MOTHER TERESA WOMEN'S UNIVERSITYKODAIKANAL-624101

DEPARTMENTOFPHYSICS

M.Sc.PHYSICS

CurriculumFramework,SyllabusandRegulations

(BasedonTANSCHE SyllabusunderChoiceBasedCreditSystems–CBCS)

(Forthe candidates to beadmitted from the AcademicYear2023-2024)

TABLEOFCONTENTS

MOTHERTERESAWOMEN'SUNIVERSITY

KODAIKANALDEPARTME NTOFPHYSICS

CHOICEBASEDCREDIT SYSTEM (CBCS)
(2023– 2024 Onwards)

M.Sc.PHYSICS

1. AbouttheDepartment

Department of Physics was established in 2002 with M.Sc. Physics. It acts as instrument for spreadingHigher Education in Physics to remote rural areas of Kodaikanal. M.Phil. and Ph.D. programme were introducedinthe year2005.

2. AbouttheProgramme-M.Sc.Physics

M.Sc.Physicsisatwo-year Postgraduate Programme that providesthelearnerswiththetheoretical and practical knowledge of Physics and its allied subjects. The Programme, with itsstrong emphasis on skilldevelopment,enrichesthelearners'research technological and employability skills and thereby ensures their broad-based futuristic developments with soundknowledgeandethical values.

3. ProgrammeEducationalObjectives(PEOs)

PEO1:TopreparethestudentstoexcelinPhysicsandtosucceedinIndustry/technical/researchbasedpro fession.

PEO2:Totrainstudentswithdepthandbreadthofknowledgein Physicssoastocomprehend,analyze,des ign and createsolutions for real-lifeproblems.

PEO3: To providestrongmathematicalandtechnicalfoundation needed tosolverealworldproblemsand also to pursuehigherstudies and researchin Physics.

PEO4:Toinculcateappropriateprofessionalandethicalattitudeinstudents in order toworktowards a broader socialcontext.

PEO5: Todevelopstudentswithleadershipqualitiesandcontinuouslearningabilityonthetechnologyn eeded for asuccessful profession.

4. Programme Outcomes (POs)

PO1: To acquireknowledgeaboutthenature,concepts,methods,techniquesandobjectivesinthecoresubjects

PO2: To cultivate scientific approachandcultureofresearchaptitude.

PO3: To enhance the problem-solvingskillsofthestudentssothatthey will be abletofacethenationallevel competitiveexams like NET, GATE and SETetc.

PO4: To understand the linksof Physicswithother disciplinesand alsotothe societalissues.

PO5: Totrainthestudentstodeveloptheiremployabilityskillsandentrepreneurial skills.

5. Program-SpecificOutcomes(PSO)

PSO1: TomakethestudentsinmasteringinthefieldofMaterialsScienceandAstrophysicsandpreparethem forresearch

PSO2: Understandandapplyinter-disciplinaryconceptsofPhysicsforunderstandinganddescribingthenatural phenomenon

PSO3: Providebasicfoundationswithasoundknowledgeofunderlyingprinciplesalongwithrecentdevelopments

PSO4: Enablestudentstoworkwithstate-of-the arttechnologies

PSO5: Abilitytoplanandexecutetheirowninnovativeideasintheformofprojects,productdesignand development.

PSO6: Know about the importance of research methodology in science by acquiringknowledgein the form ofproject, summerinternship andfield visit/industrial visit**.**

6. Eligibility

B.Sc. Physics,AppliedPhysics,withMathematicsasalliedsubjectattheUGlevel

7. GeneralGuidelinesforPGProgramme

i. Duration: TheProgramme shallextend throughaperiodof4consecutivesemestersand Thedurationofasemestershallnormallybe90daysor450hours.Examinationsshallbeconductedattheendof each semester for the respectivesubjects.

ii. Medium ofInstruction: English

8. Evaluation(25+75):**EvaluationofthecandidatesshallbethroughInternalAssessmentandEndSemester Examination.**

8.1. EvaluationPattern

EVALUATIONPATTERN		MaximumMarks (Theory& Practical)	MinimumMarks (Theory& Practical)
InternalEvaluation	ContinuousInternalAssessmentTest	**25 Marks**	**13 Marks**
	Assignments/Snap Test/Quiz		
	Seminars		
	AttendanceandClassParticipation		
ExternalEvaluation	EndSemesterExamination	**75 Marks**	**38 Marks**
Total		**100Marks**	**50Marks**

Minimumcreditsrequiredtopass:91

8.2. InternalAssessment-CIA

Theory Course: Forthe orgy courses thereshall bethree tests conductedbythefacultyconcernedandtheaverageofthebesttwocanbetaken astheContinuousInternal Assessment (CIA) foramaximum of 25marks. the duration ofeachtest shall beone/oneand ahalf hour.

ThereisnoimprovementforCIAofboththeoryandlaboratory,and,alsoforUniversityEndSemesterExamination.

8.3. EndSemesterExamination(Theory):Max.Marks:75Time:3hrs.

8.4.WrittenExaminationQuestionPaperPattern:TheoryPaper(Bloom'sTaxonomybased)

(CommonforPGProgrammes)

IntendedLearningSkills	**Maximum75Marks** **PassingMinimum:50%** **Duration:ThreeHours**
Memory Recall / Example/Counter Example / KnowledgeabouttheConcepts/Understanding	**Part –A (10x 2 = 20 Marks)**AnswerALLquestions **EachQuestioncarries2mark**
	TwoquestionsfromeachUNIT **Question1 to Question10**
Descriptions/ Application(problems)	**Part– B (5 x5 = 25 Marks)**
	AnswerALLquestions **Eachquestionscarries5Marks**
	Either-orType BothpartsofeachquestionfromthesameUNIT
	Question11(a)or11(b) To **Question15(a) or15(b)**
Analysis/Synthesis/Evaluation	**Part-C (3x 10 = 30 Marks)AnsweranyTHREEquestions** **Eachquestioncarries10Marks**
	Thereshallbe FIVEQuestionscoveringallthefive units
	Question16 toQuestion 20

Eachquestionshould carrythecourseoutcomeandcognitivelevelFor instance,

9.1.I.1. [CO1: K2]Question xxxx

9.1.I.2. [CO3: K1]Question xxxx

8.5. MethodsofAssessment

MethodsofAssessment	
Recall(K1)	Simpledefinitions,MCQ,Recallsteps,Conceptdefinitions
Understand/Comprehend K2)	MCQ,True/False, Shortest says,Conceptexplanations,Shortsummaryoroverview
Application(K3)	Suggestidea/conceptwithexamples,Suggestformulae,Solveproblems,Observe,Explain
Analyze(K4)	Problem-solving questions, Finish aprocedureinmanysteps,Differentiatebetweenvarious ideas, Map knowledge
Evaluate(K5)	Longeressay/ Evaluation essay, Critique or justifywithprosandcons
Create(K6)	Checkknowledgein specificoroffbeatsituations, Discussion,Debating or Presentations

9. Project

9.2. ProjectReport

A student should select a topic for the Project Work at the end of the third semester itself andsubmit the Project Report at the end of the fourth semester. The Project Report shall not exceed40typedpages in TimesNew Roman font with1.5linespace.

9.3. ProjectEvaluation

There is a Viva Voce Examination for ProjectWork. The Guide andan ExternalExaminershallevaluateandconducttheVivaVoceExamination.TheProjectWorkcarries100marks (Internal:25Marks; External (Viva): 75Marks).

10. ConversionofMarkstoGradePointsandLetterGrade(Performanceinacourse /Paper)

Range ofMarks	GradePoints	Letter Grade	Description
90–100	9.0–10.0	O	Outstanding
80-89	8.0–8.9	D+	Excellent
75-79	7.5–7.9	D	Distinction
70-74	7.0–7.4	A+	VeryGood
60-69	6.0–6.9	A	Good
50-59	5.0–5.9	B	Average
00-49	0.0	U	Re-appear
ABSENT	0.0	AAA	ABSENT

11. Attendance

Students must have earned 75% of attendance in each course for appearing for the examination.Students with 71% to 74% of attendance must apply for condonation in the Prescribed Form with theprescribed fee. Students with 65% to 70% of attendance must apply for condonation in the PrescribedForm with the prescribed fee along with the Medical Certificate. Students with attendance less than65% are not eligible to appear for the examination and they shall re-do the course with the priorpermissionof theHeadof theDepartment,Principal and theRegistrar of theUniversity.

12. MaternityLeave

The studentwhoavailsmaternityleave may beconsideredtoappearfortheexaminationwiththeapprovalofStaffi/c,Head oftheDepartment, ControllerofExamination andthe Registrar.

13. AnyOtherInformation

Inadditiontotheabove-mentionedregulations,anyothercommonregulationspertainingtothePG Programmes arealso applicableto this Programme.

14. FacultyCourseFileStructure-Contents

a.	AcademicSchedule	**q.**	LaboratoryExperimentsrelatedtotheCourses
b.	StudentsNameList	**r.**	InternalQuestionPaper
c.	TimeTable	**s.**	ExternalQuestionPaper
d.	Syllabus	**t.**	Sample Home AssignmentAnswerSheets
e.	LessonPlan	**u.**	Threebest,threemiddlelevelandthree averageAnswersheets
f.	StaffWorkload	**v.**	Result Analysis (CO wise andwholeclass)
g.	CourseDesign(content,CourseOutcomes(COs),Deliverymethod,mappingofCoswith ProgrammeOutcomes(POs),AssessmentPattern in terms ofRevisedBloom'sTaxonomy).	**w.**	Question Bank for Higherstudies Preparation(GATE/Placement)
h.	Sample COAssessmentTools	**x.**	Listofmenteesandtheiracademicachievements
i.	FacultyCourseAssessmentReport(FCAR)		
j.	CourseEvaluationSheet		
k.	TeachingMaterials(PPT,OHP etc.)		
l.	LectureNotes		
m.	HomeAssignmentQuestions		
n.	TutorialSheets		
o.	RemedialClassRecord,ifany		
p.	Projectsrelatedto theCourse		

FIRST SEMESTER

COURSE COMPONENTS	CourseCode	NAMEOFTHE COURSE	INST. HRS.	CREDITS	EXAMHRS.	MAX MARKS	
						CIA	EXT.
Core-I	P23PHT101	Core Theory – 1: Mathematical Physics	7	5	3	25	75
Core II	P23PHT102	Core Theory – 2: Classical Mechanics and Relativity	7	5	3	25	75
CoreIII	P23PHP103	Core Practical – 1: General	6	4	3	25	75
Elective-I	P23PHE11A /P23PHE11B	**Discipline Specific Elective – 1:** A. Energy Physics/ B. Materials Science	5	3	3	25	75
Generic Elective	P23WSG101	**Generic Course-I** – Women Empowerment	5	3	3	25	75
	Total		**30**	**20**			

SECOND SEMESTER

COURSECOMPONENTS	Course Code	NAMEOFTHECOURSE	INST. HRS.	CREDITS	MAX MARKS	
					CIA	EXT.
Core-IV	P23PHT204	Core Theory – 3: Linear and Digital Ics and Applications	6	5	25	75
Core-V	P23PHT205	Core Theory – 4: Quantum Mechanics–I	6	5	25	75
Core-VI	P23PHP206	Core Practical – 2: Electronics	6	4	25	75
Elective-II	P23PHE22A / P23PHE22B	**Discipline Centric Elective:** A. Bio Physics / B. General Relativity and Cosmology	4	3	25	75
GenericCourse-II	P23CSG202	**GenericCourse –**Cyber Security	4	3	25	75
NME-SEC-I	P23PHN201	NME-Skill Enhancement Course – I(SEC-I)- Structural Analysis by XRD	4	2	25	75
Total			**30**	**22**		

THIRD SEMESTER

COURSE COMPONENTS	COURSE CODE	NAME OF COURSE	INST. HRS.	CREDIT	MAX MARKS	
					CIA	EXT.
Core VII	P23PHT307	Core Theory – 5: Quantum Mechanics –II	6	5	25	75
Core VIII	P23PHT308	Core Theory –6: Condensed Matter Physics	6	5	25	75
Core IX	P23PHT309	Core Theory – 7: Statistical Mechanics	6	5	25	75
Core X Practical	P23PHP310	Core Practical – 3: Numerical Methods and Computer Programming (C)	6	4	25	75
Elective – V	P23PHE33A/ P23PHE33B / P23PHE33C	Elective – 3: A. Spectroscopy / B. Physics of Nano Science and Technology/ C. Analysis of Crystal Structure	3	3	25	75
NME-II	P23PHN302	Non Major Elective-2: Basic Astrophysics	3	2	25	75
Internship / Industrial Activity	P23PHI301	Internship / Industrial Activity	-	2	-	-
		Total	30	26		

FOURTH SEMESTER

COURSE COMPONENTS	COURSE CODE	NAME OF COURSE	INST. HRS.	CREDITS	MAX MARKS	
					CIA	EXT.
Core XI	P23PHT411	Core Theory – 8: Nuclear and Particle Physics	6	5	25	75
Core XII	P23PHT412	Core Theory – 9: Electromagnetic Theory	6	5	25	75
Core XIII	P23PHPR41	Core -10: Project with Viva-Voce	10	7	25	75
Elective VI	P23PHE44A/ P23PHE44B / P23PHE44C	Elective-4: Industry Entrepreneurial A.Characterization of Materials B.Solar Energy Utilization / C.Solid Waste Management	4	3	25	75
SEC-II	P23PHS402	Professional Competency Course Data analysis by Origin software	4	2	25	75

Extension Activity	P23EAS401	Extension Activity	-	1	-	-
		Total	30	23		

FIRSTSEMESTER

Core–I **Paper-1-MATHEMATICAL PHYSICS**	**I YEAR-FIRSTSEMESTER**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst.Hours**	**Marks**
P23PHT101	**MATHEMATICAL PHYSICS**	Core	7	-	-	5	7	75

Pre-Requisites
Matrices,vectors,differentiation,integration,differential equations
LearningObjectives
➢ To equip students with the mathematicaltechniquesneededforunderstandingtheoreticaltreatmentin different courses taught in their program ➢ Toextendtheirmanipulativeskillstoapplymathematicaltechniquesin theirfields ➢ Tohelpstudents applyMathematicsin solvingproblems ofPhysics

UNITS	**CourseDetails**
UNITI: **LINEAR VECTORSPACE**	Basic concepts – Definitions- examples of vector space – Linear independence - Scalar product- Orthogonality – Gram-Schmidt orthogonalization procedure – linear operators – Dual space- ket and bra notation – orthogonal basis – changeof basis – Isomorphism of vector space – projection operator –Eigen values andEigenfunctions–Directsumandinvariantsubspace–orthogonal Transformationsandrotation

UNITII: **COMPLEXANALYSIS**	Review of Complex Numbers -de Moivre's theorem-Functions of a ComplexVariable- Differentiability -Analytic functions- Harmonic Functions-ComplexIntegration-ContourIntegration,Cauchy–Riemannconditions– Singularpoints – Cauchy's Integral Theorem and integral Formula -Taylor's Series -Laurent's Expansion-Zeros and poles – Residue theorem and its Application:Potential theory - (1) Electrostatic fields and complex potentials - Parallel plates,coaxialcylindersandanannularregion(2)Heatproblems-Parallelplatesand Coaxialcylinders
UNITIII: **MATRICES**	TypesofMatricesandtheirproperties,RankofaMatrix-Conjugateofamatrix - Adjoint of a matrix - Inverse of a matrix - Hermitian and Unitary Matrices - Trace of a matrix- Transformation of matrices - Characteristic equation – EigenvaluesandEigen vectors-Cayley–Hamiltontheorem – Diagonalization

UNITIV: **FOURIERTRANSFORMS &LAPLACE TRANSFORMS**	Definitions -Fourier transform and its inverse - Transform of Gaussian function and Dirac delta function -Fourier transform of derivatives - Cosine and sinetransforms-Convolutiontheorem.Application:Diffusionequation:Flowofheat in an infinite and in a semi-infinite medium - Wave equation: Vibration of an infinite string and of a semi-infinite string. Laplace transform and its inverse - Transforms of derivatives and integrals – Differentiationandintegrationoftransforms-Diracdeltafunctions-Application – Laplace equation: Potential problem in a semi-infinite strip

UNIT V: **DIFFERENTIAL EQUATIONS**	Second order differential equation- Sturm-Liouville's theory - Series solutionwithsimpleexamples-Hermitepolynomials-Generatingfunction-Orthogonalityproperties- Recurrencerelations–Legendrepolynomials-Generating function - Rodrigue formula – Orthogonality properties – Diracdeltafunction-OnedimensionalGreen'sfunctionandReciprocitytheorem-Sturm-Liouville'stypeequationinone dimension&theirGreen's function.
UNIT VI:PROFESSIONALCOMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits,CompetitiveExaminations,EmployableandCommunication SkillEnhancement,Social Accountability and Patriotism
TEXTBOOKS	1. GeorgeArfkenandHansJWeber, 2012, Mathematical MethodsforPhysicists –AComprehensiveGuide (7thedition), Academic press. 2. P.K.Chattopadhyay,2013,*MathematicalPhysics*(2nd edition),NewAge,NewDelhi 3. AWJoshi,2017,MatricesandTensorsinPhysics,4thEdition(Paperback),New AgeInternational Pvt.Ltd., India 4. B. D. Gupta, 2009, *Mathematical Physics* (4th edition),VikasPublishing House, New Delhi. 5. H.K.DassandDr.RamaVerma,2014,MathematicalPhysics, SeventhRevisedEdition,S.Chand&CompanyPvt.Ltd.,NewDelhi.
REFERENCE BOOKS	1. E.Kreyszig,1983,AdvancedEngineeringMathematics,WileyEastern,New Delhi, 2. D.G.ZillandM.R.Cullen,2006,AdvancedEngineeringMathematics, 3. 3rd Ed. Narosa, NewDelhi. 4. S. Lipschutz, 1987, Linear Algebra, Schaum's Series, McGraw - Hill,NewYork3.E.Butkov,1968,MathematicalPhysicsAddison-Wesley,Reading, Massachusetts. 5. P. R. Halmos, 1965, Finite Dimensional Vector Spaces, 2nd Edition,AffiliatedEast West, New Delhi. 6. C.R.WylieandL.C.Barrett,1995,AdvancedEngineeringMathematics,6th Edition,InternationalEdition,McGraw-Hill,New York

