M. Sc. PHYSICS

SYLLABUS - 2018

SCHOOL OF EXCELLENCE
with
CHOICE BASED CREDIT SYSTEM (CBCS)

SCHOOL OF PHYSICAL SCIENCES
St. JOSEPH'S COLLEGE (Autonomous)
Special Heritage Status Awarded by UGC
Accredited at 'A' Grade (3rd cycle) by NAAC
College with Potential for Excellence Conferred by UGC
DBT-STAR & DST-FIST Sponsored College
TIRUCHIRAPPALLI - 620 002, INDIA

SCHOOLS OF EXCELLENCE WITH CHOICE BASED CREDIT SYSTEM (CBCS)

POSTGRADUATE COURSES

St. Joseph's College (Autonomous), a pioneer in higher education in India, strives to work towards the academic excellence. In this regard, it has initiated the implementation of five "Schools of Excellence" from the academic year 2014-15, to standup to the challenges of the 21st century.

Each School integrates related disciplines under one roof. The school system allows the enhanced academic mobility and enriched employability of the students. At the same time this system preserves the identity, autonomy and uniqueness of every department and reinforces their efforts to be student centric in curriculum designing and skill imparting. These five schools will work concertedly to achieve and accomplish the following objectives.

- Optimal utilization of resources both human and material for the academic flexibility leading to excellence.
- Students experience or enjoy their choice of courses and credits for their horizontal mobility.
- The existing curricular structure as specified by TANSCHE and other higher educational institutions facilitate the Credit-Transfer Across the Disciplines (CTAD) - a uniqueness of the choice-based credit system.
- Human excellence in specialized areas
- Thrust in internship and / or projects as a lead towards research and
- The multi-discipline nature of the newly evolved structure (School System) caters to the needs of stake-holders, especially the employers.

What is Credit system?

Weightage to a course is given in relation to the hours assigned for the course. Generally, one hour per week has one credit. For viability and conformity to the guidelines credits are awarded irrespective of the teaching hours. The following Table shows the correlation between credits and hours. However, there could be some flexibility because of practical, field visits, tutorials and nature of project work.

For PG courses, a student must earn a minimum of 110 credits as mentioned in the table below. The total number of minimum courses offered by a department are given in the course pattern.

POSTGRADUATE COURSE PATTERN (June 2018 onwards)

Part	Semester	Specification	No. of Courses	Hours	Credits	Total Credits
1	I-IV	**Core Courses** Theory Practical	 12-14 3-6	84	68	81
	II	**Self-Paced Learning**	1	-	2	
	III	**Interdisciplinary Core**	1	6	5	
	IV	**Comprehensive Examination** **Project Work**	1 1	- 6	2 4	
2	I-III	**Core Electives**	3	12	12	12
3	II	**IDC (Soft Skills)**	1	4	4	**12**
	III	**IDC (WS)** **IDC (BS)**	1 1	4 4	4 4	
4	I	**Extra Credit Courses-1 (MOOC)**	1	-	(2)	(4)
	III	**Extra Credit Courses-2 (MOOC)**	1	-	(2)	
5	IV	Outreach Programme (SHEPHERD)	1	-	5	**5**
		TOTAL		**120**		**110 (+4 extra credits)**

Note: IDC: Inter-Departmental Courses, BS: Between School, WS: Within School

However, there could be some flexibility because of practical, field visits, tutorials and nature of project work. For PG courses, a student must earn a minimum of 110 credits. The total number of courses offered by a department is given above.

Course Pattern

The Post-Graduate degree course consists of five vital components. They are core course, core electives, IDCs, Extra credit courses, and the Outreach Programme.

Core Courses

A core course is the course offered by the parent department related to the major subjects, components like theories, practicals, Inter disciplinary core, self paced learning, comprehensive examination, Project work, field visits, library record and etc.

Inter-disciplinary Core

Inter-disciplinary Core should be shared by the various Departments of every School. This course should be opted by all the students belonging to the particular school. Each department of the respective school should allocate themselves the schedule and the units of the course.

Core Elective

The core elective course is also offered by the parent department. The objective is to provide choice and flexibility within the department. There are three core electives. They are offered in different semesters according to the choice of the school.

Extra Credit Courses

In order to facilitate the students gaining extra credits, the extra credit courses are given. According to the guidelines of UGC, the students are encouraged to avail this option of enriching by enrolling themselves in the Massive Open Online Courses (MOOC) provided by various portals such as SWAYAM, NPTEL etc.

Inter-Departmental Courses (IDC)

IDC is an interdepartmental course offered by a department / School for the students belonging to other departments / school. The objective is to provide mobility and flexibility outside the parent department / School. This is introduced to make every course multi-disciplinary in nature. It is to be chosen from a list of courses offered by various departments.

