).

Unit 4

Laminar flow and exact solution of Navier-Stokes such as flow in a pipe and rotating cylinder, the law of similarity and its use in solving unsteady flows.

Unit 5

Reynolds's number and other dimensionless numbers in fluid mechanics, Prandtl's formulation of boundary layers and related problems, Non-Newtonian flows.

References:

1. Fluid Mechanics, P. K. Kundu, I. R. Cohen and D. R. Dowling, Elsevier, 5th edition
2. Michel Rieutord, Fluid Dynamics: An Introduction, Springer, 2015
3. Philip J. Pritchard, Introduction to Fluid Mechanics, John Wiley & Sons, 2011
4. Fluid Mechanics films produced by National committee on fluid Mechanics Films at MIT.
5. Fluid Mechanics: L.D. Landau and E.M. Lifshitz (2007) 2E, Pergamon Press
6. Oden Regev, Okran M. Umruhan, and Philip A. Yecko, Modern Fluid Dynamics for Physics and Astrophysics, Springer, 2016.
7. T.E. Faber, Fluid Dynamics for Physicists, CUP, 2001
8. Falkovich, Fluid Mechanics - A Short Course for Physicists, Springer , 2011

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY538	Solid State Electronic Devices	3 0 0 3

Course outcomes: On successful completion of this course, student should be able:

CO-1. To explain the concept of density of states and apply the Fermi–Dirac probability function to determine the carrier concentrations

CO-2. To outline the basic concepts of quantum mechanics and describe the behavior of electrons under various potential functions.

CO-3. To demonstrate a familiarity with the concept of allowed and forbidden energy bands in the context of quantum mechanics and Schrodinger's wave equation.

CO-4. To present schematically the design, working principles and energy band diagrams of PN junction, bipolar transistors, metal-semiconductor contacts and metal-oxide-semiconductor junctions.

CO-5. To summarize the underlying operating principles of important microelectronic and photonic devices, such as MOSFETs, bipolar junction transistors and semiconductor lasers.

CO-6. To describe the limits of ideal "black-box" models of devices and predict the effect of these non-idealities on real circuits and systems.

CO-7. To demonstrate an understanding of the principles of microfabrication in the context of manufacturing of integrated circuits and state the factors affecting device performance.

Unit 1

Crystal Growth of Semiconductors: semiconductor materials, bulk and epitaxial growth, wave propagation in discrete structures. Summary of atomic structure and band energy structure in semiconductors, carrier concentration, drift of carriers in electric and magnetic fields.

Unit 2

Excess carriers: optical absorption, luminescence, carrier lifetime and photoconductivity, carrier diffusion. Junctions: Fabrication of PN-junctions, steady state conditions, reverse bias breakdown, transient and ac-conditions, metal-semiconductor junctions, heterojunctions.

Unit 3
Field-Effect Transistors: operation, junction FET, metal-semiconductor FET, MOSFET and related structures.

Unit 4
Bipolar Junction Transistors: review of BJT operation, amplification with BJT, fabrication, minority carrier distribution and terminal currents, generalized biasing, switching, other important effects, frequency limitations. Optoelectronic Devices: Basic ideas on photodiodes, LED, Lasers, Semiconductor lasers.

Unit 5
Basics of Integrated Circuits: evolution, monolithic device elements, charge transfer devices, ultra-large-scale integration, testing and packaging.
High-frequency high-power and Nanoelectronic Devices:

Textbook/References

1. Ben G Streetman and Sanjay Banerjee, Solid State Electronic Devices, 7E, Pearson, 2016
2. Simon M. Sze, Kwok K. Ng; Physics of Semiconductor Devices, Wiley, 2012

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY539	**Optoelectronics**	**3 00 3**

Course outcomes: On successful completion of this course, student should be able:

CO-1. To explain the processes of excess electron and hole generation and recombination.

CO-2. To describe the basics of p-n junction diode and apply ambipolar transport equation in deriving the device electrical properties.

CO-3. To construct energy band diagrams of basic p-n junction as well as complex heterojunctions to describe the carrier transport phenomenon in the semiconductor junctions

CO-4. To demonstrate a knowledge of fundamental properties of optical processes in semiconductor optical sources and the operation principles of basic optical components.

CO-5. To draw schematically and describe the operation and design architecture of 1st generation solar cells and to outline the basics concepts of 2nd and 3rd generation solar cells

CO-6. To describe the structures and the operation of LEDs and lasers

CO-7. To demonstrate familiarity with the operation and designs of photodetectors

CO-8. To compare operation principles, basic designs and challenges of optical detectors and modulators of light.

Unit 1
Review of semiconductor physics for photonics: density of states in a quantum well

structure; carrier concentration & Fermi level, quasi Fermi levels. Semiconductor optoelectronic materials: hetero-structures, strained-layers, band-gap engineering; p-n junctions; Schottky junctions & Ohmic contact.

Unit 2
Interaction of Photons with Electrons and Holes in a Semiconductor; Rates of Emission and Absorption; Amplification by Stimulated Emission; Semiconductor Optical Amplifier.

Unit 3
Quantum confined Stark effect and Franz-Keldysh effect; Electro-absorption modulator: Principle of operation and device configuration. Light Emitting Diode: device structure and output characteristics, modulation bandwidth, materials for LED, and applications. white light LEDs.

Unit 4
Laser Diodes: device structure and output characteristics, single frequency lasers; DFB, DBR Lasers, VCSEL, Quantum Well and Quantum Cascade Laser, Micro-cavity lasers; Modulation of Laser Diodes, Practical Laser Diodes & Handling.

Unit 5
Photodetectors: general characteristics of photodetectors, impulse response, photoconductors, PIN, APD, array detectors, CCD, solar cell, photonic integrated circuits.

Textbooks/References

1. Optoelectronics: An Introduction to Materials and Devices, Jasprit Singh, McGraw HILL International (1996) (Text)
2. Semiconductor Devices for High-Speed Optoelectronics, Giovanni Ghione, Cambridge University Press (2009) (Text)
3. Semiconductor Optoelectronic Devices Introduction to Physics and Simulation, JOACHIM PIPREK, Academic Press (2003)
4. Optoelectronics An Introduction, John Wilson and John Hawkes, Prentice Hall (1998)

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY540	**Physics at Nanoscale**	**3 0 0 3**

Description: An introduction to nanoscience and its applications, provides a
flavour of the current excitement in the field of nanoscience. This course should be of interest to physics, chemistry and biology students.