WEBSOURCES	1. www.khanacademy.org 2. https://youtu.be/LZnRlOA1_2I 3. http://hyperphysics.phy-astr.gsu.edu/hbase/hmat.html#hmath 4. https://www.youtube.com/watch?v=_2jymuM7OUU&list=PLhkiT_RYTEU27vS_SlED56gNjVJGO2qaZ 5. https://archive.nptel.ac.in/courses/115/106/115106086/

COURSEOUTCOMES

Attheendof thecourse the studentwillbeableto

CO1	Understanduse of bracket vectornotationandexplainthemeaningofcompleteorthonormalsetofbasisvectors,andtransformationsandbeable to apply them	**K1, K2**
CO2	Abletounderstandanalytic functions, do complexintegration,byapplying CauchyIntegralFormula.Abletocomputemanyrealintegralsandinfinitesumsvia complex integration.	**K2, K3**
CO3	Analyzecharacteristicsof matricesanditsdifferenttypes, andtheprocessof Diagonalization.	**K4**
CO4	Solve equations using Laplace transform and analyze the Fourier Transformationsofdifferentfunction,grasphowthesetransformationscanspeedup analysis andcorrelatetheirimportanceintechnology	**K4, K5**
CO5	Tofindthesolutionsforphysicalproblemsusinglineardifferentialequationsandto solveboundaryvalueproblemsusingGreen'sfunction. Applyspecialfunctionsin computationofsolutionsto realworldproblems	**K2, K5**
K1-Remember; K2 –Understand; K3 -Apply;K4 -Analyze; K5 –Evaluate		

MAPPINGWITHPROGRAMOUTCOMES

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specificoutcomes**(PSO)** inthe3-point scaleofSTRONG(3),MEDIUM(2)andLOW(1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	3	3	3	3	2	3	2
CO2	2	3	3	3	3	3	3	2	2	2
CO3	3	3	3	2	2	3	3	2	3	2
CO4	3	3	3	3	2	3	3	2	2	2
CO5	3	2	3	3	2	3	3	2	2	3

Strong (3) , Medium (2)and Low(1)

Core–II **Paper-2-CLASSICALMECHANICSANDRELATIVITY**	**IYEAR-FIRSTSEMESTER**

Subject Code	Subject Name	Category	L	T	P	Credits	Inst.Hours	Marks
P23PHT102	CLASSICAL MECHANICS AND RELATIVITY	Core	7	-	-	5	7	75

Pre-Requisites
Fundamentals of mechanics, Foundation in mathematical methods.
Learning Objectives
➢ To understand fundamentals of classical mechanics. ➢ To understand Lagrangian formulation of mechanics and apply it to solve equation of motion. ➢ To understand Hamiltonian formulation of mechanics and apply it to solve equation of motion. ➢ To discuss the theory of small oscillations of a system. ➢ To learn the relativistic formulation of mechanics of a system.

UNITS	Course Details
UNITI: **PRINCIPLESOF CLASSICAL MECHANICS**	Mechanics of a single particle – mechanics of a system of particles – conservation laws for a system of particles– constraints– holonomic & non-holonomic constraints–generalized coordinates–configuration space–transformation equations–principle of virtual Work.
UNIT II: **LAGRANGIAN FORMULATION**	D' Alembert's principle–Lagrangian equationsofmotionforconservative systems – applications:(i)simplependulum(ii) Atwood'smachine(iii)project IL emotion.
UNITIII: **HAMILTONIAN EQUATIONS**	Hamilton'sPrinciple–Hamiltonianfunction,Hamilton'sEquationfrom variation principle–Hamilton'scanonicalequationsofmotion –applications:(i)simplependulum(ii)onedimensionalsimple Harmonic oscillator (iii)motionofparticleinacentral forcefield.
UNITIV: **SMALLOSCILLATIONS**	Normalfrequenciesof vibration,Eigenvalueequation,Formulationof Theproblem–transformationtonormalcoordinates– frequenciesofnormalmodes– linear triatomic molecule.
UNITV: **RELATIVITY**	Inertialandnon-inertialframes–Lorentztransformationequations– lengthcontractionandtimedilation–relativisticadditionofvelocities – Einstein'smass –energyrelation–Murkowski's space–fourvectors – position,velocity,momentum,accelerationandforceinforvectornotation and their transformations
UNIT VI: **PROFESSIONAL COMPONENTS**	Expert Lectures, Online Seminars-Webinars onIndustrialInteractions/Visits,CompetitiveExaminations,EmployableandCommunicationSkillEnhancement,SocialAccountabilityand Patriotism

TEXTBOOKS	1. H.Goldstein,2002,*ClassicalMechanics*,3rdEdition,PearsonEdu. 2. J.C.Upadhyaya,*ClassicalMechanics*,HimalayaPublishing.Co. New Delhi. 3. R. Resnick, 1968, *Introduction to Special Theory ofRelativity*,Wiley Eastern, New Delhi. 4. R.G.TakwalaandP.S.Puranik,IntroductiontoClassicalMechanics–Tata– McGrawHill, NewDelhi,1980. 5. N.C.RanaandP.S.Joag,ClassicalMechanics-Tata McGrawHill,2001
REFERENCEBOOKS	1. K.R.Symon, 1971,*Mechanics*,Addison Wesley, London. 2. S.N.Biswas,1999,*ClassicalMechanics*,Books&Allied,Kolkata. 3. GuptaandKumar,*ClassicalMechanics*,KedarNath. 4. T.W.B.Kibble,*ClassicalMechanics*,ELBS. 5. Greenwood,*ClassicalDynamics*,PHI,NewDelhi.
WEBSOURCES	1. http://poincare.matf.bg.ac.rs/~zarkom/Book_Mechanics_Goldstein_Classical_Mechanics_optimized.pdf 2. https://pdfcoffee.com/classical-mechanics-j-c-upadhyay-2014-editionpdf-pdf-free.html 3.https://nptel.ac.in/courses/122/106/122106027/ 4. https://ocw.mit.edu/courses/physics/8-09-classical-mechanics-iii-fall-2014/lecture-notes/ 5. https://www.britannica.com/science/relativistic-mechanics

COURSEOUTCOMES

Attheendof thecourse the studentwillbeable

CO1	Understandthe fundamentalsofclassicalmechanics.	**K2**
CO2	ApplytheprinciplesofLagrangianandHamiltonianmechanicstosolve Theequationsofmotion ofphysicalsystems.	**K3**
CO3	ApplytheprinciplesofLagrangianandHamiltonianmechanicstosolve Theequationsofmotion ofphysicalsystems.	**K3, K5**
CO4	Analyzethesmalloscillationsinsystemsanddeterminetheirnormal Modesofoscillations.	**K4, K5**
CO5	Understandandapplytheprinciplesof relative stickinematicstothe Mechanicalsystems.	**K2, K3**
K1-Remember; K2 –Understand; K3 -Apply;K4 -Analyze; K5 –Evaluate		

MAPPINGWITHPROGRAMOUTCOMES

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specificoutcomes**(PSO)** in the3-point scale ofSTRONG (3), MEDIUM(2)and LOW(1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	2	3	3	3	2	2	2	3	2	2
CO2	2	3	3	3	2	2	2	3	2	2
CO3	2	3	3	3	2	2	2	3	2	2
CO4	2	3	3	3	2	2	2	3	2	2
CO5	2	3	3	3	2	2	2	3	2	2

Strong– 3, Medium– 2, Low-1

CoreIII-PRACTICALI	**IYEAR-FIRSTSEMESTER**

Subject Code	Subject Name	Category	L	T	P	Credits	Inst.Hours	Marks
P23PHP101	**PRACTICAL -I -General**	Core	-	-	6	4	6	75

Pre-Requisites
Knowledgeandhands onexperienceof basic generalexperiments ofPhysics
LearningObjectives
➢ Tounderstandtheconceptofmechanicalbehaviorofmaterialsandcalculationofsameusingappropriate equations. ➢ Tocalculatethethermodynamicquantities andphysicalpropertiesofmaterials. ➢ Toanalyzetheopticalandelectricalpropertiesof materials.

CourseDetails

GeneralExperiments(Any TwelveExperiments)

1. DeterminationofYoung'smodulusandPoisson'sratiobyHyperbolicfringes-Cornu'sMethod
2. DeterminationofViscosityofthegivenliquid –Meyer'sdisc
3. MeasurementofCoefficientoflinear expansion- AirwedgeMethod
4. B-Hloopusing Anchorring.
5. DeterminationofThickness oftheenamel coatingonawirebydiffraction
6. DeterminationofRydberg'sConstant –HydrogenSpectrum
7. FPEtalon
8. DeterminationofThicknessofairfilm.-Solarspectrum– Hartmann'sformula.EdserandButlerfringes.
9. MeasurementofBand gapenergy-Thermistor
10. DeterminationofPlanckConstant–LEDMethod
11. DeterminationofSpecificchargeofanelectron–Thomson'smethod.
12. DeterminationofCompressibilityofaliquidusingUltrasonics
13. DeterminationofWavelength,Separationofwavelengths-MichelsonInterferometer
14. GMcounter–Characteristics, inversesquarelawandabsorptioncoefficient.
15. MeasurementofConductivity-Four probemethod.
16. Arcspectrum– Iron.
17. Molecularspectra– AlO band.
18. Measurementofwavelength ofDiodeLaser/He –NeLaserusing Diffractiongrating.
19. DeterminationofDiffraction patternoflightwithcircular apertureusing Diode/He-Nelaser.

20. Studythebeam divergence,spot sizeand intensityprofileofDiode/He-Nelaser. 21. MeasurementsofStandingwaveandstandingwaveco-efficient,LawofInversesquare,Receiver end transmitterbehavior,Radiation Pattern-Microwavetest bench 22. UV-Visiblespectroscopy–VerificationofBeer-Lambert'slawandidentificationofwavelengthmaxima– Extinction coefficient	
TEXTBOOKS	1. PracticalPhysics,GuptaandKumar,PragatiPrakasan. 2. KitDevelopedfordoingexperimentsinPhysics-Instructionmanual, R.Srinivas and K.RPriolkar, IndianAcademyofSciences. 3. ElectronicLaboratory Primer designapproach,S.Poornachandra, B.Sasikala,WheelerPublishing,NewDelhi. 4. Electroniclab manualVol I, K Anavas, Rajath Publishing. 5. Electroniclabmanual VolII,KAnavas, PHIeastern EconomyEdition
REFERENCE BOOKS	1. AdvancedPracticalPhysics,S.PSingh,PragatiPrakasan. 2. AnadvancedcourseinPracticalPhysics,D.Chattopadhayay,C.RRakshit,New Central Book Agency Pvt. Ltd 3. Op-Ampandlinearintegratedcircuit,RamakanthAGaykwad,EasternEconomy Edition. 4. AcourseonexperimentwithHe-NeLaser,R.S.Sirohi,JohnWiley&Sons(Asia)Pvt. Ltd. 5. ElectroniclabmanualVolII,KuriachanT.D,SyamMohan,AyodhyaPublishing.

COURSEOUTCOMES

Attheendof thecourse the studentwillbeableto

CO1	Understandthestrengthofmaterialusing Young'smodulus.	**K2**
CO2	Acquireknowledgeofthermal behavior ofthematerials.	**K1**
CO3	Understandtheoreticalprinciplesofmagnetismthroughtheexperiments.	**K2**
CO4	Acquireknowledgeabout arcspectrumand applicationsoflaser	**K1,K3**
CO5	Improvetheanalyticaland observationabilityinPhysicsExperiments	**K3, K5**
CO6	Conduct experiments onapplicationsofFET andUJT	**K4**
CO7	Analyzevariousparametersrelatedtooperationalamplifiers.	**K4**
CO8	Understandthe conceptsinvolvedin arithmeticandlogicalcircuitsusing IC's	**K2**
CO9	AcquireknowledgeaboutCombinationalLogicCircuitsandSequentialLogicCircuits	**K1**
CO10	Analyzetheapplicationsofcountersandregisters	**K4**
K1-Remember; K2 –Understand; K3 -Apply;K4 -Analyze; K5 –Evaluate		

MAPPINGWITHPROGRAMOUTCOMES

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specificoutcomes**(PSO)** inthe3-point scaleofSTRONG(3),MEDIUM(2)andLOW(1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	2	2	2	3	2	2	2	1	2	3
CO2	2	2	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3
CO4	3	2	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	2	2	2	2
CO6	2	2	2	3	3	1	1	1	3	3
CO7	2	2	3	3	3	1	1	1	3	3
CO8	3	3	3	3	3	3	2	2	3	3
CO9	3	3	3	3	3	3	1	1	1	1
CO10	3	3	3	3	3	3	1	1	1	1

Strong (3) Medium (2) andLow (1)

Elective–I - 1.ENERGYPHYSICS	**IYEAR-FIRST SEMESTER**

Subject Code	SubjectName	Category	L	T	P	Credits	Inst.Hours	Marks
P23PHE11A	**ENERGYPHYSICS**	DISCIPLINE SPEFICELECTIVE	5	-	-	3	5	75

Pre-Requisites
Knowledgeof conventionalenergyresources
LearningObjectives
➢ Tolearnaboutvariousrenewable energysources. ➢ Toknowtheways of effectivelyutilizingtheoceanic energy. ➢ Tostudythemethodofharnessing windenergyand itsadvantages. ➢ Tolearn thetechniques usefulfor theconversion ofbiomass intouseful energy. ➢ Toknowabouttutilization ofsolarenergy.

UNITS	CourseDetails
UNIT I:INTRODUCTION TO ENERGYSOURCES	Conventional and non-conventional energy sources and their availability– prospectsofRenewableenergysources–Energyfromothersources– chemicalenergy–Nuclear energy–Energy storage and distribution.
UNIT II:ENERGY FROMTHEOCEANS	Energyutilization–Energyfromtides–Basicprincipleoftidalpower–utilization of tidal energy – Principle of ocean thermal energy conversionsystems.
UNIT III:WINDENERGY SOURCES	Basic principles of wind energy conversion–power in the wind–forces inthe Blades–Wind energy conversion–Advantages and disadvantagesofwindenergyconversionsystems(WECS)-Energystorage– Applicationsofwind energy.
UNIT IV:ENERGY FROMBIOMASS	Biomass conversion Technologies– wet and dry process– Photosynthesis – BiogasGeneration:Introduction– basicprocess:Aerobicandanaerobicdigestion– Advantagesofanaerobicdigestion–factorsaffectingbiodigestion and generation of gas- bio gas from waste fuel– properties ofbiogas-utilizationofbiogas.
UNIT V:SOLARENERGY SOURCES	Solarradiationanditsmeasurements–solarcells:Solarcellsfordirectconversion of solar energy toelectric powers–solar cellparameter– solarcellelectricalcharacteristics–Efficiency–solarwaterHeater–solar Distillation–solarcooking–solargreenhouse–Solarpondanditsapplications.

TEXT BOOKS	1. G.D. Rai, 1996, Non – convention sources of, 4th edition, Khannapublishers,New Delhi. 2. S.RaoandDr.ParuLekar,Energytechnology. 3. M.P.Agarwal,SolarEnergy,S.Chandand Co.,NewDelhi(1983). 4. Solarenergy,principlesofthermalcollectionandstoragebyS.P.Sukha tme, 2nd edition,TataMcGraw-HillPublishingCo.Lt.,NewDelhi(1997). 5. EnergyTechnologybyS.RaoandDr.Parulekar.
REFERENCE BOOKS	1. Renewableenergyresources,JohnTwidellandTonyweir,TaylorandFran cisgroup, London and New York. 2. Appliedsolarenergy,A.B.Meinel and A.P. Meinal 3. JohnTwidellandTonyWeir,Renewableenergyresources,TaylorandFran cisgroup, London and New York. 4. RenewalEnergyTechnologies:APracticalGuideforBeginnersC.S.Sola nki-PHILearning 5. IntroductiontoNon-ConventionalEnergyResources-Raja et.al.,Sci.TechPublications
WEBS OURCES	1.https://www.open.edu/openlearn/ocw/mod/oucontent/view.php?id=2411&printable=1 2. https://www.nationalgeographic.org/encyclopedia/tidal-energy/ 3. https://www.ge.com/renewableenergy/wind-energy/what-is-wind-energy 4. https://www.reenergyholdings.com/renewable-energy/what-is-biomass/ 5. https://www.acciona.com/renewable-energy/solar-energy/

UNIT VI:PROFESSIONALCOMPONENTS	ExpertLectures,OnlineSeminars-WebinarsonIndustrialInteractions/Visits,CompetitiveExaminations,EmployableandCommunicationSkillEnhancement,SocialAccountabilityand Patriotism

COURSEOUTCOMES

At the end ofthecourse,thestudentwill beableto

CO1	Toidentifyvariousformsofrenewableandnon-renewableenergysources	**K1**
CO2	Understandtheprinciple ofutilizingtheoceanic energyandapplyitfor Practicalapplications.	**K2**
CO3	Discusstheworkingof awindmilland analyzethe advantages ofwindenergy.	**K3**
CO4	Distinguishaerobicdigestionprocessfromanaerobicdigestion.	**K3, K4**
CO5	Understandthe componentsofsolarradiation,theirmeasurementandapply Themtoutilizesolarenergy.	**K2, K5**
K1-Remember;K2 – Understand;K3 -Apply;K4 -Analyze;K5 -Evaluate;		

MAPPINGWITHPROGRAMOUTCOMES

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specificoutcomes**(PSO)**in the3-point scale ofSTRONG (3), MEDIUM(2)andLOW(1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	2	3	3	3	2	2	2	3	3	3
CO2	2	3	3	3	2	2	2	3	3	3
CO3	2	3	3	3	2	2	2	3	3	3
CO4	2	3	3	3	2	2	2	3	3	3
CO5	2	3	3	3	2	2	2	3	3	3

Strong (3) Medium (2)and Low(1)

Elective–I- MATERIALS SCIENCE	**IYEAR-FIRST SEMESTER**

Subject Code	Subject Name	Category	L	T	P	Credits	Inst.Hours	Marks
P23PHE11B	**MATERIALS SCIENCE**	DISCIPLINE SPECIFICE LECTIVE	5	-	-	3	5	75

Pre-Requisites
➢ Basicknowledgeondifferenttypesofmaterials
LearningObjectives
➢ Togain knowledgeon optoelectronicmaterials ➢ Tolearnaboutceramicprocessingand advancedceramics ➢ Tounderstandtheprocessingandapplicationsof polymericmaterials ➢ Togain knowledgeon thefabrication ofcompositematerials ➢ Tolearnaboutshapememoryalloys,metallicglassesand Nano materials

UNITS	Coursedetails
UNIT I:OPTOELECTRONICMATERIALS	Importanceofopticalmaterials–properties:Bandgapandlatticematching – optical absorption and emission – charge injection, quasi-Fermi levels and recombination – optical absorption, loss and gain.Opticalprocessesinquantumstructures:Inter-bandintra-bandtransitions Organic semiconductors. Light propagation in materials –Electro-optic effect and modulation, electro-absorption modulation –excite onquenching.
UNIT:IICERAMICMATERIALS	Ceramicprocessing:powderprocessing,millingandsintering– structuralceramics:zirconia,almina,siliconcarbide,tungstencarbide –electronic ceramics –refractories –glassandglassceramics
UNIT :III POLYMERICMATERIALS	Polymersandcopolymers–molecularweightmeasurement–synthesis: chain growth polymerization – polymerization techniques –glass transition temperature and its measurement – viscoelasticity –polymer processing techniques – applications: conducting polymers,biopolymersand high temperaturepolymers.
UNIT IV COMPOSITEMATERIALS	Particular inforcedcomposites–fibered inforcedcomposites– mechanicalbehavior–fabricationmethodsofpolymermatrixcomposites and metal matrix composites – carbon/carbon composites:fabrication and applications.