There are three IDCs. Among three, one is the Soft-Skill course offered by the JASS in the II Semester for the students of all the Departments. The other one is offered "With-in the school" (WS) and the third one is offered "Between the school" (BS). The IDCs are of application oriented and inter disciplinary in nature.

Subject Code Fixation

The following code system (9 characters) is adopted for Post Graduate courses:

Year of Revision	PG Code of the Dept	Semester	Specification of Part	Running number in the part
↓	↓	↓	↓	↓
18	P##	*x*	*x*	*xx*
18	**PPH**	**1**	**1**	**01**

For Example :

MSc - Physics, first semester **'Classical Mechanics'**
The code of the paper is **18PPH1101**.
Thus, the subject code is fixed for other subjects.

Specification of the Part

I - Core Courses: (Theory, Practical, Self paced Learning, Inter-disciplinary Core, Core, Comprehensive Examination, Project work)
II - Core Electives
III - Inter Departmental Courses (WS, Soft Skill & BS)
IV - Extra credit courses
V - Outreach Programme (Shepherd)

EXAMINATION

Continuous Internal Assessment (CIA):

PG - Distribution of CIA Marks	
Passing Minimum: 50 Marks	
Library Referencing	5
3 Components	35
Mid-Semester Test	30
End-Semester Test	30
CIA	**100**

Mid-Semster & End-Semester Tests

Centralised – Conducted by the office of Controller of Examinations

1. Mid-Semester Test & End-Semester Test: (2 Hours each); will have Objective + Descriptive elements; with the existing question pattern PART-A; PART-B; and PART-C
2. CIA Component III for UG & PG will be of 15 marks and compulsorily objective multiple choice question type.
3. The CIA Component III must be conducted by the department / faculty concerned at a suitable computer centres.
4. The 10 marks of PART-A of Mid-Semester and End-Semester Tests will comprise only: OBJECTIVE MULTIPLE CHOICE QUESTIONS; TRUE / FALSE; and FILL-IN BLANKS.
5. The number of hours for the 5 marks allotted for Library Referencing/ work would be 30 hours per semester. The marks scored out of 5 will be given to all the courses (Courses) of the Semester.
6. English Composition once a fortnight will form one of the components for UG General English

SEMESTER EXAMINATION

Testing with Objective and Descriptive questions

Part-A: Objective MCQs only (30 Marks)

Answers are to be marked on OMR score-sheet. The OMR score-sheets will be supplied along with the Main Answer Book. 40 minutes after the start of the examination the OMR score-sheets will be collected

Part-B & C: Descriptive (70 Marks)

Part-B: 5 x 5 = 25 marks; inbuilt choice;

Part-C: 3 x 15 = 45 marks; 3 out of 5 questions, open choice.

The Accounts Paper of Commerce will have

Part-A: Objective = 25 marks

Part-B: 25 x 3 = 75 marks

Duration of Examination must be rational; proportional to teaching hours 90 minute-examination / 50 Marks for courses of 2/3 hours/week (all Part IV UG Courses) 3-hours examination for courses of 4-6 hours/week.

GRADING SYSTEM

1. Grading

Once the marks of the CIA and the end-semester examination for each of the courses are available, they will be added. The marks thus obtained, will then be graded as per the scheme provided in the following Table-1.

From the second semester onwards, the total performance within a semester and the continuous performance starting from the first semester are indicated by Semester **Grade Point Average (GPA)** and **Cumulative Grade Point Average (CGPA)** respectively. These two are calculated by the following formulae:

GPA = $\frac{\sum_{i=1}^{n} C_i G_i}{\sum_{i=1}^{n} C_i}$ **WAM** (Weighted Averag Marks) = $\frac{\sum_{i=1}^{n} C_i M_i}{\sum_{i=1}^{n} C_i}$

where,

'C_i' is the Credit earned for the Course-*i,*
'G_i' is the Grade Point obtained by the student for the Course '*i*',
'M' is the marks obtained for the course '*i*', and
'*n*' is the number of Courses **Passed** in that semester.

CGPA: Average GPA of all the Courses starting from the first semester to the current semester.

2. Classification of Final Results

i) The classification of final results shall be based on the CGPA, as indicated in the following Table-2.

ii) For the purpose of Classification of Final Results, the candidates who earn the CGPA 9.00 and above shall be declared to have qualified for the Degree as 'Outstanding'. Similarly, the candidates who earn the CGPA between 8.00 and 8.99, 7.00 and 7.99, 6.00 and 6.99, and 5.00 and 5.99 shall be declared to have qualified for their Degree in the respective programmes as 'Excellent', 'Very Good', 'Good', and 'Above Average' respectively.

iii) Absence from an examination shall not be taken as an attempt.