Course Outcomes: After successful completion of the course, students will be able to

1) Define and describe the nanoscience and nanotechnology by historical perspective.
2) Describe and explain size effect and apply classical and quantum models analyse and characterize quantum wells, wires and dots, effective mass, excitons, plasmons, explain scaling laws.
3) Classify the clusters of noble metal, semiconductors and magnetic materials.

4) Classify and characterize carbon nanomaterials – fullerenes, CNTs, graphene and porous materials.
5) Distinguish the Hydrophobic-hydrophilic surfaces
6) Describe the synthesis of nanomaterials through physical, chemical and biological methods.
7) Describe the nanofabrication methods such as top-down and bottom-up approaches and their applications.
8) Describe, explain and be familiar with the principles of the analysis techniques such as microscopy techniques, electron microscopes, scanning probe micro- scopes, diffraction techniques, X-ray and electron, optical and electron spectroscopy techniques.
9) Describe and identify unique features in mechanical, thermal, structural, optical, electrical and magnetic properties of nanomaterials and their applications to spintronics, GMR and CMR, nanoelectronics and nanodevices.

Unit 1

Introduction: Why nanoscience and nanotechnology? historical perspective; size effect (colour, melting, magnetism etc. and Lotus effect, Gecko effect). Clusters: noble metal, semiconductors, magnetic; Magic numbers. Quantum confinement: quantum wells, wires and dots; Effective mass, excitons, plasmons, scaling laws.

Unit 2

Hydrophobic-hydrophilic surfaces, self-assembly; Some special materials: fullerenes, CNTs, graphene, porous materials.

Unit 3

Synthesis of nanomaterials: physical, chemical, biological methods; Other nanofabrication methods: top-down and bottom-up approaches.

Unit 4

Analysis techniques: microscopy techniques, electron microscopes, scanning probe microscopes, diffraction techniques, X-ray and electron, spectroscopy techniques, optical and electron.

Unit 5

Properties of nanomaterials and applications: mechanical, thermal, structural, optical, electrical, magnetic, introduction to spintronics, GMR, CMR, etc.; Nanoelectronic and nano devices.

Textbook/References

1. Optical Properties of Semiconductor Nanocrystals: S.V. Gaponenko (1997) Cambridge University Press
2. Nanotechnology: Principles and Practices: S.K. Kulkarni (2009) Capital Pub. Co.
3. Introduction to Nanotechnology: C.P. Poole, Jr. and F.J. Owens (2008) Wiley-India edition
4. The Physics of Micro/Nanofabrication: I. Brodie and J.J. Murray (1992) Springer, Plenum Press

5. Handbook of Nanofabrication: Ed. G. Wiederrecht, (2010) Elsevier
6. T. Pradeep, NANO: The Essentials: Understanding Nanoscience and Nanotechnology, McGraw Hill India (2007)
7. Kelsall et al, Nanoscale Science and Technology, Wiley, 2005

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY541	Mesoscopic Physics and Quantum Conductors	3 0 0 3

Course Outcomes: After successful completion of the course, students will be able to

1) Describe preliminary concepts of 1D, 2D, 3D electron gas, effective mass, density of states, characteristic length and time, Fermi liquid theory, apply them to solve problems.
2) Describe and apply foundations of physics to some quantum mesoscopic effects: Aharonov-Bohm effect, weak localization, Quantum point contact, Quantum Hall effect.
3) Describe and apply scattering approach to quantum conduction
4) Analyze noise in quantum systems and its consequences
5) Describe and apply basic principles to quantum electronic systems in interaction: Tomonaga-Luttinger liquid, fractional quantum Hall effect.

Unit 1

Preliminary concept: 1D and 2D electron gas, Effective mass, density of states, characteristic length and time (mean free path, coherence length, elastic time, scattering time), Reminders on Fermi liquid theory, Drift velocity versus Fermi velocity

Unit 2

Introduction to quantum mesoscopic effect: Aharonov-Bohm effect, Weak localization, Quantum point contact, Quantum Hall effect.

Unit 3

The scattering approach to quantum conduction: Toolbox, Two terminals Landauer formula, Conductance in ballistic conductors, Conductance in diffusive conductors, Multiterminal conductor: the quantum Kirchhoff law, Application of Landauer formula: quantum point contact and quantum Hall effect.

Unit 4

Noise in mesoscopic systems: Introduction: “The noise is the signal”, Fermi-Dirac versus Bose-Einstein distribution: the importance of the statistics, Thermal noise, Quantum shot noise, Vacuum fluctuation noise, Noise correlations (bunching anti bunching and Hanbury-Brown and Twiss experiment), Quasi-particles entanglement in ballistic conductors.

Unit 5

Introduction to quantum electronic systems with interaction: 1D: Tomonaga-Luttinger liquid theory, 2D: Fractional quantum Hall effect.

Reference books and courses:

1. Electronic transport in mesoscopic systems, Supriyo Datta

2. “Introduction to quantum conductors”, D.C Glattli
3. “Shot Noise in Mesoscopic Conductors”, Y M Blanter and M. Buttiker
4. “Electronic Quantum Transport in Mesoscopic Semiconductor Structures”, T. Ihn

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY542	**Thin Film Physics**	**3 0 0 3**

Description: This course introduces students to physics of thin films, their fabrication, characterization and applications.

Course Outcomes: After successful completion of the course, students will be able to
1. Recognize the importance of thin films in varied applications in science and technology.
2. Classify and describe methods of thin film fabrication - thermal evaporation, cathodic sputtering, Molecular beam epitaxy and laser ablation, electrolytic deposition, and physical and chemical vapour deposition.
3. Explain thickness measurements using electrical, mechanical, optical interference, micro balance, quartz crystal methods.
4. Describe the analytical techniques such as X-ray diffraction, electron microscopy, high and low energy electron diffraction, Auger emission spectroscopy and infer characteristics from the data.
5. Describe and explain using theories the growth of thin films, the post nucleation growth, epitaxial growth, structural defects in thin films, the elastic and plastic nature of thin films.
6. Describe and explain with illustrations the optical properties of thin films such as reflectance, transmittance and absorbance, Categorize the Anisotropic and isotropic thin film.
7. Describe and identify unique features in the electronic properties and applications of semiconductor, insulating-dielectric and superconducting films, apply the molecular-field and spin-wave theories in magnetic thin films to explain magnetic phenomena.
8. Describe applications of thin films for thin film device fabrication.