UNITV: NEWMATERIALS	Shape memory alloys: mechanisms of one-way and two-way shapememory effect, reverse transformation, thermo-elasticity and pseudo-elasticity, examples and applications -bulk metallic glass: criteria forglassformationandstability,examplesandmechanicalbehavior-Nanomaterials: classification, size effect on structural and functionalproperties, processingand properties of Nanocrystalline materials,singlewalled and multi walled carbon Nano tubes

UNITVI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable andCommunicationSkillEnhancement,SocialAccountabilityand Patriotism
TEXTBOOKS	1. Jasprit Singh, Electronic and optoelectronic properties ofsemi-conductor structures, CambridgeUniversityPress, 2007 2. P.K.Mallick.Fiber-ReinforcedComposites.CRCPress, 2008. 3. V.Raghavan,2003,MaterialsScienceandEngineering,4th Edition,Prentice-Hall India, New Delhi(Forunits 2,3,4 and 5) 4. G.K.Narula,K.S.NarulaandV.K.Gupta,1988,MaterialsScience,TataMc Graw-Hill 5. M.Arumugam,2002,MaterialsScience,3rd revisedEdition,Anuratha Agencies
REFERENCE BOOKS	1. B. S. Murty, P. Shankar, B. Raj, B. B. Rath and J. Murday. TextbookofNanoscience and Nanotechnology.Springer-Verlag,2012. 2. K. Yamauchi, I. Ohkata, K. Tsuchiya and S. Miyazaki (Eds). ShapeMemory and Super Elastic Alloys: Technologies and Applications.Woodhead Publishing Limited, 2011. 3. Lawrence H. Van Vlack, 1998. Elements of Materials Science andEngineering,6th Edition,SecondISE reprint,Addison-Wesley. 4. H. Iabch and H. Luth, 2002, Solid State Physics – An Introduction toPrinciplesof Materials Science,2nd Edition, Springer. 5. D.Hull&T.W.Clyne,Anintroductiontocompositematerials, CambridgeUniversityPress, 2008.
WEBSOURCES	1. https://onlinecourses.nptel.ac.in/noc20_mm02/preview 2. https://nptel.ac.in/courses/112104229 3. https://archive.nptel.ac.in/courses/113/105/113105081 4.https://nptel.ac.in/courses/113/105/113105025/ https://eng.libretexts.org/Bookshelves/Materials_Science/Supplemental_Modules_(Materials_Science)/Electronic_Properties/Lattice_Vibrations

COURSEOUTCOMES

Attheend ofthecourse,thestudentwill beableto

CO1	Acquireknowledgeonoptoelectronicmaterials	**K1**
CO2	Beabletoprepareceramicmaterials	**K3**
CO3	Beabletounderstandthe processingandapplicationsofpolymericmaterials	**K2, K3**
CO4	Beawareofthefabricationofcompositematerials	**K5**
CO5	Beknowledgeableofshapememoryalloys,metallicglasses,and Nano materials	**K1**
K1-Remember;K2 – Understand;K3 -Apply;K4 -Analyze;K5 -Evaluate;		

MAPPINGWITHPROGRAMOUTCOMES

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specificoutcomes**(PSO)**in the3-point scale ofSTRONG (3), MEDIUM(2)andLOW(1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	2	3	3	2	2	2	2	1	2	3
CO2	2	3	3	2	2	2	2	1	2	2
CO3	2	3	2	2	2	2	2	2	2	2
CO4	1	3	2	3	2	3	2	2	2	2
CO5	2	3	2	2	2	2	2	2	2	2

Strong (3) Medium (2) andLow (1)

GENERICCOURSEI-WOMENEMPOWERMENT

Code:P23WSG11

Course CodeYear/semester	CourseName	Category	L	T	P	Credits	Inst.Hours	Marks		
								CIA	External	Total
P23WSG101 IYEAR/ISEMESTER	**WOMENEMPOWERMENT**	**GENERIC COURSE**	**5**	**-**	**-**	**3**	**5**	**25**	**75**	**100**

LearningObjectives	
LO1	Toknowthe CourseObjectives types, determinantsof women Empowerment
LO2	Tolearnthevariousnationalandinternationalagenciesforwomenempowerment.
LO3	Toupliftwomeninsocially,economicallyandpoliticallyasempowered.
LO4	Tomakeawareof women rights and enhancetheir life
LO5	ToknowthewomenentrepreneurshipdevelopmentinIndia

Details

Unit 1: Fundamentals of Women's Studies - Meaning and Definition of the concept ofWomen's studies –Need and Scope - Women's studies as an academic discipline - Women'sStudies–InternationalWomen'sYear1975-InternationalWomen'sDecade1975-1985;TowardsEqualStatus1976–Currenttrends-Importanceofwomen's education–Life Skill Education to build capacity - Education as a tool ofWomen Empowerment - Obstacles to Women Education – Social, Economic, Culturaland otherfactors, limitations ofFormal systemofeducation.

UNIT II - Issues of Women - Girl Children and Women in Society - Social Networking – Typesof Social Networking - impact and consequences of networking - Remedial measures andstrategies for solution- NCW: Initiatives to overcome Women's issues - Ministry of Home Affairsand Networking with State Women Commissions: Cyber Crime Prevention against Women andChildren (CCPWC)-challenges - Motherhood - Single Parent - Widows – Multiple Roles ofWomen-Roleconflict,Rolechange -Social Responsibilityand GenderEmpowerment.

UNITIII-AchievementandRightsofWomen-GenderEquality:AchievementofWomen-Educational, Political, Economic, Social - Panchayat Raj - Political role and participation – Nationaland InternationalLevels;Women'sRights-PropertyRights-Redressalmechanismatdifferentlevels -RightsofWomenwithDisability: CaseStudiesonWomenAchievers inthefieldofpolitics,education,arts science, law etc.

UNIT IV – EmpowermentofWomen-Empowerment of Women: Alternative approaches - Women in Development (WID) - Women and Development (WAD) - Role of Govt. and NGOs - Help line numbers in promoting women's empowerment - National and International FundingAgenciesin promoting research onwomen.

UNIT V - Women Entrepreneurship - Types of Entrepreneurs Opportunities and Risk – Pushand Pull Factors –financial Assistance and credit facilities- Micro finance- Entrepreneurship Skilland Competencies - Women Entrepreneurship Development in India: TRYSEM – NABARD –NMEW - Support to STEP – TREAD – Rural Entrepreneurship Development Programme –Gramia Bank –Mahila bank and supportive measures- Industrial Development Bank of India(IDBI)–SmallIndustriesDevelopmentBankofIndia-SHGandEntrepreneurshipopportunities.

CourseOutcomes		
Course Outcomes	Oncompletionofthiscourse,studentswill;	
CO1	Gainknowledgeabouttheconcept,needandsc opeof women's studies.	
CO2	Acquaintandanalyzeissuesofwomen invarious Contexts.	
CO3	Understandchangingrole of womeninsocietyand Issuesrelatedtoit.	
CO4	Understandtheimportanceofwomen'seducation.	
CO5	Comprehendthe empowermentofwomenand Theirachievement.	
Text Books(LatestEditions)		
1.	RaniSandhya,"DevelopmentofWomen–IssuesandChallenges",DiscoverPublishingHousePvt Ltd, New Delhi, 2012.	

ReferencesBooks
(Latesteditionsandthestyleasgivenbelowmustbestrictlyadheredto)

1.	Anil Kumar Jha, "Gender Inequality and Women Empowerment", Axis Books,NewDelhi, 2012.
2.	NandalSantosh,"WomenandDevelopment",AMittalPublications,NewDelhi,2012
3.	NandalSantosh,"WomenandDevelopment",AMittalPublications, NewDelhi,2012.
4.	RaoPulla,"PoliticalEmpowermentofWomeninIndia–Challengesand Strategies",ABDPublishers,NewDelhi,2012.
5.	JennyEdwards,AndreaCornwall,etal."Feminisms, Empowermentand Development:ChangingWomen"sLives",KindleEdition,2014.
6.	ElsonDiane,etal."GenderEqualityandInclusiveGrowth:Economic PoliciestoAchieveSustainable Development",UNWomen,2019.
7.	PriyankaSharmaGurnani,"WomenEntrepreneurship–Emerging Dimension ofEntrepreneurshipin India" Educreation Publishing House,NewDelhi, 2016.
Websources	
1.	**https://paradisevalley.libguides.com/the111/theatre_history_websites**
2.	**https://www.britannica.com/place/England/Performing-arts**
3.	**https://www.worldhistory.org/Greek_Theatre/**
4.	**https://archive.org/details/fundamentalsofpl0000dean_y3x3**
5.	**http://scriptclickcreate.weebly.com/acting.html**
6.	**https://www.britannica.com/art/theater-building/Production-aspects-of-Expressionist-theatre**

MappingwithProgrammeOutcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	S	S	S	M	S	M
CO2	M	S	S	S	M	S	S	M	M	M
CO3	S	S	S	M	S	S	S	M	S	M
CO4	S	S	S	S	S	S	S	M	M	M
CO5	S	M	S	S	S	S	S	M	M	S

MappingwithProgramme-SpecificOutcomes

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weightedpercentageof CourseContributiontoPos	3.0	3.0	3.0	3.0	3.0

SECOND SEMESTER

Core–IV- Paper-3-LINEAR ANDDIGITAL ICs& APPLICATIONS	**IYEAR- SECONDSEMESTER**

Subject Code	**SubjectName**	**Category**	**L**	**T**	**P**	**Credits**	**Inst.Hours**	**Marks**
P23PHT203	**LINEARANDDIGITALICsANDAPPLICATIONS**	Core	6	-	-	5	6	75

Pre-Requisites
Knowledgeof semiconductor devices,basicconceptsofdigitalandanalogelectronics
LearningObjectives
➢ Tointroducethebasicbuildingblocksoflinearintegrated circuits. ➢ Toteachthelinearandnon-linearapplicationsof operational amplifiers. ➢ Tointroducethe theory andapplications ofPLL. ➢ TointroducetheconceptsofwaveformgenerationandintroduceonespecialfunctionICs. ➢ ExposuretodigitalIC‘s

UNITS	**CourseDetails**
UNIT I:INTEGRATED CIRCUITS ANDOPERATIONALAMPLIFIER	Introduction,ClassificationofIC‘s,OperationalAmplifier:DifferentialAmplifier, DC and AC analysis of dual input balanced output configuration, dualinput unbalanced output. Characteristics of Op-amps, Op-amp block diagram,ideal and practical Op-amp specifications. DC characteristics: Input & outputoffsetvoltages&currents,drift.ACcharacteristics:Frequencyresponse,slew rate,CMRRand PSRR
UNIT II:APPLICATIONS OFOP-AMP	LINEARAPPLICATIONSOFOP-AMP:Solutiontosimultaneousequations and differential equations,Instrumentation amplifiers, VtoIandIto V converters. NON-LINEARAPPLICATIONSOFOP-AMP: SampleandHoldcircuit,LogandAntilogamplifier,multiplierand Divider, Comparators,Schmitttrigger,Multivibrators,TriangularandSquarewaveform generators.

	applications, Schmitt trigger, PLL - introduction, basic principle, phase detector/comparator, voltage controlled oscillator(IC566),low pass filter, monolithic PLL and applications of PLL
UNITIV: VOLTAGE REGULATOR& DtoAANDAtoD CONVERTERS	VOLTAGEREGULATOR: Introduction, Series Op-Amp regulator, IC VoltageRegulators,IC723general purpose regulators, Switching Regulator. D to A AND A to D CONVERTERS: Introduction, basic DAC techniques -weighted resistorDAC,R-2RladderDAC,invertedR-2RDAC,AtoD converters-parallel comparatortypeADC,countertypeADC,successive ApproximationADCanddualslopeADC,DACandADCSpecifications.
UNIT III:ACTIVE FILTERS &TIMERANDPHASE LOCKEDLOOPS	ACTIVEFILTERS:Introduction,Butterworthfilters–1storder,2nd order low pass and high pass filters, band pass, band reject and all passfilters. TIMER AND PHASE LOCKED LOOPS:Introductionto IC 555timer, Descriptionoffunctionaldiagram,monostableandastableoperationsand

UNITV:CMOS LOGIC, COMBINATIONAL CIRCUITS USINGTTL74XXICs & SEQUENTIALCIRCUITS USINGTTL74XXICs	CMOSLOGIC:CMOSlogiclevels,MOStransistors,BasicCMOSInverter, NAND and NOR gates, CMOSAND-OR-INVERT and OR-AND-INVERT gates, implementation of any function using CMOS logic.COMBINATIONALCIRCUITSUSINGTTL74XXICs:Studyoflogic Gatesusing74XXICs,Four-bitparalleladder(IC7483),Comparator(IC7485), Decoder (IC 74138, IC 74154), BCD to 7-segmentdecoder(IC7447), Encoder (IC74147), Multiplexer (IC74151), DE multiplexer (IC 74154). SEQUENTIALCIRCUITSUSINGTTL74XXICs:FlipFlops(IC7474, IC7473), Shift Registers,UniversalShift Register (IC74194),4-bitasynchronousbinarycounter(IC 7493).
UNITVI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable andCommunicationSkillEnhancement,SocialAccountabilityandPatriotism
TEXTBOOKS	1. D. Roy Choudhury, Shail B. Jain (2012), Linear Integrated Circuit,4thedition,NewAge InternationalPvt.Ltd.,NewDelhi,India 2. Ramakant A. Gayakwad, (2012), OP-AMP and Linear IntegratedCircuits,4the edition,PrenticeHall/PearsonEducation,NewDelhi. 3. B.L. Theraja and A.K. Theraja, 2004, A Textbook of Electricaltechnology,S. Chand & Co. 4. V.K. Mehta and Rohit Mehta, 2008, Principles of Electronics, S.Chand& Co, 12th Edition. 5. V.Vijayendran,2008,IntroductiontoIntegratedelectronics (Digital & Analog), S. Viswanathan Printers & Publishers PrivateLtd,Reprint. V.
REFERENCE BOOKS	1. SergioFranco(1997),Designwithoperationalamplifiersandanalogintegratedcircuits,McGrawHill,New Delhi. 2. Gray,Meyer(1995),AnalysisandDesignofAnalogIntegratedCircuits, Wiley International, New Delhi. 3. MalvinoandLeach(2005),DigitalPrinciplesandApplications5th

	Edition,TataMcGrawHill,NewDelhi 4. Floyd,Jain(2009),DigitalFundamentals,8thedition,PearsonEducation,NewDelhi. 5. IntegratedElectronics,Millman&Halkias,TataMcGrawHill,17thReprint(2000) 6. JohnF.Wakerly,"DigitalDesignPrinciplesandPractices",PrenticeHall, 3rdEdition,2005. 7. M.MorrisMano,MichaelD.Ciletti,"DigitalDesign‖,PearsonEducation/PHI, 3rd Edition, 2008
WEBSOURCES	1. https://nptel.ac.in/course.html/digitalcircuits/ 2. https://nptel.ac.in/course.html/electronics/operationalamplifier/ 3. https://www.allaboutcircuits.com/textbook/semiconductors/chpt-7/field-effect-controlled-thyristors/ 4. https://www.electrical4u.com/applications-of-op-amp/ 5. https://www.geeksforgeeks.org/digital-electronics-logic-design-tutorials/

COURSEOUTCOMES

Attheend ofthecoursethestudentwillbeableto

CO1	Learnaboutthebasicconceptsforthecircuitconfigurationforthedesignof Linearintegrated circuitsanddevelopsskilltosolveproblems	**K1, K5**
CO2	Developskillstodesignlinearandnon-linearapplicationscircuitsusingOp-Ampanddesigntheactivefilterscircuits.	**K3**
CO3	GainknowledgeaboutPLL,anddeveloptheskillsto designthesimple Circuit's usingIC555timerand cansolveproblemsrelatedtoit.	**K1, K3**
CO4	Learn aboutvarioustechniquestodevelopA/DandD/Aconverters.	**K2**
CO5	AcquiretheknowledgeabouttheCMOSlogic,combinationalandsequential circuits	**K1, K4**
K1-Remember; K2 –Understand; K3 -Apply;K4 -Analyze; K5 –Evaluate		

MAPPINGWITHPROGRAMOUTCOMES

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specificoutcomes**(PSO)**in the3-point scale ofSTRONG (3), MEDIUM(2)andLOW(1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	3	2	2	3	3	3	2
CO2	3	3	3	3	1	3	3	3	2	1
CO3	3	3	3	3	1	3	3	3	2	1
CO4	3	3	3	3	1	3	3	3	2	1
CO5	3	3	3	2	1	1	2	3	2	1

Strong(3) Medium (2)and Low(1)

Paper4 –QUANTUMMECHANICS– I	**IYEAR-SECONDSEMESTER**

Subject Code	**SubjectName**	**Category**	**L**	**T**	**P**	**Credits**	**Inst.Hours**	**Marks**
P23PHT204	**QUANTUMMECHANICS– I**	Core	6	-	-	5	6	75

Pre-Requisites
Newton'slawsofmotion,Schrodinger'sequation,integration,differentiation.
LearningObjectives
➢ Todeveloptthephysicalprinciplesandthemathematicalbackgroundimportanttoquantummechanicaldescriptions. ➢ Todescribethepropagation ofaparticleina simple,one-dimensional potential. ➢ ToformulateandsolvetheSchrodinger' equation toobtainEigenvectorsandenergiesforparticleinathree-dimensional potential. ➢ Toexplainthemathematicalformalismandthesignificanceofconstantsofmotion,andseetheirrelation to fundamental symmetries in nature ➢ TodiscusstheApproximationmethodslikeperturbationtheory,VariationalandWKB Methodsforsolving the Schrodinger equation.