Table-1: Grading of the Courses

Marks Range	Grade Point	Corresponding Grade
90 and above	10	O
80 and above but below 90	9	A+
70 and above but below 80	8	A
60 and above but below 70	7	B+
50 and above but below 60	6	B
Below 50	NA	RA

Table-2: Final Result

CGPA	Classification of Final Results	Corresponding Grade
9.00 and above	O	Outstanding
8.00 to 8.99	A+	Excellent
7.00 to 7.99	A	Very Good
6.00 to 6.99	B+	Good
5.00 to 5.99	B	Above Average
Below 5.00	RA	Re-appearance

Credit based weighted Mark System is to be adopted for individual semesters and cumulative semesters in the column 'Marks Secured' (for 100).
A Pass in Outreach Programme (SHEPHERD) will continue to be mandatory although the marks will not count for the calculation of the CGPA.

Declaration of Result:

Mr./Ms. _____ has successfully completed the Post Graduate in _____ programme. The candidate's Cumulative Grade Point Average (CGPA) is _____ and the class secured _____ by completing the minimum of 110 credits.
The candidate has also acquired _____ (if any) extra credits offered by the parent department courses.

M. Sc. PHYSICS
Course Pattern - 2018 Set

Sem.	Code	Course	Hr	Cr
I	18PPH1101	Core 1: Classical Mechanics	6	6
	18PPH1102	Core 2: Mathematical Physics	6	6
	18PPH1103	Core 3: Analog and Digital Electronics	6	6
	18PPH1104	Core 4: Physics Practical-I	4+4	4
	18PPH1301	IDC-1 (WS): Physics for Competitive Examinations	4	4
	18PPH1401	Extra Credit Course-I: (MOOC) Medical Physics	-	(2)
		Total for Semester-I	**30**	**26**
II	18PPH2105	Core 5: Quantum Mechanics	6	6
	18PPH2106	Core 6: Electromagnetic theory	6	6
	18PPH2107	Core 7: Condensed Matter Physics	6	6
	18PPH2108	Core 8: Physics Practical-II	4+4	4
	18PPH2109A	Self-paced Learning: Physics of Thin Film & Crystal Growth*	-	2
	18PPH2109B	Self-paced Learning: Ultrasonics – Fundamentals, Sources, Measurement & Applications		
	18PSS2301	IDC-2: Soft Skills	4	4
		Total for Semester-II	**30**	**28**
III	18PPH3110	Core 9: Statistical Mechanics and Thermodynamics	4	4
	18PPH3111	Core 10: Physics Practical-III	4+4	4
	18PPH3201A	Core Elective-1A: Material Science-I (or)	4	4
	18PPH3201B	Core Elective-1B: Mathematical Methods of Computational Physics		
	18SPS3101A	Interdisciplinary Core: Spectroscopy and Statistical Thermodynamics	6	5
	18SPS3101B	Interdisciplinary Core: Spectroscopy **		
	18SPS3101C	Interdisciplinary Core: Sensors and Transducers		
	18PPH3202A	Core Elective-2A: Advanced Instrumentation Techniques (or)	4	4
	18PPH3202B	Core Elective-2B: Programming using Python		
	18PPH3302	IDC-3(BS): Modern Photography	4	4
	18PPH3402	Extra Credit Course-II: (MOOC) Fiber Optic Communication	-	(2)
		Total for Semester-III	**30**	**25**
IV	18PPH4112	Core 11: Nuclear, Particle and Radio Astronomy	6	6
	18PPH4113	Core 12: Design of Microcontroller and Arduino Physics Instruments	6	6
	18PPH4114	Core 13: Physics Practical IV	4+4	4
	18PPH4115	Comprehensive Examination	-	2
	18PPH4116	Project Work	6	4
	18PPH4203A	Core Elective 3A: Material Science-II (or)	4	4
	18PPH4203B	Core Elective 3B: Advanced Quantum Mechanics		
		Total for Semester-IV	30	26
I-IV	16PCW4501	Outreach Programme (SHEPHERD)	-	5
		Total for All Semesters	**120**	**110**

** Intellectual resources will be shared among Chemistry, Electronics and Physics Departments
WS – IDC within School
BS – IDC between Schools
#Elective - Specialization 1A and 3A / 1B and 3B
*Elective - Extension 2A or 2B
$ OOC techniques applied

Programme Outcomes (POs):

1. Graduates are prepared to be creators of new knowledge leading to innovation and **entrepreneurship employable** in various sectors such as private, government, and research organizations.
2. Graduates are trained to evolve new technologies in their own discipline.
3. Graduates are groomed to engage in lifelong learning process by exploring their knowledge independently.
4. Graduates are framed to design and conduct experiments /demos/create models to analyze and interpret data.
5. Graduates ought to have the ability of effectively communicating the findings of Biological sciences incorporating with existing knowledge.