Unit 1 Preparation methods: Physical methods: thermal evaporation, cathodic sputtering, Molecular beam epitaxy and laser ablation methods. Chemical methods: electrolytic deposition, chemical vapour deposition.

Unit 2 Thickness measurement and Characterisation: electrical, mechanical, optical interference, microbalance, quartz crystal methods. Analytical techniques of characterization: X-ray diffraction, electron microscopy, high and low energy electron diffraction, Auger emission spectroscopy.

Unit 3 Growth and structure of films: General features - Nucleation theories - Effect of electron bombardment on film structure - Post nucleation growth - Epitaxial film growth - Structural defects.

Unit 4 Properties of films: elastic and plastic behaviour. Optical properties - Reflectance and transmittance spectra - Absorbing films - Optical constants of film material - Multilayer films - Anisotropic and isotropic films. Electric properties to films: Conductivity in metal, semiconductor and insulating films - Discontinuous films - Superconducting films.

Unit 5 Magnetism of films: Molecular field theory - Spin wave theory - Anisotropy in magnetic films - Domains in films - Applications of magnetic films.
Thin film devices: fabrication and applications.

Textbooks:

1. K.L. Chopra, Thin Film Phenomena, McGraw Hill (1983),
2. George Hass. Physics of Thin Films: Volumes 1':12. Academic Press (1963).

References

1. K.L. Chopra and I.J. Kaur, Thin Film Solar Cells, Plenum Press (1983).
2. L.I. Maissel and Giang (Eds.), Handbook of Thin film Technology, McGraw Hill (1970).
3. J.C. Anderson, The Use of Thin Films in Physical Investigation, Academic Press (1966).
4. J.J. Coutts, Active and Passive Thin Film Devices, Academic Press (1978).
5. R.W. Berry, P.M. Hall and M.T. Harris, Thin Film Technology, Van Nostrand (1968). 47

18PHY543 Methods of Experimental Physics 3 0 0 3

Description: To build up the necessary background required to design and carry out important experiments, exposure to the physics behind recent experimental techniques. A reasonable section of topics may be chosen from below.

Course Outcomes: After successful completion of the course, students will be able to develop an understanding, and be able to

1) Classify and describe the concepts of errors and noise in measurements
2) Calculate the errors in measurements.
3) Explain different kinds of techniques involved in measurements.
4) Explain the working of different transducers.
5) Explain thin film deposition and different characterisation techniques.

Contents:

Unit 1 Measurements, uncertainties, error analysis, curve fitting; the value of "zero" in experimental physics, measurement of noise and analysis of noise, filtering and noise reduction, interference, shielding and grounding, phase sensitive detection and Phase locked loops; electrical measurements and precautions: I-V, C-V, resistivity.

Unit 2 Magnetic measurements and precautions: vibrating sample magnetometer, SQUID; Vacuum techniques: units, gauges, pumps, materials.
Techniques of temperature measurements: very low, medium and very high-temperature thermometers, thermocouples, thermistors, pyrometer, spectroscopy.

Unit 3 Transducers and sensors: temperature, pressure/vacuum, magnetic field, vibration, optical, and particle detectors.

Unit 4 Thin film deposition methods: physical, e-beam, sputter, chemical vapor deposition, molecular beam epitaxy, spin coatings, dip coating, electroplating, electroless plating. Techniques of optical spectroscopy and optoelectronic devices: UV-Vis absorption, photoluminescence, electroluminescence, light-emitting diodes, solar cells.

Unit 5 Advanced experimental techniques: AFM, atomic and molecular traps, NMR, nano-materials and devices, time-resolved measurements.

References:

1. Practical Physics: G.L. Squires (2001) 4 edition, Cambridge University Press
2. Astronomical Optics: D.J. Schroeder (1999) 2 edition, Academic Press
3. Experimental Physics: R.A. Dunlap (1988) 1 edition, Oxford University Press
4. Characterization of Materials: J.B. Wachtman and Z.H. Kalman (1992) Butterworth-Heinemann

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY545	FOURIER OPTICS	3 0 0 3

(Pre-requisite: The course on Wave Optics, good academic standing and Instructor approval)

Course Outcomes:

1. Introduction to the discipline of Optics and its role in the modern society
2. Introduction to the realm of Computational Fourier Optics and review analytic Fourier Theory
3. Physical understanding of Sampling and Shannon-Nyquist Sampling theorem. Student will learn about sampling of functions and their Discrete Fourier Transform
4. Programming of functions, vectors, arrays and Fourier Transforms
5. Understand Scalar Diffraction theory, Monochromatic fields and irradiance & analytic diffraction solution with Fraunhofer diffraction as example. Student will learn about propagation simulation – Fresnel propagation and sampling & Fraunhofer propagation
6. Understand transmittance functions – Tilt, Lens, Grating and other periodic functions
7. Learn fundamentals of imaging & simulation of diffraction limited imaging; Basics of Wavefront aberrations – Optical Path Difference, Primary aberrations, Pupil and Transfer functions, Image quality and Wavefront sampling

Unit 1: Analytic Fourier Theory Review

Analysis of two-dimensional signals and systems – Fourier analysis in 2D, Local Spatial Frequency and Spatial Frequency localization, Linear systems, Two dimensional sampling.

Unit 2: Scalar diffraction & propagation solutions, Simulations

Scalar diffraction theory – Introduction, vector to scalar theory, mathematical preliminaries, Kirchhoff formulation of diffraction by a planar screen, Rayleigh-Sommerfeld formulation, Huygens-Fresnel principle, Angular spectrum of plane waves.

Unit 3: Diffraction

Fresnel and Fraunhofer diffraction – Background, Fresnel and Fraunhofer approximations, Examples of Fraunhofer diffraction patterns and Fresnel diffraction calculations.

Unit 4: Transmittance functions, Lenses & Gratings
Wave optics analysis of coherent optical systems – thin lens as a phase transformation, Fourier transforming properties of lenses, image formation: monochromatic illumination.

Unit 5: Imaging and diffraction limited imaging, wave front aberrations and modulation, simulations
Frequency analysis of optical imaging systems – generalized treatment, frequency response for diffraction limited coherent and incoherent imaging; Aberrations and their effects on frequency response, comparisons of coherent and incoherent imaging, resolution beyond classical diffraction limit; Wave front modulation – incoherent image and coherent optical information processing systems, applications.
* The course has a practical (computational) component.