UNITS	**CourseDetails**
UNIT I:BASICFORMALISM	InterpretationofthewavefunctionTimedependentSchrodingerequation –Time independent Schrodinger equation – Stationary states – Ehrenfest'stheorem – Linear vector space – Linear operator – Eigen functions andEigen Values – Hermitian Operator – Postulates of Quantum Mechanics –Simultaneousmeasurabilityofobservables– GeneralUncertaintyrelation
UNIT II: ONEDIMENSIONALAND THREE-DIMENSIONAL ENERGY EIGENVALUE PROBLEMS	Square – well potential with rigid walls – Square well potential with finitewalls – Square potential barrier– Alpha emission – Bloch waves inaperiodic potential – Kronig-penny square – well periodic potential – Linearharmonic oscillator: Operator method – Particle moving in a sphericallysymmetricpotential–Systemoftwointeractingparticles– Hydrogenatom –Rigid rotator
UNITIII:GENERALFORMALISM	Dirac notation–Equationsofmotions–Schrodingerrepresentation– Heisenbergrepresentation–Interactionrepresentation– Coordinaterepresentation–Momentumrepresentation– Symmetriesandconservation laws–Unitarytransformation–Parityandtimereversal

UNIT IV: APPROXIMATIONMETHODS	Time independent perturbation theory for non-degenerate energy levels – Degenerate energy levels – Stark effect in Hydrogen atom – Ground and excited state – Variation method – Helium atom – WKB approximation – Connection formulae (no derivation)–WKB quantization–Application to Simple harmonic oscillator.
UNIT V: ANGULARMOMENTUM	Eigenvalue spectrum of general angular momentum – Ladder operators and their algebra–Matrix representation– Spin angular momentum–Addition of angular momenta – CG Coefficients – Symmetry and anti – symmetry of wave functions–Construction of wave-functions and Pauli'sexclusion Principle.
UNITVI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable andCommunicationSkillEnhancement,Social AccountabilityandPatriotism
TEXTBOOKS	1. P.M.MathewsandK.Venkatesan,ATextbookofQuantumMechanics, 2nd edition(37th Reprint),Tata McGraw-Hill, New Delhi,2010. 2. G.Aruldhas,QuantumMechanics,2ndedition,PrenticeHallofIndia, NewDelhi, 2009. 3. DavidJGriffiths,IntroductiontoQuantumMechanics.4thedition,Pearson,2011. 4. SLGuptaandIDGupta,AdvancedQuantumTheoryandFields,1st Edition, S.Chand& Co.,New Delhi, 1982. 5. A.GhatakandS.Lokanathan,QuantumMechanics:TheoryandApplications,4th Edition,Macmillan,India, 1984.
REFERENCE BOOKS	1. E.Merzbacher,QuantumMechanics,2nd Edition,JohnWileyandSons,New York, 1970. 2. V.K.Thankappan,QuantumMechanics,2ndEdition,WileyEasternLtd,New Delhi, 1985. 3. L.D.LandauandE.M.Lifshitz,QuantumMechanics,1st edition,PergomonPress, Oxford,1976. 4. S.N.Biswas,QuantumMechanics,BooksandAlliedLtd.,Kolkata,1999. 5. V.Devanathan,QuantumMechanics,2ndedition,AlphaScienceInternationalLtd, Oxford, 2011.
WEBSOURCES	1. http://research.chem.psu.edu/lxjgroup/download_files/chem565-c7.pdf 2. http://www.feynmanlectures.caltech.edu/III_20.html 3. http://web.mit.edu/8.05/handouts/jaffe1.pdf 4. https://hepwww.pp.rl.ac.uk/users/haywood/Group_Theory_Lectures/Lecture_1.pdf 5. https://theory.physics.manchester.ac.uk/~xian/qm/chapter3.pdf

COURSEOUTCOMES

At the end of the course the student will be able to

CO1	Demonstrates a clear understanding of the basic postulates of quantum mechanics which serve to formalize the rules of quantum Mechanics	K1, K5
CO2	Is able to apply and analyze the Schrodinger equation to solve one Dimensional problems and three dimensional problems	**K3, K4**
CO3	Can discuss the various representations, space timesymmetries and Formulationsoftimeevolution	**K1**
CO4	Canformulateandanalyzetheapproximationmethodsforvarious Quantummechanicalproblems	**K4, K5**
CO5	Toapplynon-commutativealgebrafortopics suchasangularandspin Angularmomentumandhence explainspectrallinesplitting.	**K3, K4**
K1-Remember; K2 –Understand; K3 -Apply;K4 -Analyze; K5 –Evaluate		

MAPPINGWITHPROGRAMOUTCOMES

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specificoutcomes**(PSO)** in the3-point scale ofSTRONG (3), MEDIUM(2)andLOW(1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	3	3	2	3	2	2	3
CO2	3	3	3	3	3	S	3	2	2	3
CO3	2	3	3	2	3	2	3	2	2	3
CO4	3	3	3	3	3	2	3	3	2	3
CO5	3	3	3	2	3	S	3	3	2	3

Strong (3) Medium (2)and Low (1)

CoreVI-PRACTICALII	**IYEAR-SECONDSEMESTER**

Subject Code	SubjectName	Category	L	T	P	Credits	Inst.Hours	Marks
P23PHP202	**PRACTICALII-ELECTRONICS**	Core	-	-	6	4	6	75

Pre-Requisites
Knowledgeandhandlingofbasic electronicsexperimentsofPhysics
LearningObjectives
➢ Toanalyzetheopticalandelectricalpropertiesof materials. ➢ Toobservethe applications ofFETandUJT. ➢ Tostudythedifferentapplicationsofoperational amplifiercircuits. ➢ TolearnaboutCombinationalLogicCircuitsandSequentialLogicCircuits
ELECTRONICS (Anytwelve experiments) 1. ConstructionofrelaxationoscillatorusingUJT 2. FETCSamplifier-Frequencyresponse,inputimpedance,outputimpedance 3. StudyofimportantelectricalcharacteristicsofIC741.V-ICharacteristicsofdifferentcoloursofLED. 4. Study ofattenuationcharacteristics ofWien'sbridgenetwork and design ofWien's bridgeoscillatorusing Op-Amp. 5. StudyofattenuationcharacteristicsofPhaseshiftnetworkanddesignofPhaseshiftoscillatorusing Op-Amp. 6. Construction of Schmidt triggers circuit using IC 741 for a given hysteresis- application assquarer. 7. ConstructionofsquarewaveTriangularwavegeneratorusingIC741 8. ConstructionofaquadraturewaveusingIC 324 9. Constructionofpulsegeneratorusingthe IC741–applicationasfrequencydivider 10. ConstructionofOp-Amp-4bitDigitaltoAnalogconverter(BinaryWeightedandR/2Rladdertype) 11. StudyofBinarytoGrayandGraytoBinarycode conversion. 12. StudyofR-S,clockedR-SandD-FlipflopusingNANDgates 13. Studyof J-K, Dand Tflip flops using IC 7476/7473 14. ArithmeticoperationsusingIC7483-4-bitbinaryadditionandsubtraction. 15. StudyofArithmetic logicunitusing IC74181. 16. ConstructionofEncoderandDecodercircuits usingICs.

TEXTBOOKS	1. PracticalPhysics,GuptaandKumar,PragatiPrakasan 2. KitDevelopedfordoingexperimentsinPhysics-Instructionmanual, R.SrinivasanK.RPriolkar, IndianAcademyofSciences 3. Op-Ampandlinearintegratedcircuit,RamakanthAGaykwad,EasternEconomy Edition. 4. Electroniclabmanual VolI, K ANavas, RajathPublishing 5. ElectroniclabmanualVolII,KANavas,PHIeasternEconomyEdition
REFERENCE BOOKS	1.AnadvancedcourseinPracticalPhysics,D.Chattopadhayay, C.RRakshit,NewCentralBookAgencyPvt.Ltd 2. AdvancedPracticalPhysics,S.PSingh,PragatiPrakasan 3. AcourseonexperimentwithHe-NeLaser,R.S.Sirohi,JohnWiley& Sons (Asia)Pvt.ltd 4. Electronic lab manual Vol II, Kuriachan T.D, Syam Mohan, AyodhyaPublishing 5. ElectronicLaboratoryPrimeradesignapproach,S.Poornachandra, B.Sasikala,WheelerPublishing,NewDelhi

METHODOFEVALUATION

ContinuousInternal Assessment	**End SemesterExamination**	**Total**
25	75	**100**

COURSEOUTCOMES

Attheendof thecourse the studentwillbeableto

CO1	UnderstandthestrengthofmaterialusingYoung'smodulus	K2
CO2	Acquireknowledgeofthermal behaviourofthematerials	K1
CO3	Understandtheoreticalprinciplesofmagnetismthroughtheexperiments.	K2
CO4	Acquireknowledgeabout arcspectrumand applicationsoflaser	K1
CO5	ImprovetheanalyticalandobservationabilityinPhysicsExperiments	K4
CO6	ConductexperimentsonapplicationsofFET andUJT	K5
CO7	Analyzevariousparametersrelatedtooperationalamplifiers	K4
CO8	Understandthe concepts involvedinarithmeticandlogicalcircuitsusing IC's	K2
CO9	AcquireknowledgeaboutCombinationalLogicCircuitsandSequentialLogicCircuits	K3
CO10	Analyzetheapplicationsofcountersandregisters	K4
K1-Remember;K2 –Understand; K3 -Apply;K4 -Analyze;K5– Evaluate		

MAPPINGWITHPROGRAMOUTCOMES

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specificoutcomes**(PSO)**in the3-point scale ofSTRONG (3), MEDIUM(2)andLOW(1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	2	2	2	S	S	2	2	2	3	3
CO2	2	2	S	S	S	2	2	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3
CO4	3	2	3	3	3	3	2	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3
CO6	2	2	2	3	3	2	2	2	3	3
CO7	2	2	3	3	3	2	2	3	3	3
CO8	3	3	3	3	3	3	3	3	3	3
CO9	3	3	3	3	3	3	3	3	3	3
CO10	3	3	3	3	3	3	3	3	3	3

Strong (3) Medium (2)and Low(1)

Elective II- BIO PHYSICS	**IYEAR– SECONDSEMESTER**

Subject Code	**SubjectName**	**Category**	**L**	**T**	**P**	**Credits**	**Inst.Hours**	**Marks**
P23PHE22A	**BIOPHYSICS**	DISCIPLINE CENTRICE LECTIVE	4	-	-	3	4	75

Pre-Requisites
Fundamental conceptsofPhysicsandBiology
LearningObjectives
➢ Tounderstandthephysicalprinciplesinvolvedincell functionmaintenance. ➢ Tounderstandthefundamentalsofmacromolecularstructuresinvolvedinpropagationoflife. ➢ Tounderstand the bio physicalfunctionofmembraneandneuron. ➢ Tounderstandvariouskindsofradiationandtheireffectsonlivingsystemandtoknowthehazardsposed by such radiations andtherequiredprecautions. ➢ Tounderstand the physical principles behind the various techniques available for Interrogatingbiologicalmacromolecules.

UNITS	**CourseDetails**
UNIT I:CELLULARBIOPHYSICS	ArchitectureandLifeCycleofcells–OrganellesofProkaryoticandEukaryotic cell – Cell size and shape – Fine structure of Prokaryotic and Eukaryotic cell organization–Compartment&assembliesmembranesystem – Extracellular matrix - Molecular mechanisms of Vesicular traffic – Electricalactivities ofcardiacandneuronalcells.
UNIT II:MOLECULARBIOPHYSICS	Macromolecularstructure:Proteinstructure–amino acids, peptide bonds,primary,secondary, tertiaryand quaternarystructures of proteins Nucleic acid structure:nucleosidesandnucleotides,RNAstructure, DNAstructureandconformation. SpecialBio-macromolecules:Metalloproteins,nucleoproteins,ribozymes,chaperons and prions.
UNIT III:MEMBRANE AND NEUROBIOPHYISCS	Models membranes - Biological membranes and dynamics – MembraneCapacitors–Transportacrosscellandorganellemembranes– Ionchannels. Nervoussystem:Organizationofthenervoussystem–Membranepotential –Originsofmembranepotential-Electrochemicalpotentials–Nernstequation– Goldman equation.

UNIT IV:RADIATION BIOPHYSICS	X-Ray:Effectsonbio-macromolecules– GammaRadiation:Molecularеffectsofgammaradiation,Radiationeffectsonnucleicacidsandmembranes,Effectsoncellandorganelles– UVradiation:Effectsonbio-

	Macromoleculesandproteins–Radiationhazardsandprotection– useofradiationsin cancer.
UNIT V:PHYSICAL METHODS INBIOLOGY	Spectroscopy: UV-Visible absorption spectrophotometry – Optical Rotatory Dispersion (ORD)–StructureDetermination:X-rayCrystallography,Electronspinresonance(ESR)andbiologicalapplications. Chromatography:Thinlayerchromatography(TLC),Gasliquidchromatography(GLC)–Centrifugation:Differentialcentrifugation, density gradient centrifugation. Electrophoresis: Gel electrophoresis, Polyacrylamide gel electrophoresis.
UNITVI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and CommunicationSkillEnhancement,SocialAccountabilityandPatriotism

TEXTBOOKS	1. Thecell:Amolecularapproach,GeoffreyM.Cooper,ASMPress,2013. 2. Biophysics,VasanthaPattabhi,N. Gautham,NarosaPublishing,2009 3. Biophysics,P.S.MishraVKEnterprises,2010. 4. Biophysics,M.A Subramanian,MJPPublishers,2005. 5. Bioinstrumentation,L.Veerakumari,MJPPublishers,2006.
REFERENCE BOOKS	1. ChemicalBiophysicsbyDanielABeard(CambridgeUniversityPress,2008). 2. EssentialcellbiologybyBruceAlbert etal(GarlandScience) 3. Biophysics,W.Hoppe,W.Lohmann,H.MarklandH.Ziegler.SpringerVerlag, Berlin (1983). 4. Membrane Biophysics by Mohammad Ashrafuzzaman, Jack A.Tuszynski,(Springer science& business media). 5. BiologicalspectroscopybyIainD.Campbell,RaymondA.Dwek
WEBSOURCES	1. GeneralBio:http://www.biology.arizona.edu/DEFAULT.html 2. Spectroscopy:http://www.cis.rit.edu/htbooks/nmr/inside.htm **3.** Electrophoresis:**http://learn.genetics.utah.edu/content/labs/gel/** **4.** Onlinebiophysicsprograms: **http://mw.concord.org/modeler/** **5. https://blanco.biomol.uci.edu/WWWResources.html**

COURSEOUTCOMES

Atthe end of thecourse, thestudent will beableto

CO1	Understandthestructuralorganizationandfunctionoflivingcellsandshouldableto applythecellsignaling mechanism and itselectricalactivities.	**K2, K3**
CO2	Comprehensionoftherole of bimolecular conformationto function.	**K1**
CO3	Conceptual understanding of the function of biologicalmembranesand alsotounderstandthe functioning of nervous system.	**K2, K5**
CO4	Toknowtheeffectsofvariousradiationsonlivingsystemsandhowtopreventilleffects of radiations.	**K1, K5**
CO5	Analyzeandinterpret datafromvarioustechniquesviz.,spectroscopy, crystallography,chromatographyetc.,	**K4**

K1-Remember; K2 – Understand; K3 -Apply; K4 -Analyze; K5 -Evaluate;

APPINGWITHPROGRAMOUTCOMES

Map course outcomes (CO) for each course with program outcomes (PO) and program specificoutcomes(PSO)in the3-point scale ofSTRONG (3), MEDIUM(2)and LOW(1)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	2	1	2	1	3	3	2
CO2	3	3	3	2	1	2	1	3	3	2
CO3	3	3	3	3	1	1	2	3	3	2
CO4	3	3	3	2	1	1	2	3	3	3
CO5	3	3	3	3	1	1	2	3	3	3

Strong(3) Medium (2)and Low(1)

Elective II-GENERAL RELATIVITY AND COSMOLOGY	IYEAR– SECONDSEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst.Hours	Marks
P23PHE22B	GENERAL RELATIVITY AND COSMOLOGY	DISCIPLINE CENTRICE LECTIVE	4	-	-	3	4	75

Pre-Requisites
Skill in mathematics and mechanics
Learning Objectives
➢ To give an introduction to students in the areas of general relativity and cosmology

UNITS	Course Details
UNIT I: TENSORS	Tensors in index notation -Kronecker and Levi Civita tensors - inner and outer products - contraction - symmetric and anti-symmetric tensors – quotient law - metric tensors - covariant and contra variant tensors - vectors – thetangentspace-dualvectors-tensors-tensorproducts-theLevi-Civitatensor-tensors in Riemann spaces
UNIT I: TENSORSFIELD	Vector-fields, tensor-fields, transformation of tensors - gradient and Laplaceoperatoringeneralcoordinates-covariantderivativesandChristof reconnection -Elasticity:Fieldtensor-fieldenergytensor-straintensor-Tensorof elasticity-curvature tensor
UNIT III: GENERALRELATIVITY	The space time interval - the metric - Lorentz transformations - space-timediagrams -world-lines - proper time - energy-momentum vector - energy-momentumtensor-perfectfluids-energy-momentumconservation-paralleltransport-theparallelpropagator-geodesics-affineparameters-theRiemanncurvaturetensor-symmetriesoftheRiemanntensor-theBianchiidentity
UNIT IV:TENSOR INRELATIVITY	Ricci and Einstein tensors - Weyl tensor - Killing vectors - the Principle ofEquivalence - gravitational redshift - gravitation as space-time curvature – theNewtonian limit - physics in curved space-time - Einstein's equations – theWeak Energy Condition - causality - spherical symmetry - the Schwarzschildmetric-perihelion precession
UNIT V:COSMOLOGY	Expansion of the Universe - thermal history - and the standard cosmologicalmodel-Friedman-Robertson-Walkertypemodelsoftheuniverse-Primordial inflation and the theory of cosmological fluctuations - Theory andobservations of the cosmic microwave background and of the large-scalestructureoftheUniverse-Darkmatteranddarkenergy-theoreticalquestions and observational evidence - inflation - origin of galaxies and otheropenproblems

UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars-Webinars on Industrial Interactions/Visits, Competitive Examinations ,Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. M.R.Spiegel,*VectorAnalysis,Schaum'aoutlineseries*,McGrawHill,NewYork,1974. 2. JamesHartle,*Gravity:AnintroductiontoEinstein'sgeneralrelativity,*SanFrancisco, Addison-Wesley, 2002 3. SeanCarroll,*SpacetimeandGeometry:AnIntroductiontoGeneralRelativity*,(Addison-Wesley,2004). 4. JerzyPlebanskiandAndrzejKrasinski,*AnIntroductiontoGeneralRelativityandCosmology*, CambridgeUniversity Press 2006 5. Meisner,ThorneandWheeler: *Gravitation* W.H.Freeman&Co.,SanFrancisco 1973
REFERENCEBOOKS	1. RobertM.Wald: *Space, Time, and Gravity: the Theory of the Big Bang and Black Holes*, Univ. of Chicago Press. 2. J.V.Narlikar, *Introduction toCosmology,*Jones&Bartlett1983 3. Steven Weinberg,*Gravitation and Cosmology*, NewYork,Wiley,1972. 4. Jerzy Plebanski and AndrzejKrasinski, *An Introduction to General Relativity and Cosmology*,Cambridge University Press 2006 *5.* RAdler,MBazin& MS chiffer, *Introduction to General Relativity*
WEBSOURCES	1. http://www.fulviofrisone.com/attachments/article/486/A%20First%20Course%20In%20General%20Relativity%20-%20Bernard%20F.Schutz.pdf 2. https://link.springer.com/book/9780387406282 3. https://ocw.mit.edu/courses/8-962-general-relativity-spring-2020/resources/lecture-18-cosmology-i/ 4. https://arxiv.org/abs/1806.10122 5. https://uwaterloo.ca/applied-mathematics/future-undergraduates/what-you-can-learn-applied-mathematics/relativity-and-cosmology

COURSE OUT COMES

Attheendof thecourse,thestudentwillbeableto

CO1	Skill fully handle tensors	**K1**
CO2	Understanding of the underlying the oretical aspects of general relativity and cosmology	**K2**
CO3	Gain knowledge on space time curvature	**K1**
CO4	Equipped to take up research incosmology	**K3,K4**
CO5	Confidentlysolveproblemsusingmathematicalskills	**K5**
K1-Remember;K2 – Understand;K3 -Apply;K4 -Analyze;K5 -Evaluate;		

MAPPINGWITH PROGRAMOUTCOMES

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific out comes**(PSO)**in the3-point scale of STRONG (3), MEDIUM(2)and LOW(1)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	1	3	2	3	2	2	2	2
CO2	3	3	1	3	2	3	2	2	2	2
CO3	3	2	1	2	1	2	1	1	3	2
CO4	3	2	1	2	1	2	1	1	3	2
CO5	3	2	1	2	1	2	1	1	3	2

ProvidedbytheDepartmentofComputerScience

GENERICCOURSE	IYEAR– SECOND SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst.Hours	Marks
P23CSG202	CYBER SECURITY	GENERIC COURSE	4	-	-	3	4	75

Skill Enhancement Course –1(SEC-1)	IYEAR– SECOND SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst.Hours	Marks
P23PHNM21	STRUCTURAL ANALYSIS BY XRD	NME_SKILL ENHANCEMENT COURSE	4	-	-	2	4	75

Pre-Requisites
Knowledge of X-ray, basic concepts of refraction and diffraction
Learning Objectives
➢ To enable the students to acquire knowledge in XRD ➢ To know the methods in X-Ray Diffraction Method ➢ At the end of the course, the students will be able to plan experimental projects and execute them.

UNITS	Course Details
UNITI: Instrumentation	Principle-Collimator-Monochromators-Detectors
UNITII: Counter Methods	Geiger-MullerTubeCounter-ProportionalCounter-ScintillationDetectors-SolidState Semi-conductor Detectors-Semiconductor Detectors
UNITIII: X-Ray Diffraction Methods	Laue'sPhotographicMethod-TransmissionLaueMethod-BackReflectionMethod:Bragg'sX,RaySpectrometerMethod,RotatingCrystalMethod-CompleteRotationMethod-Oscillation Method,Powder CrystalMethod

UNITIV: X-Ray Fluorescence Methods	X-ray Fluorescence Spectrometers-Energy Dispersion Spectrometers-Analyticalapplications-X-ray Diffraction-Reciprocal Lattice Concept-DiffractionPatterns-AutomaticDiffractometers-ChoiceXRadiation-SpecimenPreparation-X-rayPowderDatafile.
UNITV: X-Ray diffractionquantitativeanalysis	StructuralApplications-StructuralanalysisusingJCPDSsoftware-CrystalTopography-AUGER Emission Spectroscopy-AES Instrumentation-QuantitativeAnalysiswithAES-ScanningAugerMicroprobe(SAM)-ElectronSpectroscopyforchemicalanalysis(ESCA)-ChemicalShift-ESCAInstrumentation-ESCAElectron Analyzers –Dectors -Scanning ESCA-QuantitativeAnalysis.
TEXTBOOKS	1 Willard Merritt, Instrumental Methods of Analysis, CBS publishers &distributors-(1986) 2 B.D. Cullity, Elements of X-Ray Diffraction Hardcover , Pearson Publisher-(2001) 3 KaiminShih,X-RayDiffraction:Structure,Principles&Applications(MaterialsScienceand Technologies), Nova sciencePublisher-(2013) 4 E.W.Nuffield,X-raydiffractionmethods,Wiley-(1967)
REFERENCE BOOKS	1. MyeongkyuLee,X-RayDiffractionforMaterialsResearchFromFundamentalsto Applications, Wiley-(2016) 2. EmilZolotoyabko,BasicConceptsofX-RayDiffraction, Wiley-(2014)
WEB SOURCES	6. https://www.twi-global.com/technical-knowledge/faqs/x-ray-diffraction 7. https://imf.ucmerced.edu/sites/imf.ucmerced.edu/files/page/documents/x-ray_powder_diffraction.pdf 8. https://ethz.ch/content/dam/ethz/special-interest/chab/icb/van-bokhoven-group-dam/coursework/Characterization-Techniques/2018/XRD_lecture_AnaBPinar_2017_part_1.pdf 9. https://old.amu.ac.in/emp/studym/100012857.pdf

COURSEOUTCOMES

Atthe endof thecourse, thestudent willbeableto

CO1	Ableto understand the instrumentation ofXRD	K2
CO2	GetknowledgeabouttheCounters	K1
CO3	UnderstandstheX-Raydiffractionmethods	K2
CO4	Knowshowtouse XRD analysis	K3
CO5	Knowswhereto apply XRD	K1
K1-Remember; K2 –Understand; K3 -Apply;K4 -Analyze; K5 –Evaluate		

MAPPINGWITHPROGRAMOUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specificoutcomes**(PSO)**in the3-point scale ofSTRONG (3), MEDIUM(2)andLOW(1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	2	3	2	3	3	3	2	3	1
CO2	2	2	3	3	3	3	3	3	3	2
CO3	2	2	3	2	3	3	3	2	3	1
CO4	1	3	3	3	3	3	3	3	3	2
CO5	3	3	3	3	3	3	3	3	3	2

Strong (3) Medium (2)and Low(1)

CORE VII **Paper 7 - QUANTUM MECHANICS – II**	**II YEAR - THIRD SEMESTER**

THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
P23PHT 305	**QUANTUM MECHANICS – II**	**Core**	**6**	**-**	**-**	**5**	**6**	**75**

Pre-Requisites
Knowledge of postulates of Quantum mechanics, properties of Hermitian operators, ladder operators, degeneracy, angular momentum techniques and commutation rules
Learning Objectives
➢ Formal development of the theory and the properties of angular momenta, both orbital and spin ➢ To familiarize the students to the crucial concepts of scattering theory such as partial wave analysis and Barn approximation. ➢ Time-dependent Perturbation theory and its application to study of interaction of an atom with the electromagnetic field ➢ To give the students a firm grounding in relativistic quantum mechanics, with emphasis on Dirac equation and related concepts ➢ To introduce the concept of covariance and the use of Feynman graphs for depicting different interactions

UNITS	Course Details
UNIT 1: SCATTERING THEORY	Scattering amplitude – Cross sections – Born approximation and its validity – Scattering by a screened coulomb potential – Yukawa potential – Partial wave analysis – Scattering length and Effective range theory for s wave – Optical theorem – Transformation from centre of mass to laboratory frame.
UNIT II: PERTURBATION THEORY	Time dependent perturbation theory – Constant and harmonic perturbations – Fermi Golden rule – Transition probability Einstein's A and B Coefficients – Adiabatic approximation – Sudden approximation – Semi – classical treatment of an atom with electromagnetic radiation – Selection rules for dipole radiation
UNIT III: RELATISTIC QUANTUM MECHANICS	Klein – Gordon Equation – Charge And Current Densities – Dirac Matrices – Dirac Equation – Plane Wave Solutions – Interpretation Of Negative Energy States – Antiparticles – Spin of Electron – Magnetic Moment Of An Electron Due To Spin
UNIT IV: DIRAC EQUATION	Covariant form of Dirac Equation – Properties of the gamma matrices – Traces – Relativistic invariance of Dirac equation – Probability Density – Current four vector – Bilinear covariant – Feynman's theory of positron (Elementary ideas only without propagation formalism)
UNIT V: CLASSICAL FIELDS AND SECOND QUANTIZATION	Classical fields – Euler Lagrange equation – Hamiltonian formulation – Noether's theorem – Quantization of real and complex scalar fields – Creation, Annihilation and Number operators – Fock states – Second Quantization of K-G field.
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. P. M. Mathews and K. Venkatesan, A Text book of Quantum Mechanics,2nd Edition, Tata McGraw-Hill, New Delhi, 2010. 2. G. Aruldhas, Quantum Mechanics, 2nd Edition, Prentice-Hall of India, NewDelhi,2009 3. L. I. Schiff, Quantum Mechanics, 3rd Edition, International Student Edition, McGraw-Hill Kogakusha, Tokyo, 1968 4. V. Devanathan, Quantum Mechanics, 1st Edition, Narosa Publishing House, New Delhi, 2005. 5. NouredineZettili, Quantum mechanics concepts and applications, 2nd Edition, Wiley, 2017

REFERENCE BOOKS	1. P. A. M. Dirac, The Principles of Quantum Mechanics, 4th Edition, Oxford University Press, London, 1973. 2. B. K. Agarwal&HariPrakash, Quantum Mechanics, 7th reprint, PHI Learning Pvt. Ltd., New Delhi, 2009. 3. Deep Chandra Joshi, Quantum Electrodynamics and Particle Physics,1st edition,I.K.International Publishing house Pvt. Ltd., 2006 4. Ghatak and S. Lokanathan, Quantum Mechanics: Theory and Applications, 4th Edition, Macmillan India, New Delhi. 5. E. Merzbacher, Quantum Mechanics, 2nd edition, John Wiley and Sons, New York, 1970
WEB SOURCES	1. https://ocw.mit.edu/courses/physics/8-05-quantum-physics-ii-fall-2013/lecture notes/MIT8_05F13_Chap_09.pdf 2. http://www.thphys.nuim.ie/Notes/MP463/MP463_Ch1.pdf 3. http://hep.itp.tuwien.ac.at/~kreuzer/qt08.pdf 4. https://www.cmi.ac.in/~govind/teaching/rel-qm-rc13/rel-qm-notes-gk.pdf 5. https://web.mit.edu/dikaiser/www/FdsAmSci.pdf

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Familiarize the concept of scattering theory such as partial wave analysis and Born approximation	K1
CO2	Give a firm grounding in relativistic quantum mechanics, with emphasis on Dirac equation and related concepts	K2
CO3	Discuss the relativistic quantum mechanical equations namely, Klein-Gordon and Dirac equations and the phenomena accounted by them like electron spin and magnetic moment	K1, K4
CO4	Introduce the concept of covariance and the use of Feynman graphs for depicting different interactions	K1, K3
CO5	Demonstrate an understanding of field quantization and the explanation of the scattering matrix.	K5
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	3	3	3	3	3	3	3
CO2	3	3	2	3	3	3	3	3	3	3
CO3	3	2	2	3	3	2	3	3	3	3
CO4	2	1	1	3	3	1	2	2	3	3
CO5	2	1	1	3	3	2	2	2	3	3

Strong (3) Medium (2) and Low (1)

CORE VIII **Paper 8 - CONDENSED MATTER PHYSICS**	**II YEAR - THIRD SEMESTER**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
P23PHT306	**CONDENSED MATTER PHYSICS**	Core	6	-	-	5	6	75

Pre-Requisites
Basic knowledge of atomic physics, quantum mechanics and statistical mechanics.
Learning Objectives
➢ To describe various crystal structures, symmetry and to differentiate different types of bonding. ➢ To construct reciprocal space, understand the lattice dynamics and apply it to concept of specific heat. ➢ To critically assess various theories of electrons in solids and their impact in distinguishing solids. ➢ Outline different types of magnetic materials and explain the underlying phenomena. ➢ Elucidation of concepts of superconductivity, the underlying theories – relate to current areas of research.

UNITS	**Course Details**
UNIT I: CRYSTAL PHYSICS	Basis and Crystal Structure-Types of lattices –Index system for crystal plane – Simple crystal structures –Diffraction of waves by crystals- Bragg's law – Scattered Wave Amplitude - Reciprocal Lattice (sc, bcc, fcc). Structure and properties of liquid crystals. Diffraction Conditions - Laue equations - Brillouin zone - Structure factor - Atomic form factor - Inert gas crystals - Cohesive energy - ionic crystals - Madelung constant.
UNIT II: LATTICE DYNAMICS	Vibrations of crystals with monoatomic basis- First Brillouin zone- Lattice with two atoms per primitive cell - Group and phase velocities - Quantization of lattice vibrations - Phonon momentum - Inelastic scattering by phonons - Debye's model for density of states-Einstein Model of the Density of States-Thermal Conductivity - Umklapp processes.
UNIT III: THEORY OF FREE ELECTRON FERMI GAS	Energy levels in one dimension - Free electron gas in three dimensions –Heat capacity of the electron gas-Hall Effect-Thermal conductivity of metals - Nearly free electron model- Bloch theorem - Kronig-Penney model –Wave equations of electron in a periodic potential-Restatement of the Bloch theorem-Kronig Penny model in reciprocal space- Empty lattice Approximation- Approximate Solution Near a Zone Boundary

UNIT IV: MAGNETISM	Diamagnetism - Langevin Diamagnetic Equation-Quantum Theory of Diamagnetism of mononuclear systems- Paramagnetism- Quantum Theory of Paramagnetism- Rare earth ion - Hund's rule - Quenching of orbital angular momentum –Ferromagnetic order - Curie point - Exchange integral - Magnons - Thermal excitation of magnons - Curie temperature and susceptibility of ferrimagnets - Theory of antiferromagnetism - Neel temperature- Ferromagnetic domains-Bloch wall

UNIT V: Superconductivity	**Experimental facts:** Occurrence - Effect of magnetic fields - Meissner effect – Critical field – Critical current - Entropy and heat capacity - Energy gap –Isotope Effect-Microwave and infrared properties - Type I and II Superconductors. **Theoretical Explanation:** Thermodynamics of super conducting transition - London equation - Coherence length – Isotope effect - Cooper pairs – Bardeen Cooper Schrieffer (BCS) Theory –BCS Theory of Superconductivity-Flux quantization in a superconducting ring- Type II superconductors- Single particle tunneling - Josephson tunneling - DC and AC Josephson effects - High temperature Superconductors
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
BOOK FOR STUDY	C. Kittel, 1996, *Introduction to Solid State Physics,* 7th Edition, Wiley, New York.
REFERENCE BOOKS	1. Rita John, Solid State Physics, Tata Mc-Graw Hill Publication. 2. A. J. Dekker, *Solid State Physics*, Macmillan India, New Delhi. 3. M. Ali Omar, 1974, *Elementary Solid State Physics – Principles and Applications,* Addison - Wesley 4. H. P. Myers, 1998, *Introductory Solid State Physics,* 2nd Edition, Viva Book, New Delhi. 5. J. S. Blakemore, 1974 , *Solid state Physics*, 2nd Edition, W.B. Saunder, Philadelphia 6. H. M. Rosenburg, 1993, *The Solid State,* 3rd Edition, Oxford University Press, Oxford. 7. J. M. Ziman, 1971, Principles *of the Theory of Solids*, Cambridge University Press, London. 8. C. Ross-Innes and E. H. Rhoderick, 1976, *Introduction to Superconductivity*, Pergamon, Oxford. 9. J. P. Srivastava, 2001, *Elements of Solid State Physics,* Prentice-Hall of India, New Delhi.
WEB SOURCES	1. http://www.physics.uiuc.edu/research/electronicstructure/389/389-cal.html 2. http://www.cmmp.ucl.ac.uk/%7Eaph/Teaching/3C25/index.html 3. https://www.britannica.com/science/crystal 4. https://www.nationalgeographic.org/encyclopedia/magnetism/ 5. https://www.brainkart.com/article/Super-Conductors_6824/

COURSE OUTCOMES:

At the end of the course, the student will be able to:

CO1	Student will be able to list out the crystal systems, symmetries allowed in a system and also the diffraction techniques to find the crystal structure	K1
CO2	Students will be able to visualize the idea of reciprocal spaces, Brillouin Zone and their extension to band theory of solids.	**K1, K2**
CO3	Student will be able to comprehend the heat conduction in solids	**K3**
CO4	Student will be able to generalize the electronic nature of solids from band theories.	**K3, K4**
CO5	Student can compare and contrast the various types of magnetism and conceptualize the idea of superconductivity.	**K5**
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	2	3	2	2	2	2	2	2	2
CO2	3	2	3	2	3	2	3	3	2	3
CO3	3	3	3	2	3	2	3	3	2	3
CO4	2	2	2	2	2	2	2	2	2	3
CO5	2	2	2	2	2	2	2	2	2	3

Strong (3) Medium (2) and Low (1)

CORE IX **Paper 9 - STATISTICAL MECHANICS**	**II YEAR –Third SEMESTER**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
P23PHT307	**STATISTICAL MECHANICS**	Core	6	-	-	5	6	75

Pre-Requisites
Laws of thermodynamics, phase transition, entropy, ensembles, partition function, classical and quantum statistics, thermal equilibrium, Brownian motion
Learning Objectives
➢ To acquire the knowledge of thermodynamic potentials and to understand phase transition in thermodynamics ➢ To identify the relationship between statistic and thermodynamic quantities ➢ To comprehend the concept of partition function, canonical and grand canonical ensembles ➢ To grasp the fundamental knowledge about the three types of statistics ➢ To get in depth knowledge about phase transitions and fluctuation of thermodynamic properties that vary with time

UNITS	**Course Details**
UNIT I: PHASE TRANSITIONS	Thermodynamic potentials - Phase Equilibrium - Gibb's phase rule - Phase transitions and Ehrenfest's classifications –Third law of Thermodynamics. Order parameters – Landau's theory of phase transition - Critical indices - Scale transformations and dimensional analysis.
UNIT II: STATISTICAL MECHANICS AND THERMODYNAMICS	Foundations of statistical mechanics - Specification of states of a system - Micro canonical ensemble - Phase space – Entropy - Connection between statistics and thermodynamics – Entropy of an ideal gas using the micro canonical ensemble - Entropy of mixing and Gibb's paradox.