Textbook/References
1. J.W. Goodman, Introduction to Fourier Optics, 3E, Roberts & Company Publishers, 2005 (Prescribed)
2. E.G. Steward, Fourier Optics – An Introduction, Dover, 2004
3. J.D. Gaskill, Linear systems, Fourier Transforms, and Optics, Wiley, 1978

Skills: Entire course centents with tutorials, assignments and computational projects help build foundations develops skills in optical physics and will students will find useful in optics industry and optical software development.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY546	LASERS AND APPLICATIONS	3 0 03

Description: This course introduces to the students the theory of Laser operation, different types of lasers and their applications.

Course Outcomes: After successful completion of the course, students will be able to
1) Describe and apply laws of radiative transitions, calculate transition rates and explain certain transitions, black-body radiation, absorption, spontaneous and stimulated emissions
2) Arrive at conditions for producing laser, apply threshold requirements to obtain population inversion and lasing, power optimization, describe two-level and four-level systems.
3) Describe and explain laser cavity modes.
4) Explain mode locking and pulse shortening techniques.
5) Classify lasers and laser systems, describe many examples.
6) Describe laser applications in various fields of science, engineering, industry, medicine.

Unit 1
Radiative transitions: Radiative decay of excited states, spontaneous emission, decay rate,

transition probability, spectral line-widths and line shapes, broadening mechanisms.
Radiation and thermal equilibrium: Radiation in a cavity, oscillation modes, Rayleigh-Jeans formula, Planck's law, relationship between cavity and blackbody radiations, absorption and stimulated emission, Einstein's A and B coefficients.

Unit 2

Conditions for producing a Laser: Absorption and gain of homogeneously broadened radiative transition, gain coefficient and stimulated emission cross section for homogeneous and inhomogeneous broadening; Necessary and sufficient conditions for laser action: Population inversion, saturation intensity, development and growth of a laser beam, shape or geometry of amplifying medium, exponential growth factor (gain), threshold requirements with and without cavity. Laser oscillation above threshold: Laser gain saturation, Laser beam growth beyond the saturation intensity, optimization of laser output power, laser output fluctuations - laser spiking, relaxation oscillations; Laser amplifiers; Requirements for obtaining population inversions: Inversions and two-level systems, rate equations for three and four level systems, pumping mechanisms.

Unit 3

Laser cavity modes: Longitudinal laser cavity modes, FP resonator, transverse laser cavity modes, Properties of laser modes - spectral and spatial hole burning. Stable laser resonators: Stable curved mirror cavities, ABCD Matrices, cavity stability criteria, unstable and ring resonators. Q-switching: Theory, giant pulses, methods of producing Q-switching within a laser cavity, gain switching. Mode locking: Theory, picosecond optical pulses, techniques for producing mode-locking. Pulse shortening techniques: Generation of ultra-short optical pulses, Self-phase modulation, pulse compression (shortening) with gratings or prisms, femtosecond optical pulses and techniques to characterize femtosecond pulses; Properties of laser beams and techniques to characterize laser beam.

Unit 4

Classification of lasers and laser systems: Two level, three level and four level laser systems, Laser systems involving low density media – He-Ne, Ar -ion, Kr- ion, He-Cd, and Copper vapour lasers; Molecular gas systems: CO2, N2, and Excimer lasers; X-ray laser, FEL laser; Laser systems involving high gain media: Dye, Solid state - Ruby, and NdYAG, Nd-glass lasers; Pico and Femtosecond lasers – Alexandrite laser, Ti-Sapphire laser, fiber laser; Laser diode – threshold current and power output, Semiconductor lasers - hetero-junction lasers, Quantum well lasers, DFB laser, surface emitting lasers, Rare-earth doped lasers.

Unit 5

Laser cooling and trapping of atoms: magnetic and optical traps, optical molasses Lasers in computing- optical logic gates.
Lasers in medicine: Photodynamic therapy, laser angioplasty, lasers in surgery.
Industrial applications of lasers: laser absorption in metals, semi-conductors, and insulators; welding, surface treatments, material removal, cutting, scribing, marking etc., generation of plasma, optical fibre splicing, and laser deposition of thin films; Laser Displays.
Lasers in chemistry: isotope separation, laser induced chemical reactions – IR photochemistry. Ultrafast processes in Bio-molecules-monitoring fast chemical reactions, study of photochemical processes and stimulation photochemical reactions.

Fluorescence spectroscopy, energy transfer, sensitization and quenching phenomena, Fluorescence of dyes and rare earth ions.

References:
1. Laser fundamentals, 2nd Ed: W. T. Silfvast, Cambridge University Press 2004. (Text).
2. Fundamentals of Photonics, 2nd Ed: B. E. Salch, M. Teich, John Wiley Sons (2007)
3. Lasers: Theory and application: Ghatak and Thyagarajan, McMillan, 2002.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY551	**COMPUTATIONAL PHYSICS II**	**3 0 03**

(Minor Course Prerequisite: Computational Physics I and instructor's approval)

Course Outcomes: After successful completion of this course, students shall be able to
1) Calculate scattering cross-sections for various scattering problems.
2) Select an appropriate level of Basis Sets for a given problem.
3) Perform HF/TB/EHT calculations on simple systems. Generate pseudopotentials using available software
4) Code MD programs; Example: N particles that interact via a two-body potential of finite range.
5) Code Monte-Carlo Problems: Generating Polymer configurations; Brownian Motion

Unit 1
Quantum Scattering with spherical symmetric potential, calculation of scattering cross sections; Variational method of Schrodinger equation: examples, generalized eigenvalue problem.

Unit 2
Hartree-Fock Method: Born-Oppenheimer approximation, helium atom, many-electron systems, self-consistency and Hartree-Fock theory, basis functions.

Unit 3
Density Functional Theory: local density approximation, exchange and correlation, one- and two-particle excitations, DFT calculations for helium atom, applications.
Solving Schrodinger equation in periodic solids, some example calculations, tight-binding calculations, calculations in k-space for crystals, energy band diagrams, introduction to pseudopotential and other methods.

Unit 4
Introduction to molecular dynamics simulations: molecular dynamics at constant energy, integration methods, different ensembles, molecular systems, long-range interactions, Langevin dynamics simulation, dynamical quantities.

Unit 5
Monte Carlo method: Importance sampling through Markov chains, Ising model, phase transitions, monatomic gas.

Textbooks/References

1. Thijssen, Computational Physics, 2E, CUP, 2007
2. Mark Newman, Computational Physics, CreateSpace Independent Publishing Platform, 2012
3. Alejandro L. Garcia, Numerical Methods for Physicists, 2E, Addison Wesley, 2000
4. Fitzpatrick, Lecture note on Computational Physics, University of Texas at Austin http://farside.ph.utexas.edu/teaching/329/329.pdf
5. Numerical Recipes, 3E, by W. H. Press, S. A. Teukolsky, W. Vetterling, and B. P. Flannery (Cambridge University Press)

Skills: Entire course contents with tutorials and assignments help build foundations and develops computational thinking and programming skills leading to industrial computing and engineering software applications in industries and research labs. Employability: Design and implementation of Applications in Scientific Computing.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY552	Computational Condensed Matter Physics	3 0 03

Course Outcomes: After successful completion of this course, students shall be able to

1) Apply basic Quantum mechanics to two problems of chemical interest: The hydrogen-like atom, and the harmonic oscillator.
2) Recognise the complexity of two- to many-electron systems. Examine a simple HF/SE/EHT program for small molecules or linear systems.
3) Choose appropriate DFT functionals for appropriate molecular/solid state properties like Energies, Spectra.
4) Code simple numerical algorithms for parallel processing.
5) Code/Program a simple HF/DFT/EHT code for very small molecular/solid state systems. [This is to gain experience in developing algorithms, coding, testing, debugging.]
6) Write a full production code for calculating molecular properties from data generated from commercial codes. Students shall clearly document the code and upload the code on open-source repositories.

Unit 1 Basics of Quantum Mechanics: Basic postulates, expansions, operators and observables, recap and summary of concepts from Previous QM courses.

Unit 2 One and many-electron atoms Schrodinger equation, energy levels, eigenfunctions of bound states, basics of interaction of electromagnetic field with atoms, Schrodinger equation and solutions for two-electron atoms, central field approximation, Thomas-Fermi model of the atom, Hartree-Fock and self-consistent field, molecular structure and molecular properties in brief.

Unit 3 DFT: Fundamental background, electron correlation, Hohenberg-Kohn theorems and their application, Kohn-Sham equations, plane wave solutions, density functionals: Local Density Approximation (LDA); Modern hybrid functionals: GGA, example PBE, advantages and failures.

Unit 4 Computational algorithms, floating point numbers and numerical accuracy, Monte Carlo Methods, molecular dynamics, FFT, brief introduction to parallelism and other topics of relevance.

Unit 5 A brief project on a chosen topic. Possible topics: Coding a simple HF program, running and adapting existing codes on DFT, Monte Carlo, or MD and the interpretation of the results.

Books:
1. Physics of Atoms and Molecules: Bransden and Jochain
2. Computational Physics: J. M. Thijssen
3. Handbook of Computational Quantum Chemistry: David B. Cook
4. A bird's-eye view of density-functional theory: Klaus Capelle
(available online at: https://arxiv.org/abs/cond-mat/0211443)

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY633 BIOPHOTONICS 3 0 0 3

Description:
The course introduces to the students the basic concepts of optical physics required to explain life on earth. This course should help students to do research in biophotonics and also to develop advanced equipment for medical industry.

Course Outcomes: After successful completion of the course, students will be able to
1) Explain optics of eye, photosynthesis, fluorescence and optical imaging systems.
2) Understand the physics of Photo-excitation, Optical coherence tomography, special and time-resolved imaging, fluorescence resonance energy transfer, nonlinear optical imaging, Bio-imaging and multi-photon microscopy.
3) Develop articulated arm delivery, hollow tube wave-guides, and fiber optic delivery systems.
4) Design and develop optical biosensors, microscopes and Bio-imaging probes, devices for tissue engineering using light.
5) Understand and explain Phot-dynamic therapy, photo–sensitizers for photodynamic therapy, Contouring and restructuring of tissues using laser, laser tissue regeneration, and femto-second laser surgery.
6) Understand and describe various tools for Flow cytometry, DNA analysis, biomaterials and medicine.

Unit 1
Photobiology: Interaction of light with cells and tissues, Photo–processes in Biopolymers, human eye and vision, photosynthesis. Photo-excitation: free space propagation, optical fiber delivery system, articulated arm delivery, hollow tube wave-guides. Optical coherence

tomography, special and time-resolved imaging, fluorescence resonance energy transfer(FRET) imaging, nonlinear optical imaging, Bio-imaging:

Unit 2
Transmission microscopy, Kohler illumination, microscopy based on phase contrast, dark-field and differential interference contract microscopy, fluorescence, confocal and multi-photon microscopy. Applications of bio-imaging: Bio-imaging probes and fluorophores, imaging of microbes, cellular imaging and tissue imaging.

Unit 3
Optical biosensors: Fluorescence and energy transfer sensing, molecular beacons and optical geometries of bio-sensing, biosensors based on fibre optics planar waveguides, evanescent waves, interferometry and surface Plasmon resonance. Flow cytometry: Basics, fluorochromes for flow cytometry, DNA analysis.

Unit 4
Laser activated therapy: Photdynamic therapy, photo–sensitizers for photodynamic therapy, applications of photodynamic therapy, two photon phoyodynamic therapy. Tissue engineering using light: Contouring and restructuring of tissues using laser, laser tissue regeneration, femto-second laser surgery.

Unit 5
Laser tweezers and laser scissors, design of laser tweezers and laser scissors, optical trapping using non-Gaussian optical beam, manipulation of single DNA molecules, molecular motors, lasers for genonmocs and proteomics, semiconductor quantum dots for bio imaging, metallic nano-particles and nano-rods for bio-sensing. Photonics and biomaterials: Bacteria as bio-synthesizers for photonic polymers.

TEXTS:

1. Introduction to Bio-photonics - V N Prasad (Wiley-Interscience April 2003)
2. Biomedical photonics: A Handbook - Tu Vo Dinh (CRC Press, Boca Raton, FL 2003)

References

1. A Handbook of Optical Biomedical diagnostics, SPIE press monograph vol pm 107
2. Biomedical Optics - Principles and Imaging - Lihong V and Hsin-IWU, Wiley Interscience 1sted, 2007
3. Optical coherence Tomography - Principles and Applications – Mark E.Brezinski, (Academic press 1sted, 2006)
4. Biophysics - An Introduction - Rodney Cotterill, (John Wiley Student edition)

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY636 FIBER OPTIC SENSORS & APPLICATIONS 3 0 0 3

Description:
The course introduces to the students the concepts of various optical fibers and their applications to sensor technology. This course should help students to do research in sensors

in presence of harsh electromagnetic fields and to develop advanced equipment for industry.