UNIT III: CANONICAL AND GRAND CANONICAL ENSEMBLES	Trajectories and density of states - Liouville's theorem - Canonical and grand canonical ensembles - Partition function - Calculation of statistical quantities - Energy and density fluctuations.
UNIT IV: CLASSICAL AND QUANTUM STATISTICS	Density matrix - Statistics of ensembles - Statistics of indistinguishable particles - Maxwell-Boltzmann statistics - Fermi-Dirac statistics – Ideal Fermi gas – Degeneracy - Bose-Einstein statistics - Plank radiation formula - Ideal Bose gas - Bose-Einstein condensation.
UNIT V: REAL GAS, ISING MODEL AND FLUCTUATIONS	Cluster expansion for a classical gas - Virial equation of state – Calculation of the first Virial coefficient in the cluster expansion - Ising model - Mean-field theories of the Ising model in three, two and one dimensions - Exact solutions in one dimension. Correlation of space-time dependent fluctuations - Fluctuations and transport phenomena - Brownian motion - Langevin's theory - Fluctuation-dissipation theorem - The Fokker-Planck equation
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. S. K. Sinha, 1990, Statistical *Mechanics*, Tata McGraw Hill, New Delhi. 2. B. K. Agarwal and M. Eisner, 1998, *Statistical Mechanics*, Second Edition New Age International, New Delhi. 3. J. K. Bhattacharjee, 1996, *Statistical Mechanics*: An Introductory Text, Allied Publication, New Delhi. 4. F. Reif, 1965, *Fundamentals of Statistical and Thermal Physics*, McGraw - Hill, New York. 5. M. K. Zemansky, 1968, *Heat and Thermodynamics*, 5th edition, McGraw-Hill New York.
REFERENCE BOOKS	1. R. K. Pathria, 1996, *Statistical Mechanics*, 2nd edition, Butter WorthHeinemann, New Delhi. 2. L. D. Landau and E. M. Lifshitz, 1969, *Statistical Physics*, Pergamon Press, Oxford. 3. K. Huang, 2002, *Statistical Mechanics*, Taylor and Francis, London 4. W. Greiner, L. Neiseand H.Stoecker, *Thermodynamics and Statistical Mechanics*, Springer Verlang, New York. 5. A. B. Gupta, H. Roy, 2002, *Thermal Physics*, Books and Allied, Kolkata.
WEB SOURCES	1. https://byjus.com/chemistry/third-law-of-thermodynamics/ 2. https://web.stanford.edu/~peastman/statmech/thermodynamics.html 3. https://en.wikiversity.org/wiki/Statistical_mechanics_and_thermodynamics 4. https://en.wikipedia.org/wiki/Grand_canonical_ensemble 5. https://en.wikipedia.org/wiki/Ising_model

COURSE OUTCOMES:

~~At the end of the course the student will be able to:~~

CO1	To examine and elaborate the effect of changes in thermodynamic quantities on the states of matter during phase transition	K5
CO2	To analyze the macroscopic properties such as pressure, volume, temperature, specific heat, elastic moduli etc. using microscopic properties like intermolecular forces, chemical bonding, atomicity etc. Describe the peculiar behaviour of the entropy by mixing two gases Justify the connection between statistics and thermodynamic quantities	**K4**
CO3	Differentiate between canonical and grand canonical ensembles and to interpret the relation between thermodynamical quantities and partition function	**K1**
CO4	To recall and apply the different statistical concepts to analyze the behaviour of ideal Fermi gas and ideal Bose gas and also to compare and distinguish between the three types of statistics.	**K4, K5**
CO5	To discuss and examine the thermodynamical behaviour of gases under fluctuation and also using Ising model	**K3**
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	1	1	2	3	1	1	3
CO2	3	3	3	1	1	2	3	1	1	3
CO3	3	3	3	1	1	2	3	2	1	3
CO4	3	3	3	1	1	2	3	2	1	3
CO5	3	3	3	1	1	2	3	1	1	3

Strong (3) Medium (2) and Low (1)

CORE X Practical **Paper - 10 - Practical – III -NUMERICAL METHODS AND COMPUTER PROGRAMMING (C)**	**II YEAR - THIRD SEMESTER**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
P23PHP303	**Practical – III NUMERICAL METHODS AND COMPUTER PROGRAMMING (C)**	Core	-	-	6	4	6	75

Pre-Requisites

Basic knowledge in differential equation and linear algebra
Basic knowledge of operating system and computer fundamentals.

Learning Objectives

- The aim and objective of the course on Computational Practical is to familiarize the of M.Sc. students with the numerical methods used in computation and programming using any high level language such as C
- To equip the computational skill using various mathematical tools.
- To apply the software tools to explore the concepts of physical science.
- To approach the real time activities using physics and mathematical formulations.

Course Details

(Any Twelve Experiments)

1. Lagrange interpolation with Algorithm, Flow chart and output.
2. Newton forward interpolation with Algorithm, Flow chart and output.
3. Newton backward interpolation with Algorithm, Flow chart and output.
4. Curve-fitting: Least squares fitting with Algorithm, Flow chart and output.
5. Numerical integration by the trapezoidal rule with Algorithm, Flow chart and output.
6. Numerical integration by Simpson's rule with Algorithm, Flow chart and output.
7. Numerical solution of ordinary first-order differential equations by the Euler method with Algorithm, Flow chart and output.
8. Numerical solution of ordinary first-order differential equations by the Runge- Kutta method with Algorithm, Flow chart and output.
9. Finding Roots of a Polynomial - Bisection Method –
10. Finding Roots of a Polynomial - Newton Raphson Method –
11. Solution of Simultaneous Linear Equation by Gauss elimination method.
12. Solution of Ordinary Differential Equation by Euler
13. Runge Kutta Fourth Order Method for solving first order Ordinary Differential Equations
14. Newton's cotes formula
15. Trapezoidal rule
16. Simpson's 1/3 rule
17. Simpson's 3/8 rule
18. Boole's rule
19. Gaussian quadrature method (2 point and 3 point formula)
20. Giraffe's root square method for solving algebraic equation

TEXT BOOKS	1. Numerical methods using Matlab – John Mathews &Kurtis Fink, Prentice Hall, New Jersey 2006 2. Numerical methods in Science and Engineering - M.K. Venkataraman, National Publishing Co. Madras, 1996 3. V. Rajaraman, 1993, Computer Oriented Numerical Methods, 3rd Ed. (Prentice-Hall, New Delhi. 4. M.K. Jain, S.R. Iyengar and R.K. Jain, 1995, Numerical Methods for Scientific and Engineering Computation, 3rd Ed. New Age International, New Delhi. 5. S.S. Sastry, Introductory Methods of Numerical Analysis, PHI, New Delhi.
REFERENCE BOOKS	1. S.D. Conte and C. de Boor, 1981, Elementary Numerical Analysis, An Algorithmic Approach, 3rd Ed., International Ed. (McGraw-Hill). 2. B.F. Gerald and P.O. Wheately, 1994, Applied Numerical Analysis, 5th Edition, Addison Wesley, Reading, MA. 3. B. Carnahan, H.A. Luther and J.O. Wikes, 1969, Applied Numerical Methods (Wiley, New York. 4. S.S. Kuo, 1996, Numerical Methods and Computers, Addison - Wesley, London. 5. V. Rajaraman,Programming in FORTRAN/ Programming in C, PHI, New Delhi.

METHOD OF EVALUATION:

Continuous Internal Assessment	End Semester Examination	Total
25	75	**100**

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Program with the C Program with the C or any other high level language	K1
CO2	Use various numerical methods in describing/solving physics problems.	K4
CO3	Solve problem, critical thinking and analytical reasoning as applied to scientific problems.	K5
CO4	To enhance the problem-solving aptitudes of students using various numerical methods.	K5
CO5	To apply various mathematical entities, facilitate to visualize any complicate tasks.	K3
CO6	Process, analyze and plot data from various physical phenomena and interpret their meaning	K4

CO7	Identify modern programming methods and describe the extent and limitations of computational methods in physics	K1
CO8	Work out numerical differentiation and integration whenever routine are not applicable.	K5
CO9	Apply various interpolation methods and finite difference concepts.	K4
CO10	Understand and apply numerical methods to find out solution of algebraic equation using different methods under different conditions, and numerical solution of system of algebraic equation.	K1, K4
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) **and** LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	2	2	2	3	3	2	2	2	3	3
CO2	2	2	3	3	3	2	2	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3
CO4	3	2	3	3	3	3	2	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3
CO6	2	2	2	3	3	2	2	2	3	3
CO7	2	2	3	3	3	2	2	3	3	3
CO8	3	3	3	3	3	3	3	3	3	3
CO9	3	3	3	3	3	3	3	3	3	3
CO10	3	3	3	3	3	3	3	3	3	3

Strong (3) Medium (2) and Low (1)

Elective – V **SPECTROSCOPY**		**II YEAR - Third SEMESTER**						
Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
P23PHE33A	**SPECTROSCOPY**	Core	3	-	-	3	3	75

Pre-Requisites

Thorough understanding of electromagnetic spectrum, mathematical abilities, knowledge of molecules, their structure, bond nature, physical and chemical behaviour

Learning Objectives

- To comprehend the theory behind different spectroscopic methods
- To know the working principles along with an overview of construction of different types of spectrometers involved
- To explore various applications of these techniques in R &D.
- Apply spectroscopic techniques for the qualitative and quantitative analysis of various chemical compounds.
- Understand this important analytical tool

UNITS	**Course Details**
UNIT I: **MICROWAVE SPECTROSCOPY**	Pure rotational spectra of diatomic molecules - Polyatomic molecules - Study of linear molecules and symmetric top molecules - Hyperfine structure - Experimental technique.
UNIT II: **INFRA-RED SPECTROSCOPY**	Vibrational spectroscopy of diatomic and simple polyatomic molecules - Harmonic Oscillator – Anharmonic Oscillator - Rotational vibrators - Normal modes of vibration of Polyatomic molecules - Experimental techniques - Applications of infrared spectroscopy
UNIT III: **RAMAN SPECTROSCOPY**	Classical theory of Raman Scattering - Raman effect and molecular structure - Raman effect and crystal structure - Experimental techniques - Applications of Raman Spectroscopy
UNIT IV: **NMR and ESR**	Theory of NMR - Bloch equations - Steady state solution of Bloch equations - Theory of chemical shifts - Experimental methods - Applications of NMR to quantitative measurements Quantum Mechanical treatment of ESR - Nuclear interaction and hyperfine structure Relaxation effects - Basic principles of spectrographs - Applications of ESR method

UNIT V: ELECTRONIC SPECTROSCOPY OF ATOM	The structure of atom – electronic angular momentum – many electron atoms – the angular momentum of many electron atom – photoelectron spectroscopy and X-ray fluorescence spectroscopy
TEXT BOOKS	1. C.N.Banwell and E.M.McCash, 1994, Fundamentals of Molecular Spectroscopy, 4th Edition, TataMcGraw - HillPublications,NewDelhi. 2. G. Aruldas, 2001, Molecular Structure and Spectroscopy, Prentice - Hall of India Pvt.Ltd., New Delhi. 3. D.N. Satyanarayana, 2004, Vibrational Spectroscopy and Applications, New Age International Publications, New Delhi 4. Atomic and Molecular Spectra : Laser by Rajkumar, (KNRM Publication-Meerut)
REFERENCE BOOKS	1. Atta Ur Rahman, 1986, Nuclear Magnetic Resonance, SpingerVerlag, New York. 2. Towne and Schawlow, 1995, Micorwave Spectroscopy, McGraw-Hill, 3. Raymond Chang, 1980, Basic Principles of Spectroscopy, Mc Graw-Hill, Kogakusha,Tokyo. 4. D.A. Lang, Raman Spectroscopy, McGraw-Hill International, N.Y.

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Understand fundamentals of rotational spectroscopy, view molecules as elastic rotors and interpret their behaviour. Able to quantify their nature and correlate them with their characteristic properties.	**K2**
CO2	Understand the working principles of spectroscopic instruments and theoretical background of IR spectroscopy. Able to correlate mathematical process of Fourier transformations with instrumentation. Able to interpret vibrational spectrum of small molecules.	**K2, K3**
CO3	Interpret structures and composition of molecules and use their knowledge of Raman Spectroscopy as an important analytical tool	**K5**
CO4	Use these resonance spectroscopic techniques for quantitative and qualitative estimation of a substances	**K4**
CO5	Learn the electronic transitions caused by absorption of radiation in the UV/Vis region of the electromagnetic spectrum and be able to analyze a simple UV spectrum.	**K1, K5**
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate		

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	2	3	3	3	3	3	2
CO2	2	2	2	3	3	3	3	3	3	2
CO3	3	2	3	3	3	3	3	3	3	3
CO4	3	2	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3

Strong (3) Medium (2) and Low (1)

Elective – V PHYSICS OF NANOSCIENCE AND TECHNOLOGY	**II YEAR – THIRD SEMESTER**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
P23PHE33B	**PHYSICS OF NANOSCIENCE AND TECHNOLOGY**	ELECTIVE	3	-	-	3	3	75

Pre-Requisites
Basic knowledge in Solid State Physics
Learning Objectives
➢ Physics of Nanoscience and Technology is concerned with the study, creation, manipulation and applications at nanometer scale. ➢ To provide the basic knowledge about Nanoscience and technology. ➢ To learn the structures and properties of Nanomaterials. ➢ To acquire the knowledge about synthesis methods and characterization techniques and its applications.

UNITS	**Course Details**
UNIT I: FUNDAMENTALS OF NANOSCIENCE AND TECHNOLOGY	Fundamentals of NANO – Historical Perspective on Nanomaterial and Nanotechnology -– Classification of Nanomaterial's – Metal and Semiconductor Nanomaterial's - 2D, 1D, 0D nanostructured materials - Quantum dots – Quantum wires – Quantum wells - Surface effects of nanomaterials.
UNIT II: PROPERTIES OF NANOMATERIALS	Physical properties of Nano materials: Melting points, specific heat capacity, and lattice constant - Mechanical behavior: Elastic properties – strength - ductility - superplastic behavior - Optical properties: - Surface Plasmon Resonance – Quantum size effects - Electrical properties - Conductivity, Ferroelectrics and dielectrics - Magnetic properties – super para magnetism – Diluted magnetic semiconductor (DMS).
UNIT III: SYNTHESIS AND FABRICATION	Physical vapour deposition - Chemical vapour deposition - sol-gel – Wet deposition techniques - electrochemical deposition method – Plasma arching - Electrospinning method - ball milling technique - pulsed laser deposition - Nanolithography: photolithography – Nanomanipulator.
UNIT IV: CHARACTERIZATION TECHNIQUES	Powder X-ray diffraction – X-ray photoelectron spectroscopy (XPS) - UV-visible spectroscopy – Photoluminescence - Scanning electron microscopy (SEM) - Transmission electron microscopy (TEM) - Scanning probe microscopy (SPM) - Scanning tunneling microscopy (STM) – Vibrating sample Magnetometer.