Course Outcomes: After successful completion of the course, students will be able to
1) Understand Explain principle and technology of fiber optics, electro optic and integrated optic modulators.
2) Understand the basic concepts and specifications of optical fiber sensors, micro-bend, evanescent fiber sensors, and polarization modulated sensors.
3) Explain the principle of temperature and strain sensing, multiplexing. FBG, Long period fiber grating sensors and refractive index sensing.
4) Design and develop Interferometric, Mach-Zehnder and Michelson types optical fiber sensors.
5) Understand and explain physics and technology of temperature, pressure and strain measurements, encoded sensors, and fiber optic biosensors.
6) Understand and describe of fiber optic gyroscopes, Faraday effect sensors, Magnetostriction and Lorentz force sensors, applications in industrial and environmental monitoring.

Unit 1

MM and SM fibers for sensing, Lasers & LEDs suitable for sensing, PIN & APDs for fiber optic sensing. Principles of electro optic modulators bulk & integrated optic modulators. Optical sensor types, advantages and disadvantages of fiber optic sensors, Sensor system performance: basic specifications, Intensity modulated sensors, reflective concept, micro-bend concept, evanescent fiber sensors, polarization modulated sensors.

Unit 2

In-fiber Bragg grating based sensors – sensing principles – temperature and strain sensing, integration techniques, cross sensitivity, FBG multiplexing techniques. Long period fiber grating sensors - temperature and stain sensing, refractive index sensing, optical load sensors and optical bend sensors.

Unit 3

Interferometric sensors, Mach-Zehnder& Michelson interferometric sensors, Theory-expression for fringe visibility, Fabry-Perot fiber optic sensors – theory and configurations, optical integration methods and multiplication techniques, application – temperature, pressure and strain measurements, encoded sensors.

Unit 4

Sagnac interferometers for rotation sensing fiber gyroscope sensors – Sagnac effect – open loop biasing scheme – closed loop signal processing scheme – fundamental limit – performance accuracy and parasitic effects – phase-type bias error – shupe effect – anti-shupe winding methods – applications of fiber optic gyroscopes. Faraday effect sensors. Magnetostriction sensors - Lorentz force sensors.

Unit 5

Biomedical sensors, sensors for physical parameters, pressure, temperature, blood flow, humidity and radiation loss, sensors for chemical parameters. pH, oxygen, carbon, dioxide, spectral sensors. Distributed fiber optic sensors – intrinsic distributed fiber optic sensor –

optical time domain reflectometry-based Rayleigh scattering – optical time domain reflectometry based Raman scattering – optical time domain reflectometry – quasi – distributed fiber optic sensors. An overview on the optical fiber sensors in nuclear power industry, fly-by light aircraft, oil field services, civil and electrical engineering, industrial and environmental monitoring.

Textbooks

1. Francis T. S Yu, Shizhuo Yin (Eds), Fiber Optic Sensors, Marcel Dekker Inc., New York, 2002
2. Dakin J and Culshow B., (Ed), Optical fiber sensors, Vol I, II, III, Artech House, 1998
3. Pal B. P, Fundamentals of fiber optics in telecommunication and sensor systems, Wiley Eastern, 1994

REFERENCES

1. Jose Miguel Lopez-Higuera (Ed), Handbook of optical fiber sensing technology, John Wiley and Sons Ltd., 2001
2. Eric Udd (Ed), Fiber optic sensors: An introduction for engineers and scientists, John Wiley and Sons Ltd., 1991
3. B. D Gupta, Fiber optic Sensors: Principles and applications, New India Publishing Agency, New Delhi., 2006
4. Bio-medical sensors using optical fibers, Report on progress in physics Vol 59.1,1996

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY637	FIBER OPTICS AND TECHNOLOGY	3 0 0 3

Unit 1 Classification of fiber: based on refractive index profiles, modes guided applications and materials. Fibers for specific applications: polarization maintaining fibers (PMF), dispersion shifted and dispersion flattened fibers, doped fibers. Photonic crystal fibers, holly fibers. Fiber specifications: Numerical aperture of SI and GI fibers, Fractional refractive index difference, V – parameter, Cut off wavelength, dispersion parameter, bandwidth , rise time and Non linearity coefficient.

Unit 2 Impairment in fibers: group velocity dispersion (GVD), wave guide and modal dispersions. Polarization mode dispersion (PMD), Birefringence – liner and circular.
Fiber drawing and fabrication methods: modified chemical vapor deposition (MCVD) and VAD techniques.

Unit 3 Mode theory of fibers – different modes in fibers. Dominant mode, Derivations for modal equations for SI and GI fibers. Approximate number of guided modes in a fiber (SI and GI fibers).Comparison of single mode and multimode fibers for optical communications. LED and LD modulators. Coupling of light sources to fibers – (LED and LD) – Derivations required. Theory and applications of passive optical components: connectors, couplers, splices, Directional couplers, gratings: FBGs and AWGs, reflecting stars: Optical add drop multiplexers and SLMs.

Unit 4 Active components: Optical Amplifiers (OAS) - Comparative study of OAS - SLAs, FRAs, FBAs EDFAs and PDFAs based on signal gain, pump efficiency, Noise Figure, Insertion loss and bandwidth. Design and Characterization of forward pumped EDFAs.

Unit 5 Fiber measurements: Attenuation measurement – cut back method. Measurement of dispersion – differential group delay, Refractive index profile measurement.
Numerical aperture (NA) measurement, diameter measurement, mode field diameter (MFD) measurement, V-Parameter, Cut off wavelength Measurement, splicing and insertion losses, OTDR – working principle and applications. OSA - Basic block schematic and applications in measurements. (John M senior)

Textbooks:

1. Gerd Keiser, Optical Fiber communications, MC Graw Hill,200
2. Maynbav, Optical Fiber Technology, Pearson Education, 2001
3. John M senior, Optical fiber communications, PHI, 1992

References

1. Joseph C Palais, Optical Fiber communications, Pearson Education.1998.
2. Dennis Derickson, Fiber optic test and measurement, Prentice hall,1998.
3. 3 David Bailey and Edwin wright, practical Fiber optics, Elsevier 2003.
4. Franz and Jain, optical Fiber communication systems and Components, Narosa Publishers, 2004.
5. Ajoy Ghatak and K. Thyagarajan, Introduction to Fiber optics: Cambridge university press,1999.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY638	**NANOPHOTONICS**	**3 0 0 3**

Description: This course introduces concepts in nanophotonics and experimental methods and devices required in nanophotonics study.