UNIT V: APPLICATIONS OF NANOMATERIALS	Sensors: Nanosensors based on optical and physical properties - Electrochemical sensors – Nano-biosensors. Nano Electronics: Nanobots - display screens - GMR read/write heads - Carbon Nanotube Emitters – Photocatalytic application: Air purification, water purification -Medicine: Imaging of cancer cells – biological tags - drug delivery - photodynamic therapy - Energy: fuel cells - rechargeable batteries – supercapacitors – photovoltaic.
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. A textbook of Nanoscience and Nanotechnology, Pradeep T., Tata McGraw-Hill Publishing Co. (2012). 2. Principles of Nanoscience and Nanotechnology, M.A. Shah, Tokeer Ahmad, Narosa Publishing House Pvt Ltd., (2010). 3. Introduction to Nanoscience and Nanotechnology, K. K. Chattopadhyay and A.N. Banerjee, PHI Learning Pvt. Ltd., New Delhi, (2012). 4. Nanostructured Materials and Nanotechnology, Hari Singh Nalwa, Academic Press, (2002). 5. Nanotechnology and Nanoelectronics, D.P. Kothari, V. Velmurugan and Rajit Ram Singh, Narosa Publishing House Pvt. Ltd, New Delhi. (2018)

REFERENCE BOOKS	1. Nanostructures and Nanomaterials – HuozhongGao – Imperial College Press (2004). 2. Richard Booker and Earl Boysen, (2005) Nanotechnology, Wiley Publishing Inc. USA 3. Nano particles and Nano structured films; Preparation, Characterization and Applications, J. H. Fendler John Wiley and Sons. (2007) 4. Textbook of Nanoscience and Nanotechnology, B. S. Murty, et al., Universities Press. (2012) 5. The Nanoscope (Encyclopedia of Nanoscience and Nanotechnology), Dr. ParagDiwan and AshishBharadwaj (2005) Vol. IV - Nanoelectronics Pentagon Press, New Delhi.
WEB SOURCES	1. www.its.caltec.edu/feyman/plenty.html 2. http://www.library.ualberta.ca/subject/nanoscience/guide/index.cfm 3. http://www.understandingnano.com 4. http://www.nano.gov 5. http://www.nanotechnology.com

COURSE OUTCOMES:
At the end of the course, the student will be able to:

CO1	Understand the basic of Nanoscience and explore the different types of nanomaterials and should comprehend the surface effects of the nanomaterials.	K1, K2
CO2	Explore various physical, mechanical, optical, electrical and magnetic properties nanomaterials.	**K1**
CO3	Understand the process and mechanism of synthesis and fabrication of nanomaterials.	**K2, K3**
CO4	Analyze the various characterizations of Nano-products through diffraction, spectroscopic, microscopic and other techniques.	**K4**
CO5	Apply the concepts of Nano science and technology in the field of sensors, robotics, purification of air and water and in the energy devices.	**K3**
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate;		

MAPPING WITH PROGRAM OUTCOMES:
Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	2	1	1	3	3	3	3
CO2	3	3	3	2	1	1	3	3	3	3
CO3	3	3	2	2	1	1	3	3	3	3
CO4	3	3	3	2	1	1	3	3	3	3
CO5	3	3	2	2	1	1	3	3	3	3

Strong (3) Medium (2) and Low (1)

Pre-Requisites

Elective V- ANALYSIS OF CRYSTAL STRUCTURES	II YEAR – THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
P23PHE33C	ANALYSIS OF CRYSTAL STRUCTURES	ELECTIVE	3	-	-	3	3	75

Fundamentals of crystal structures, symmetry and X-Ray Diffraction techniques

Learning Objectives

- To teach the concept of crystal structures and symmetry, and diffraction theory
- To provide students with a background to X-ray generation, scattering theory and experimental diffraction from single crystals
- To provide instruction on the methods and basis for determining low-molecular weight crystal structures using X-ray Crystallography
- To give the students a background to the instrumentation used for powder diffraction and structure refinement using Rietveld method
- To teach the different levels of structure exhibited by proteins and nucleic acids and methods used in protein crystallography.

UNITS	Course details
UNIT I: CRYSTAL LATTICE	Unit cell and Bravais lattices - crystal planes and directions - basic symmetry elements operations - translational symmetries - point groups - space groups - equivalent positions - Bragg's law - reciprocal lattice concept -Laue conditions - Ewald and limiting spheres - diffraction symmetry - Laue groups.
UNIT II: DIFFRACTION	X-ray generation, properties - sealed tube, rotating anode, synchrotron radiation - absorption - filters and monochromators Atomic scattering factor - Fourier transformation and structure factor - anomalous dispersion - Laue, rotation/oscillation, moving film methods- interpretation of diffraction patterns - cell parameter determination - systematic absences - space group determination.
UNIT III: STRUCTURE ANALYSIS	Single crystal diffractometers - geometries - scan modes - scintillation and area detectors -intensity data collection - data reduction - factors affecting X-ray intensities - temperature and scale factor - electron density - phase problem - normalized structure factor - direct method fundamentals and procedures -Patterson function and heavy atom method - structure refinement - least squares method - Fourier and difference Fourier synthesis - R factor - structure interpretation - geometric calculations - conformational studies - computer program packages.
UNIT IV: POWDER METHODS	Fundamentals of powder diffraction - Debye Scherrer method - diffractometer geometries - use of monochromators and Soller silts –

	Sample preparation and data collection - identification of unknowns - powder diffraction files (ICDD) - Rietveld refinement fundamentals - profile analysis - peak shapes - whole pattern fitting - structure refinement procedures – auto-indexing – structure determination from powder data - new developments. Energy dispersive X-ray analysis – texture studies - crystallite size determination - residual stress analysis - high and low temperature and high pressure crystallography (basics only).
UNIT V: PROTEIN CRYSTALLOGRAPHY	Globular and fibrous proteins, nucleic acids - primary, secondary, tertiary and quaternary structures - helical and sheet structures - Ramachandran map and its significance – crystallization methods for proteins - factors affecting protein crystallization - heavy atom derivatives – methods used to solve protein structures - anomalous dispersion methods.
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism.
TEXT BOOKS	1. Azaroff, L.V., "Elements of X-Ray Crystallography", Techbooksl, New York, 1992. 2. Blundell, T.L. and Johnson, L., "Protein Crystallography", Academic Press, New York, 1986. 3. Cullity, B.D. and Stock,S.R. "Elements of X-ray Diffraction", Pearson, 2014. 4. H.L. Bhat, Introduction to Crystal Growth Principles and Practice CRC Press, Taylor & Francis Group, Boca Raton, Florida, 2015. 5. B.R. Pamplin, Crystal Growth, Pergamon Press, Oxford, 1975.
REFERENCE BOOKS	1. Glusker, J.P. and Trueblood, K.N. Crystal Structure Analysis: A Primer", Oxford University, Press, New York, 1994. 2. Ladd, M.F.C. and Palmer, R.A., "Structure Determination by X-ray Crystallography", Plenum Press, New York, 3rd Edition, 1993. 3. Stout, G.H. and Jensen, L."X-ray Structure Determination, A Practical Guide", Macmillan:,New York, 1989. 4. Woolfson, M.M. "An Introduction to X-ray Crystallography" Cambridge University Press, New York, 1997. 5. Sam Zhang, Lin Ki, Ashok Kumar, Materials Characterization Techniques, CRC Press, Taylor & Francis Group, Boca Raton, Florida, 2009
WEB SOURCES	1. https://archive.nptel.ac.in/courses/112/106/112106227/ 2. https://archive.nptel.ac.in/courses/104/108/104108098/ 3. https://www.digimat.in/nptel/courses/video/102107086/L11.html 4. https://onlinecourses.nptel.ac.in/noc19_cy35/previewhttps://onlinecourses.nptel.ac.in/noc19_cy35/preview 5. https://nptel.ac.in/courses/104/104/104104011/

COURSE OUTCOMES:
At the end of the course, the student will be able to:

CO1	Understand crystal symmetry and reciprocal lattice concept for X-ray diffraction	K2
CO2	Gain a working knowledge of X-ray generation, X-ray photography with Laue, oscillation and moving film methods, and space group determination	**K1,K3**
CO3	Get an exposure to crystal structure determination using program packages	**K1,K4**
CO4	Understand the instrumentation used for powder diffraction, data collection, data interpretation, and structure refinement using Rietveld method	**K2, K4**
CO5	Get an insight into the structural aspects of proteins and nucleic acids, crystallization of proteins and methods to solve protein structures	**K5**
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate;		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	2	3	2	1	2	2	2
CO2	3	3	3	2	2	2	1	2	2	2
CO3	3	3	2	2	2	2	2	2	2	2
CO4	3	2	2	2	2	2	2	2	2	2
CO5	3	2	2	2	2	2	2	2	2	2

Strong (3) Medium (2) and Low (1)

NME-II– BASIC OF ASTROPHYSICS	**II YEAR – THIRD SEMESTER**

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
P23PHN302	**BASIC OF ASTROPHYSICS**	NME	3	-	-	2	3	75

Objectives:

- To provide the fundamental knowledge about electromagnetic spectrum and telescopes
- To gain knowledge about Planetary and Interplanetary space
- To know Stars, Suns, Planets, Asteroids, Meteors and Comets

UNIT I: ELECTROMAGNETIC SPECTRUM AND TELESCOPE: The nature of light: Light as an electric vibration, the electromagnetic radiation from a heated object, Doppler shift. Tools of the astronomer: Optical & Space telescopes (Galielian, Newtonian, & Hubble Space Telescope), Magnifying power & Resolving power of telescopes

UNIT II: INTRODUCTION TO PLANETARY AND INTERPLANETARY SPACE:
Kepler's Laws, Earth-Moon System, Solar and Lunar types, Exploration of Solar System by Telescopes, Rockets and Satellites. Structure of Earth's Atmosphere- Lower, Middle and Upper Troposphere, Stratosphere, Ionosphere, Protonosphere, Interplanetary space, Earth as a Magnetic Comet.

UNIT III: STARS: Measuring stellar characteristics (temperature, distance, luminosity, mass, size) - HR diagram - stellar structure (equilibrium, nuclear reactions, energy transport) - stellar evolution; Stellar Evolution (HR diagram): Life cycle; Stellar Processes (Nuclear) and spectral classification of Stars O, B, A, F, G, K, M.

UNIT IV: THE SUN AND PLANETS: Origin of the solar system, Internal structure and surface features of sun, Sun spots and Magnetic field on the sun and Solar activity. Surface features of planets, Atmospheres and Magnetic fields of Planets and their moons.

UNIT V: ASTEROIDS, METEORS AND COMETS: Asteroids: Discovery and designation, Origin, Nature and Orbits of Asteroids. Meteors: Meteor showers and sporadic meteors. Comets: Periodic comets, Brightness variation in Comets. Gas production rates, dust and ion tails.

TEXT BOOKS:

1. V.B. Bhatia, Textbook of Astronomy and Astrophysics with elements of cosmology, Alpha Science International Ltd. 2001.
2. B.W.Carroll&D.A.Ostlie: An Introduction to Modern Astrophysics, 2nd Edn, Cambridge University Press, 2017
3. Shu F, The Physical Universe, University of Science Press,1981
4. K.D.Abhyankar, Astrophysics: Stars and Galaxies- Tata McGraw Hill Publication,1992

Core XI **Paper 11 - NUCLEAR AND PARTICLE PHYSICS**	**II YEAR - FOURTH SEMESTER**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
P23PHT408	**NUCLEAR AND PARTICLE PHYSICS**	Core	6	-	-	5	6	75

Pre-Requisites
Knowledge of basic structure of atom and nucleus.
Learning Objectives
➢ Introduces students to the different models of the nucleus in a chronological order ➢ Imparts an in-depth knowledge on the different types of detectors, experiments to study it and the types of nuclear reactions and their principles ➢ Provides students with details of nuclear decay with relevant theories ➢ Exposes students to the Standard Model of Elementary Particles

UNITS	**Course Details**
UNIT I: **NUCLEAR MODELS**	Fermi Gas Model- Liquid drop model – shell model – magic numbers – Extreme Single Particle Model-Square well of infinite depth-Harmonic Oscillator Potential, Spin-Orbit Potential-Single Particle Model-Collective Nuclear Model-Vibrational States-Rotational States- Unified Model- Deformed Shell Model-Nilsson Model - Superconductivity Model
UNIT II: **DETECTION AND MEASUREMENT OF NUCLEAR RADIATIONS**	Ionization Chamber-Semi-conductor Detectors-Diffused junction detector-Surface barrier detector-Lithium drifted junction detector-Regions of Multiplicative operation-Proportional Counter-Geiger Muller Counter-Scintillation counters-Different Processes in the Scintillation Counter-Cerenkov Counters-Cloud Chamber-Bubble Chamber-Spark Chamber-Nuclear Emulsions
UNIT III: **NUCLEAR REACTIONS**	Types of Nuclear Reactions- Conservation Laws- Nuclear reaction Kinematics-Nuclear Transmutations-Charged Particle reaction spectroscopy-Neutron spectroscopy- Nuclear cross-section-Classical analysis of cross section- Partial wave analysis of reaction cross section-Thick Target Yield- Requirements for a reaction-Reaction mechanism -General features of reaction cross sections-Inverse Reaction-Principle of detailed balance- Compound Nucleus-Compound Nucleus reactions

UNIT IV: **NUCLEAR DECAY**	Alpha Particles-Determination of q/m for the α-particles-Range of α-particle-Energy of α-particles-Range-Velocity Energy -Life Time relations-Alpha Decay Energy and Mass Number-Alpha Particle Spectra-Gamow's Theory of Alpha Decay Beta Decay-Neutrino-Fermi theory of Beta Decay- Energy Life time relationships-Fermi theory of Beta decay
UNIT V: **ELEMENTARY PARTICLES**	Classification of Elementary Particles – Fundamental interactions-Gravitational-Electromagnetic-Strong and Weak Interactions-Conversation Laws-Invariance under charge-Parity-C.P., time and CPT-Electron and Positron- Proton and antiproton-Neutron and Antineutron -Neutrino and antineutrino-Graviton-Phonon and Gluon-Meson: Muons-Tauons-Pions-K-Mesons-η-Mesons-Hyperons: ʌ, ∑, Ξ, Ω-Hyperons-Hyper nuclei-Resonance states-Elementary particle symmetries-Quarks-Isospin of Quarks
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
BOOK FOR STUDY	1. D. C. Tayal – Nuclear Physics – Himalaya Publishing House (2011)
REFERENCE BOOKS	1. K. S. Krane – Introductory Nuclear Physics – John Wiley & Sons (2008) 2. R. Roy and P. Nigam – Nuclear Physics – New Age Publishers (1996) 3. S. B. Patel – Nuclear Physics – An introduction – New Age International Pvt Ltd Publishers (2011) 4. S. Glasstone – Source Book of Atomic Energy – Van Nostrand Reinhold Inc.,U.S.- 3rd Revised edition (1968) 5. L. J. Tassie – The Physics of elementary particles – Prentice Hall Press (1973) 6. H. A. Enge – Introduction to Nuclear Physics – Addison Wesley, Publishing Company. Inc. Reading. New York, (1974). 7. Kaplan – Nuclear Physics – 1989 – 2nd Ed. – Narosa (2002) 8. Bernard L Cohen – Concepts of Nuclear Physics – McGraw Hill Education (India) Private Limited; 1 edition (2001) 9. B.L. Cohen, 1971, Concepts of Nuclear Physics, TMCH, New Delhi.
WEB SOURCES	1. http://bubl.ac.uk/link/n/nuclearphysics.html 2. http://www.phys.unsw.edu.au/PHYS3050/pdf/Nuclear_Models.pdfhttp://www.scholarpedia.org/article/Nuclear_Forces 3. https://www.nuclear-power.net/nuclear-power/nuclear-reactions/ 4. http://labman.phys.utk.edu/phys222core/modules/m12/nuclear_models.html 5. https://www.ndeed.org/EducationResources/HighSchool/Radiography/radioactivedecay.html

COURSE OUTCOMES:
At the end of the course, the student will be able to:

CO1	Gain knowledge about the concepts of helicity, parity, angular correlation and internal conversion.	K1, K5
CO2	Familiarity with experimental methods and techniques used in nuclear and particle physics, such as detection methods, data analysis, and instrumentation	K2, K3
CO3	Use the different nuclear models to explain different nuclear phenomena and the concept of resonances through Briet-Weigner single level formula	K3
CO4	Understand different types of radioactive decay processes (alpha, beta) and their implications in nuclear physics	K3, K4
CO5	Summarize and identify allowed and forbidden nuclear reactions based on conservation laws of the elementary particles.	K5
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	2	2	2	2	2	2	2	2
CO2	3	3	2	2	1	2	1	2	2	2
CO3	3	3	1	2	1	2	1	1	2	2
CO4	3	3	2	3	2	3	2	2	3	3
CO5	3	3	2	3	2	3	2	3	3	3

Strong (3) Medium (2) and Low (1)

CORE - XII **Paper 12 - ELECTROMAGNETIC THEORY**	**II YEAR - FOURTH SEMESTER**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
P23PHT409	**ELECTROMAGNETIC THEORY**	Core	6	-	-	5	6	75

Pre-Requisites

Different coordinate systems, Laplace's equation, conducting & non-conducting medium, basic definitions in magnetism, propagation of electromagnetic waves, plasma

Learning Objectives

- To acquire knowledge about boundary conditions between two media and the technique of method of separation of variables
- To understand Biot – Savart's law and Ampere's circuital law
- To comprehend the physical ideas contained in Maxwell's equations, Coulomb & Lorentz gauges, conservation laws
- To assimilate the concepts of propagation, polarization, reflection and refraction of electromagnetic waves
- To grasp the concept of plasma as the fourth state of matter

UNITS	**Course Details**
UNIT I: ELECTROSTATICS	Boundary value problems and Laplace equation – Boundary conditions and uniqueness theorem – Laplace equation in three dimension – Solution in Cartesian and spherical polar coordinates – Examples of solutions for boundary value problems. Polarization and displacement vectors - Boundary conditions - Dielectric sphere in a uniform field – Molecular polarizability and electrical susceptibility – Electrostatic energy in the presence of dielectric – Multipole expansion.
UNIT II: MAGNETOSTATICS	Biot-Savart's Law - Ampere's law - Magnetic vector potential and magnetic field of a localized current distribution - Magnetic moment, force and torque on a current distribution in an external field - Magneto static energy - Magnetic induction and magnetic field in macroscopic media - Boundary conditions - Uniformly magnetized sphere.
UNIT III: MAXWELL EQUATIONS	Faraday's laws of Induction - Maxwell's displacement current - Maxwell's equations - Vector and scalar potentials - Gauge invariance - Wave equation and plane wave solution- Coulomb and Lorentz gauges - Energy and momentum of the field - Poynting's theorem - Lorentz force - Conservation laws for a system of charges and electromagnetic fields.