Course Outcomes: After completing this course student will be able to

1) understand and describe interaction of electrons and photons at the nanoscale and microscopy.
2) gain an understanding and describe quantum optical effects at nanoscale.
3) gain an understanding and describe plasmonic effects in metallic nanoscale materials and strudtures
4) gain an understanding and describe concepts related to nanocontrol of excitation dynamics in nanostructures, growth and characterization using XRD, XPS, SEM, TEM, SPM
5) gain an understanding and describe the concepts of photonic bandgap crystals, optical circuitry, role in optical communication, and related nanoelectronic devices.

Unit 1 Introduction to nanoscale interaction of photons and electrons. Near field interaction and microscopy - near field optics and microscopy - single molecule spectroscopy - nonlinear optical process.

Unit 2 Materials for nanophotonics - quantum confinement - optical properties with examples - dielectric confinement - super lattices - organic quantum confined structures.

Unit 3 Plasmonics - metallic nanoparticles and nanorods - metallic nanoshells - local field enhancement - plasmonic wave guiding - applications of metallic nanostructures.

Unit 4 Nanocontrol of excitation dynamics - nanostructure and excited states - rare earth doped nanostructures - up converting nanophores - quantum cutting. Growth and characterization of nanomaterials – epitaxial – PLD – nanochemistry - XRD-XPS-SEM-TEM-SPM.

Unit 5 Concept of photonic band gap – photonic crystals – theoretical modeling – features - optical circuitry - photonic crystal in optical communication - nonlinear photonic crystal - applications. Nanoelectronic devices – Introduction - single electron transistor. Basic ideas of nanolithography and biomaterials - nanophotonics for Biotechnology and Nanomedicine – nanophotonics and the market place.

Textbooks:

1. Paras N. Prasad, Nanophotonics, Wiley Interscience, 2004

2. Lukas Novotny and Bert Hecht, Principles of Nano-Optics, Cambridge University Press, 2006

References

1. Herve Rigneault, jean-Michel Lourtioz, Claude Delalande, Juan Ariel Levenson, Nanophotonics, ISTE Publishing Company, 2006.

2. Surface Plasmon Nanophotonics, Mark L. Brongersma, Pieter G. Kik, Springer-Verlag, 2006.

3. Photonic Crystals, by John D. Joannopoulos, Robert D. Meade, Joshua N. Winn Princeton University Press.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18PHY553	**NONLINEAR DYNAMICS***	**3 0 0 3**

Description: In this introductory course in the subject, a basic training to students will be provided to work out the may concepts, including, fixed points, their stability and bifurcations in dynamical systems and apply these to real-world systems like population dynamics, epidemics, chemical reactions, lasers, neurons, nonlinear oscillators etc. The course will run in parallel with computer laboratory sessions so that students will also receive training in the analysis of time series data, power spectra, bifurcation diagrams, fractals and so on.

Course Outcomes: After successful completion of the course, students will be able to develop an understanding, and be able to

1) Classify non-linear dynamical systems, types and features of chaos, describe

continuous and discrete systems, perform linear stability analysis and determine fixed-points, stability and flows, bifurcations, apply to population dynamics and other examples.
2) Describe, analyse and characterise 2D and higher-dimensional systems and determine limit cycles, bifurcations, attractors, chaos, Lorenz, Rossler, and pendulum systems.
3) Describe, analyse and characterise discrete dynamical systems and analyse logistic and circles maps and characterize bifurcations, period doubling, Lyapunov exponent.
4) Describe, analyse and characterise Henon and Poincare maps, quasiperiodicity, measures of chaos, basin boundary, Lyapunov exponents, fractals and fractal dimensions.
5) Explore and characterize chaos control techniques, analyse stochastic resonance, synchronization, spatiotemporal chaos, time series.

Unit 1 Nonlinear dynamical systems: classification, chaos, features of chaos, continuous and discrete dynamical systems; 1-d flows: fixed points and stability, linear stability analysis, bifurcations, flows on a circle, population dynamics.

Unit 2 2-d flows: classification of fixed points, stability analysis, limit cycles, bifurcations, predator-prey systems; higher-dimensional systems: stability, attractors, bifurcations, chaos, Lorenz system, Rossler system, pendulum.

Unit 3 Discrete dynamical systems, 1-d systems: logistic map, bifurcations, period doubling, chaos, Lyapunov exponent, circle map.

Unit 4 2-d systems: Henon map, quasiperiodicity, Arnold tongue; measures of chaos, Poincare map, basin boundary, FFT, Lyapunov exponents; Fractals: dimensions, multi-fractals, f-alpha spectrum.

Unit 5 A selection advanced topics: control of chaos, stochastic resonance, synchronization, spatiotemporal chaos, time series analysis, complex networks.
*The course involves computational component.

References:
1. Nonlinear Dynamics and Chaos: Steven Strogatz (2001) Westview Press
2. Chaos and Nonlinear Dynamics: Hilborn (2009) Oxford University Press
3. Chaos: An Introduction to Dynamical Systems: K.T. Alligood, T.D. Sauer and J.A. Yorke (1996) Springer
4. Chaos in Dynamical Systems: E. Ott (2003) Cambridge University Press
5. Nonlinear Dynamics: M. Lakshmanan and S. Rajasekar (2003) Springer
6. G.L. Baker and J.P. Gollub, Chaotic Dynamics, 2nd edition, Cambridge University Press, New York, 1996
7. C. Sprott, Chaos and Time-Series Analysis, Oxford University Press, 2003.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

Open Electives (Physics)

18OEL267 Perspectives in Astrophysics and Cosmology 3 0 0 3

Course Outcomes: After successful completion of the course, students will be able to

CO1: Describe the history of astronomy and astrophysics- both Indian and western contributions;

CO2: Solve problems in Celestial Mechanics and astronomical distance measurements.

CO3: Describe the evolution and classification of stars using H-R diagram

CO4: Describe exotic objects like black holes, supernova, neutron stars, pulsars, Quasars etc.

CO5: Distinguish between various cosmological models like steady state, open, critical, closed, pulsating etc.

CO6: Describe about CMBR, expansion of space-time fabric, Einstein rings, the horizon problem, flatness problem, Inflationary model, Dark matter Dark energy etc.

CO7: Analyse different shades of Anthropic principle - Strong, Weak intermediate.

Unit 1 Historical Introduction - Copernicus, Galileo - Solar system-Planets, Comets, meteorites, asteroids, satellites, Constellations and Astrology, Olbers paradox.

Unit 2 Constellations, Distance scales and measurements - Parallax methods - Moving cluster, Statistical and Spectroscopic and dynamic parallax methods.

Unit 3 Introduction to Celestial Mechanics – Kepler's laws. Black body temperature of stars Hertz-Sprung Russel diagram - Stellar evolution - white dwarfs, red giants, neutron stars, pulsars, black holes.

Unit 4 Special Relativity – Minkowski space, Introduction to General Relativity - space-time curvature.

Unit 5 Cosmology - Red shift – Galaxies - CMBR Big bang, Various cosmic models - Horizon and Flatness, problem of Dark matter and Energy. Anthropic Principle. Relation to Biology.

References

1. Arnab Rai Choudhuri, Astrophysics for Physicists, Cambridge University Press, 2010.
2. An Introduction to Astrophysics, Baidyanath Basu, Tanuka Chattopadhyay, 2nd Edition, PHI Learning Pvt. Ltd.
3. The New Physics and Cosmology Zanjoc, Oxford 2004.
4. Caroll Ostie, An Introduction to Modern Astrophysics, 2nd Ed., Pearson, Addison Wesley.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18OEL297 HISTORY AND PHILOSOPHY OF SCIENCE (3 0 0 3)

Description: Normally the students of science lack a broad historical perspective about the discoveries of science which essential for greater appreciation and even understanding of some the concepts. This course is aimed at bridging this gap.

Course Outcomes: After successful completion of the course, students will be able to

1) Describe the Indian and world history of science starting from Copernican revolution and the rise of modern science in a nutshell.
2) Identify the ancient Indian contribution to science, technology, architecture, Mathematics and Medicine, Astronomy etc.
3) Describe the ancient revolutionary work and writings of Euclid, Aryabhata, Brahmagupta, Jyestadeva, Newton etc.
4) Analyze the aims or goals and philosophy of science to utilize their knowledge and talent to serve society at large.

Contents:

Unit 1 Why History of Science? Astronomy in the ancient world - people, theory and instruments (4 hours) - Astronomy across civilizations of the old world, main discoveries, their contribution and instruments during those times.

Unit 2 The Dark ages in Europe - the Arabian influence - The Islamic science, translations and original contributions of Arabians, dark ages Europe, logic, literature and scientific method, early universities of Europe.

Unit 3 Indian tradition in Science and Technology - an overview - Indian contributions in science and technology - mathematics, astronomy and other sciences.

Unit 4 Texts that changed the course of history science - Elements of Euclid, Aryabhatiya of Aryabhata, Brahmasputa Sidhanta of Brahmagupta, Yuktibhasa of Jyestadeva, Philosophiae Natturalis Principia Mathematica.

Unit 5 The Copernican revolution and the rise of modern science - The background of Copernican revolution, interaction between civilizations, the rise of modern sciences - when and why?

Text and Background Literature:
History and philosophy of science is yet to be established as full-fledged discipline. A suggested anthology of reading materials:
1. Essential reading on history of sciences (in-house publication)
2. http://www.Open2.net/whattheancients/ (Documentaries)

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

18OEL298 EU HISTORY OF SCIENCE AND TECHNOLOGY 4 0 0 3

Description: From Galileo to Einstein, from the split of science and religion to the discovery of machines and computers, science have played a major role in the history of European Union and largely contributed to the place of European Union in the world nowadays.
In this course we will review some major contributions in science and technology made in EU, in particular in Physics, which allowed cultural, philosophical and technical revolutions. We will try to put as best as we can the discovery in their historical context and present elements of biography of the some of the most prominent scientists involved in these discoveries. We will also look at past and present influence, in particular Indian influence on EU science and technology advances. These courses will outreach scientific concept of each

discovery for bachelor students in science. The course will follow thematic line, which will be as much as possible historically ordered.

Course Outcomes: After successful completion of the course, students will be able to
1) Get awareness about developments in science from pre-Socratic period to modern era
2) Develop skills to comprehend science history literature, summarize.
3) Develop sense of how much hard word and uncountable human-hours was involved in bringing science to current level of advancement and get inspired
4) Develop a deeper sense of appreciation of laws of physics studying history of its development.

1. The Greek legacy: Eratosthenes, Ptolemy (2h):
   a. Pre-Socratic period: the Pythagoreans school.
   b. Classic period: Plato and Aristotle
   c. Astronomy and Mathematics in the Hellenistic period: Ptolemy, Eratosthenes, Hipparchus, Euclid, Archimedes.
2. Elements of Indian Astronomy and Mathematics and their influence on Europe (6h):
   a. Prehistory: the Vedic period, discoveries in mathematics, astronomy and medicine.
   b. Middle age
   c. Late middle age: science technology transfer with Europe.
3. The scientific revolution at renaissance. (6h)
   a. Copernicus, Galileo, Kepler, Newton: motion in the solar system.
   b. Separation between science and religion.
   c. Technology major inventions: printing technics, navigation instrument: astrolabe, sextant.
4. Thermodynamics and thermal machine and the industrial revolution (6h).
   a. Invention of thermal machine and industrial revolution in Europe.
   b. XVIIe to XVIIIe: the birth of thermodynamic with chemistry and thermal machine
   c. XIXe: Formalization of thermodynamic laws and principles (Carnot, Joule, Clapeyron, Kelvin)
   d. Development of statistical mechanics (Boltzmann, Gibbs)
5. Light, Electricity and electromagnetism:
   a. Coulomb, Maxwell, Ampere (4h)
6. Einstein contribution (Photo electric effect, Relativity, etc.) (2h)
7. Radioactivity: Pierre et Marie Curie (2h).
   a. Introduction on Mendeley and periodic table.
   b. Discovery of Radioactivity
   c. Elements of biography of Marie Curie
8. Discovery of quantum mechanics:
   a. Introduction on black body radiation (Planck), photo electric effect (Einstein) and wave-particle duality.
   b. The Copenhagen interpretation: Bohr, Heisenberg, Pauli, Planck
9. Technology discovery in the context of the 2nd world war (4h)
   a. Nuclear energy
   b. Turing machine
   c. Jet engine
10. A few remarkable recent advances in quantum mechanics (4h):

a. Violation of Bell's inequalities (A. Aspect)
b. Mesoscopic physics and quantum Circuits
c. Cold atoms (C. Cohen Tannoudji)
d. Quantum material: Graphene, topological insulators.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)