UNIT IV: WAVE PROPAGATION	Plane waves in non-conducting media - Linear and circular polarization, reflection and refraction at a plane interface - Waves in a conducting medium - Propagation of waves in a rectangular wave guide. Inhomogeneous wave equation and retarded potentials - Radiation from a localized source - Oscillating electric dipole
UNIT V: ELEMENTARY PLASMA PHYSICS	The Boltzmann Equation - Simplified magneto-hydrodynamic equations - Electron plasma oscillations - The Debye shielding problem - Plasma confinement in a magnetic field - Magneto-hydrodynamic waves - Alfven waves and magnetosonic waves.
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. D. J. Griffiths, 2002, *Introduction to Electrodynamics*, 3rd Edition, Prentice-Hall of India, New Delhi. 2. J. R. Reitz, F. J. Milford and R. W. Christy, 1986, *Foundations of Electromagnetic Theory*, 3rd edition, Narosa Publishing House, New Delhi. 3. J. D. Jackson, 1975, *Classical Electrodynamics*, Wiley Eastern Ltd. New Delhi. 4. J. A. Bittencourt, 1988, *Fundamentals of Plasma Physics*, Pergamon Press, Oxford. 5. Gupta, Kumar and Singh, Electrodynamics, S. Chand & Co., New Delhi
REFERENCE BOOKS	1. W. Panofsky and M. Phillips, 1962, *Classical Electricity and Magnetism*, Addison Wesley, London. 2. J. D. Kraus and D. A. Fleisch, 1999, *Electromagnetics with Applications*, 5th Edition, WCB McGraw-Hill, New York. 3. B. Chakraborty, 2002, *Principles of Electrodynamics*, Books and Allied, Kolkata. 4. P. Feynman, R. B. Leighton and M. Sands, 1998, *The Feynman Lectures on Physics*, Vols. 2, Narosa Publishing House, New Delhi. 5. Andrew Zangwill, 2013, Modern Electrodynamics, Cambridge University Press, USA.
WEB SOURCES	1. http://www.plasma.uu.se/CED/Book/index.html 2. http://www.thphys.nuim.ie/Notes/electromag/frame-notes.html 3. http://www.thphys.nuim.ie/Notes/em-topics/em-topics.html 4. http://dmoz.org/Science/Physics/Electromagnetism/Courses_and_Tutorials/ 5. https://www.cliffsnotes.com/study-guides/physics/electricity-and-magnetism/electrostatics

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Solve the differential equations using Laplace equation and to find solutions for boundary value problems	K1, K5
CO2	Use Biot-Savart's law and Ampere circuital law to find the magnetic induction & magnetic vector potential for various physical problems	**K2, K3**
CO3	Apply Maxwell's equations to describe how electromagnetic field behaves in different media	**K3**
CO4	Apply the concept of propagation of EM waves through wave guides in optical fiber communications and also in radar installations, calculate the transmission and reflection coefficients of electromagnetic waves	**K3, K4**
CO5	Investigate the interaction of ionized gases with self-consistent electric and magnetic fields	**K5**
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	1	2	2	3	3	1	3
CO2	3	3	3	1	2	2	3	3	1	3
CO3	3	3	3	1	2	2	3	3	1	3
CO4	3	3	3	1	2	2	3	3	1	3
CO5	3	3	3	1	2	2	3	3	1	3

Strong (3) Medium (2) and Low (1)

Elective VI **CHARACTERIZATON OF MATERIALS**	**II YEAR – FOURTH SEMESTER**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
P23PHE44A	**CHARACTERIZATON OF MATERIALS**	ELECTIVE	1	-	3	3	4	75

Pre-Requisites
Fundamentals of Heat and Thermodynamics, Basics of Optical systems, Microscopic systems, Electrical measurements and Fundamentals of Spectroscopy.
Learning Objectives
➢ To make the students learn some important thermal analysis techniques ➢ To introduce the students the basics of x-ray diffraction techniques and some important spectroscopic techniques. ➢ To gain familiarity with the instrumentation used in each spectroscopic technique, including UV-Visible spectrophotometers, FTIR spectrometers, Raman spectrometers, and Fluorescence spectrometers

UNITS	**Course details**
UNIT I **THERMAL ANALYSIS**	Introduction – thermogravimetric analysis (TGA) – instrumentation – determination of weight loss and decomposition products
UNIT II **X-RAY DIFFRACTION**	Principles and instrumentation for Powder X-ray diffraction-interpretation of diffraction patterns - indexing - phase identification - residual stress analysis - Particle size, texture studies- Uses
UNIT III **UV-VISIBLE SPECTROSCOPY**	Principles and instrumentation of UV-Visible Spectroscopy-Analysis-Applications
UNIT IV **INFRARED & RAMAN SPECTROSCOPY**	Principles and instrumentation of FTIR and Raman Spectroscopy-Analysis-Applications
UNIT V **FLURESCENCE SPECTROSCOPY**	Principles and instrumentation of Fluorescence Spectroscopy-Analysis-Applications

UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars, Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism.

TEXT BOOKS	Unit –I -Instrumental method by Willard ,Merritt, Dean, Settle Unit –II -Microscopy and microtechnique by R. Marimuthu Unit –III-Thin flim fundamental by A.Goswami,Thinflim phenomena by Kasturi L .chopra Unit –IV- Nanomaterials and Nanoscience by Asim k Das ,Mahua das Unit –V-Spectroscopy by GurdeepR.chatwal ,sham K.Anand 1. Elements of X-Ray Diffraction by B.D.Cullity ,S.R.Stock 2. R. A. Stradling and P. C. Klipstain. Growth and Characterization of semiconductors. Adam Hilger, Bristol, 1990. 3. J. A. Belk. Electron microscopy and microanalysis of crystalline materials. Applied Science Publishers, London, 1979. 4. Lawrence E. Murr. Electron and Ion microscopy and Microanalysis principles and Applications. Marcel Dekker Inc., New York, 1991 5. D. Kealey and P. J. Haines. Analytical Chemistry. Viva Books Private Limited, New Delhi, 2002. 6. Li, Lin, Ashok Kumar Materials Characterization Techniques Sam Zhang; CRC Press, (2008).
REFERENCE BOOKS	1. Cullity, B.D., and Stock, R.S., "Elements of X-Ray Diffraction", Prentice-Hall, (2001). 2. Murphy, Douglas B, Fundamentals of Light Microscopy and Electronic Imaging, Wiley-Liss, Inc. USA, (2001). 3. Tyagi, A.K., Roy, Mainak, Kulshreshtha, S.K., and Banerjee, S., Advanced Techniques for Materials Characterization, Materials Science Foundations (monograph series), Volumes 49 – 51, (2009).Volumes 49 – 51, (2009). 4. Wendlandt, W.W., Thermal Analysis, John Wiley & Sons, (1986). 5. Wachtman, J.B., Kalman, Z.H., Characterization of Materials, ButterworthHeinemann, (1993)

WEB SOURCES	1. https://cac.annauniv.edu/uddetails/udpg_2015/77.%20Mat%20Sci(AC).pdf 2. http://www.digimat.in/nptel/courses/video/113106034/L11.html 3. https://nptel.ac.in/courses/104106122 4. https://nptel.ac.in/courses/118104008 5. https://www.sciencedirect.com/journal/materials-characterization

COURSE OUTCOMES:

At the end of the course, the student will be able to:

CO1	Describe thermal analysis techniques and make interpretation of the results.	K1, K3
CO2	The theory and experimental procedure for x- ray diffraction and some and their applications.	**K2**
CO3	Understand the fundamental principles and theoretical background of UV-Visible, FTIR, Raman, and Fluorescence spectroscopy	**K2, K3**
CO4	Acquire skills in acquiring spectroscopic data, such as absorption spectra (UV-Visible), infrared spectra (FTIR), Raman spectra, and fluorescence spectra.	**K3, K4**
CO5	Develop the ability to interpret spectra obtained from UV-Visible, FTIR, Raman, and Fluorescence spectroscopy.	**K4,K5**
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate;		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) **and** LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	2	2	2	2	2	2	3
CO2	3	3	3	2	2	2	2	2	2	2
CO3	3	3	2	2	2	3	2	2	2	2
CO4	2	2	2	3	2	3	2	2	2	2
CO5	2	2	2	2	2	2	3	2	2	2

Strong (3) Medium (2) and Low (1)

Elective VI **SOLAR ENERGY UTILIZATION**	**II YEAR – FOURTH SEMESTER**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
P23PHE44B	**SOLAR ENERGY UTILIZATION**	ELECTIVE	1	-	3	3	4	75

Pre-Requisites
Basic knowledge of heat energy, way of transfer of heat, solar energy, materials types
Learning Objectives
➢ To impart fundamental aspects of solar energy utilization. ➢ To give adequate exposure to solar energy related industries ➢ To harness entrepreneurship skills ➢ To understand the different types of solar cells and channelizing them to the different sectors of society ➢ To develop an industrialist mindset by utilizing renewable source of energy

UNITS	**Course Details**
UNIT I: **HEAT TRANSFER & RADIATION ANALYSIS**	Conduction, Convection and Radiation – Solar Radiation at the earth's surface - Determination of solar time – Solar energy measuring instruments.
UNIT II: **SOLAR COLLECTORS**	Physical principles of conversion of solar radiation into heat flat plate collectors - General characteristics – Focusing collector systems – Thermal performance evaluation of optical loss.
UNIT III: **SOLAR HEATERS**	Types of solar water heater - Solar heating system – Collectors and storage tanks – Solar ponds – Solar cooling systems.
UNIT IV: **SOLAR ENERGY CONVERSION**	Photo Voltaic principles – Types of solar cells – Crystalline silicon/amorphous silicon and Thermo - electric conversion - process flow of silicon solar cells- different approaches on the process- texturization, diffusion, Antireflective coatings, metallization.
UNIT V: **NANOMATERIALS IN FUEL CELL APPLICATIONS**	Use of nanostructures and nanomaterials in fuel cell technology - high and low temperature fuel cells, cathode and anode reactions, fuel cell catalysts, electrolytes, ceramic catalysts. Use of Nano technology in hydrogen production and storage. Industrial visit – data collection and analysis - presentation
UNIT VI: **PROFESSIONAL COMPONENTS**	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. Solar energy utilization -G.D. Rai –Khanna publishers – Delhi 1987. 2. Maheshwar Sharon, Madhuri Sharon, Carbon "Nano forms and Applications", McGraw-Hill, 2010. 3. Soteris A. Kalogirou, „Solar Energy Engineering: Processes and Systems", Academic Press, London, 2009 4. Tiwari G.N, "Solar Energy – Fundamentals Design, Modelling and applications, Narosa Publishing House, New Delhi, 2002 5. Sukhatme S.P. Solar Energy, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.
REFERENCE BOOKS	1. Energy – An Introduction to Physics – R.H.Romer, W.H.Freeman.(1976) 2. Solar energy thermal processes – John A.Drife and William. (1974) 3. John W. Twidell& Anthony D.Weir, 'Renewable Energy Resources,2005 4. John A. Duffie, William A. Beckman, Solar Energy: Thermal Processes, 4th Edition, john Wiley and Sons, 2013 5. Duffie, J.A., Beckman, W.A. , "Solar Energy Thermal Process", John Wiley and Sons,2007.
WEB SOURCES	1. https://pdfs.semanticscholar.org/63a5/a69421b69d2ce9f359bbfc86c63556f9a4fb 2. https://books.google.vg/books?id=l-XHcwZo9XwC&sitesec=buy&source=gbs_vpt_read 3. www.nptel.ac.in/courses/112105051 4. www.freevideolectures.com 5. http://www.e-booksdirectory.com

COURSE OUTCOMES:

At the end of the course, the student will be able to:

CO1	Gained knowledge in fundamental aspects of solar energy utilization	K1
CO2	Equipped to take up related job by gaining industry exposure	**K3**
CO3	Develop entrepreneurial skills	**K5**
CO4	Skilled to approach the needy society with different types of solar cells	**K4**
CO5	Gained industrialist mindset by utilizing renewable source of energy	**K2, K3**
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate;		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	2	3	3	3	2	2	2	3	2
CO2	2	3	2	2	3	3	2	3	2	2
CO3	2	3	2	2	2	2	3	3	3	2
CO4	2	2	2	3	2	3	2	3	3	2
CO5	2	2	3	2	3	3	3	3	3	3

Strong (3) Medium (2) and Low (1)

Elective VI -SOLID WASTE MANAGEMENT	**II YEAR – FOURTH SEMESTER**

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
P23PHE44C	**SOLID WASTE MANAGEMENT**	ELECTIVE	1	-	3	3	4	75

Pre-Requisites
Basic knowledge of solid waste and its type
Learning Objectives
➢ To gain basic knowledge in solid waste management procedures ➢ To gain industry exposure and be equipped to take up a job. ➢ To harness entrepreneurial skills. ➢ To analyze the status of solid waste management in the nearby areas. ➢ To sensitize the importance of healthy practices in waste managements

UNITS	Course Details
UNIT I: SOLID WASTE MANAGEMENT	Introduction - Definition of solid waste - Types – Hazardous Waste: Resource conservation and Renewal act – Hazardous Waste: Municipal Solid waste and non-municipal solid waste.
UNIT II: SOLID WASTE CHARACTERISTICS	Solid Waste Characteristics: Physical and chemical characteristics - SWM hierarchy - factors affecting SW generation
UNIT III: TOOLS AND EQUIPMENT	Tools and equipment - Transportation - Disposal techniques - Composting and land filling technique
UNIT IV: ECONOMIC DEVELOPMENT	SWM for economic development and environmental protection Linking SWM and climate change and marine litter.
UNIT V: INDUSTRIAL VISIT	SWM Industrial visit – data collection and analysis - presentation
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. Handbook of Solid Waste Management /Second Edition, George Tchobanoglous, McGraw Hill (2002). 2. Prospects and Perspectives of Solid Waste Management, Prof. B BHosett, New Age International (P) Ltd (2006). 3. Solid and Hazardous Waste Management, Second Edition, M.N Rao, BS

	Publications / BSPBooks (.(2020 4. Integrated Solid Waste Management Engineering Principles and Management, Tchobanoglous, McGraw Hill (2014). 5. Solid Waste Management (SWM), VasudevanRajaram, PHI learning private limited, 2016
REFERENCE BOOKS	1. Municipal Solid Waste Management, Christian Ludwig, Samuel Stucki, Stefanie Hellweg, Springer Berlin Heisenberg, 2012 2. Solid Waste Management Bhide A. D Indian National Scientific Documentation Centre, New Delhi Edition 1983 ASIN: B0018MZ0C2 3. Solid Waste Techobanoglous George; Kreith, Frank McGraw Hill Publication, New Delhi 2002, ISBN 9780071356237 4. Environmental Studies Manjunath D. L. Pearson Education Publication, New Delhi, 20061SBN-I3: 978-8131709122 5. Solid Waste Management Sasikumar K. PHI learning, New Delhi, 2009 ISBN 8120338693
WEB SOURCES	1. https://www.meripustak.com/Integrated-Solid-Waste-Management-Engineering-Principles-And-Management-Issues-125648 2. https://testbook.com/learn/environmental-engineering-solid-waste-management/ 3. https://www.meripustak.com&gclid=Cj0KCQjwuuKXBhCRARIsA-gM0iVpismAJN93CHA1sX6NuNeOKLXfQJ_jxHCOVH3QXjJ1iACq30KofoaAmFsEALw_wcB 4. https://images.app.goo.gl/tYiW2gUPfS2cxdD28 5. https://amzn.eu/d/5VUSTDI

COURSE OUTCOMES:

At the end of the course, the student will be able to:

CO1	Gained knowledge in solid waste management	K1
CO2	Equipped to take up related job by gaining industry exposure	**K5**
CO3	Develop entrepreneurial skills	**K3**
CO4	Will be able to analyze and manage the status of the solid wastes in the nearby areas	**K4**
CO5	Adequately sensitized in managing solid wastes in and around his/her locality	**K5**
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate;		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	2	3	3	3	2	2	2	2	2	3
CO2	2	3	3	2	2	2	3	3	3	2
CO3	2	3	2	2	2	2	3	3	3	2
CO4	3	2	2	2	2	3	3	3	3	2
CO5	2	3	3	2	2	2	3	3	2	3

Strong (3) Medium (2) and Low (1)

NME- II **DATA ANALYSIS BY ORIGIN SOFTWARE**	**II YEAR – FOURTH SEMESTER**

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
P23PHS402	**DATA ANALYSIS BY ORIGIN SOFTWARE**	NME	4			2	4	75

Objectives:

- To develop understanding of the basics of Data analysis using Origin software.
- To enhance practical skills to analyze data using Origin software.
- To Determine baseline and curve fitting
- To Acquire skills to install and start-up origin software
- To Analyze data with Origin 7.5 version

Unit 1: Basic Data Analysis

Starting Origin, Reading Data, Subtracting Reference Data, Viewing Worksheet Data, Normalizing the Data, creating a Baseline, Fitting the Data, The Fitting Session, Calibration, Error analysis. Setting Range and Integrating the Data, Displaying the Integration Results, Plotting the Integration Area Data

Unit 2: Baseline Determinations & Curve Fitting

Starting the Baseline Session, User Adjustment of Linear Segments, choosing a Baseline Option, Cursor Draw Baseline - General Comment, Fitting Example 1, Fitting Example 2, Fitting Example3

χ 2 (chi-sqr) Minimization, Response Time – VP-DSC, Line Types for Fit Curves, Inserting an Origin graph into Microsoft® Word.

Unit 3: Origin version 7.5

Introduction, installing origin, uninstalling origin, selecting a User Files Folder, Licensing Origin, Registering Origin, Setting the Origin Display Language.

Introduction, Data Exchange, Analysis, Programming, The Origin Workspace, Origin Project Files, Project Windows, Window Templates, Themes, Tutorials

Reference

1. DSC Data Analysis in Origin ® Tutorial Guide Version 5.0 - October 1998
2. https://www.chem.purdue.edu/courses/chm224/Miscellaneous/INTRODUCTION%20TO%20ORIGIN%202012.pdf
3. https://www.originlab.com/pdfs/GettingStarted.PDF
4. https://www.originlab.com/pdfs/Origin_8.1_Getting_Started_Booklet.pdf

Course Outcome:

CO1: Understand basics of data analysis [K2]
CO2: Identify the selector tools and integrating the data [K4]
CO3: Determine baseline and curve fitting [K5]
CO4: Computing χ 2 and making use of details in Origin [K5]
CO5: Acquire skills to install and start-up origin software 7.5 version [K2]

Outcome Mapping

PO/CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	3	3	3	3	3	2	3	3
CO2	3	3	3	2	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	2	3
CO4	3	3	3	3	3	3	3	3	3	3	3
CO5	3	3	2	3	3	3	3	3	2	3	3

Strongly correlating (S) : 3 Marks
Moderately correlating (M): 2 Marks
Weekly correlating (W) : 1 Marks
No correlation (N) : -