Programme Specific Outcomes (PSOs):

1. Research – Acquire recent knowledge towards research
2. Entrepreneurship and Employability
3. Exploring problem solving
4. Adopt new technology
5. Projects and model design
6. Effective communicating the findings
7. Experimental skill
8. Higher Education towards social relavent.

_____

Semester I **Hours/Week: 6**
18PPH1101 **Credits : 6**

CLASSICAL MECHANICS

Course Outcomes:

1. Acquire knowledge about conservation laws and constraints.
2. Apply Lagrangian formulation to solve problems in mechanics
3. Acquire knowledge about central force problem
4. Understand Kepler problem
5. Acquire knowledge about Hamilton's formulation
6. Apply Hamilton's formulation to solve problems in mechanics
7. Acquire knowledge to derive Euler's equations and to apply them for rigid body dynamics
8. Understand the concepts of relativistic mechanics

Unit-I: FUNDAMENTAL PRINCIPLES AND LAGRANGIAN FORMULATION (15 hr)

Mechanics of a particle and system of particles - conservation laws - constraints - generalized coordinates - D'Alembert's principle and Lagrange's equation- applications –Lagrangian formulation - Lagrange's equations in presence of non-conservative Forces-Generalized potential-Hamilton's principle - Calculus of Variations-Lagrange's equation of motion from Hamilton's principle - conservation theorems and symmetry properties.

Unit-II: TWO-BODY CENTRAL FORCE PROBLEMS (15 hr)

Reduction to equivalent one- body central force Problem-Equations of motion and first integrals - The equivalent one - dimensional problem and classification of orbits- The Kepler problem: Inverse square law of force-The Laplace - Runge - Lenz Vector - Scattering in a central force field - Scattering in laboratory and centre of mass frames.

Unit-III: HAMILTON'S FORMULATION (15 hr)

Cyclic coordinates -Hamiltonian- Hamilton's canonical equations of motion - Physical significance of H-Hamilton equations from variational principle - Δ-variation-Principle of least action-other forms of the action principle.

Canonical transformations - The Harmonic oscillator-Infinitesimal constant transformations- Lagrange and Poisson brackets - Hamilton - Jacobi method - Action angle variables - Kepler problem in action angle variables.

Unit-IV: RIGID BODY DYNAMICS & OSCILLATORY MOTION (15 hr)

Euler angles - Euler's theorem on the motion of the rigid body-Infinitesimal rotations-rate of change of vector - Moments and Products of inertia - Euler's

equations-symmetrical top - applications - theory of small oscillations and normal modes - frequencies of free vibration and normal coordinates - Linear tri-atomicmolecule.

Unit-V: RELATIVISTIC MECHANICS (15 hr)

Algebra of tensors - quotient law - fundamental tensor - Cartesian tensors - Basic postulates of special theory of relativity - Lorentz transformations in real four dimensional spaces- Covariant four dimensional formulations - force and energy equations in relativistic mechanics - Lagrangian and Hamiltonian formulation of relativistic mechanics.

Books for Study:

1. Herbert Goldstein, Charles P. Poole, John L. Safko, Classical Mechanics, 3rd Edition, Pearson Education, 2002.
2. Gupta, Kumar, Sharma, Classical Mechanics, Pragathi Prakashan Publications, 27th edition, 2012. (for problems)
3. J.C. Upadhyaya, Classical Mechanics, Himalaya publishing house, 2nd revised edition (re-print),2017(for problems)
4. Dr. Surekha Tomar, CCIR-UGC NET/JRF, Upkar Prakshan, 3rd edition (for problems)

Unit	Book	Sections
I	1 3	1.1 -1.4, 1.6, 2.1- 2.3, 2.6 2.9,2.10
II	1	3.1-3.3, 3.7, 3.9, 3.10,3.11
III	1 2 3	8.2, 8.5,9.1, 9.2,9.3, 9.5, 9.6, 9.7,10.1, 10.6, 10.7,10.8 3.1,3.3,3.5,3.20 5.10,5.11,5.12
IV	1	4.4,4.6,4.8,4.9, 5.3, 5.5, 5.7, 6.1- 6.4
V	1 2	5.2, 7.4, 7.5 7.1, 7.2,7.3-7.6

Books for Reference:

1. Rana, N.C. and Joag, P. S.: Classical Mechanics, (New Delhi, Tata McGraw Hill, 1998) (Units I, II &III).
2. Madhumangal Pal, A course on Classical Mechanics, Narosa Publishing House, New Delhi, 2009.
3. Joshi, AW, Matrices & Tensors in Physics. New Age International Publications third edition, 2010

Relationship Matrix for Course Outcomes, Programme Outcomes and Programme Specific Outcomes

Semester I	Code 18PPH1101				Title of the Paper CLASSICAL MECHANICS								Hours 6	Credits 6
Course Outcomes (COs)	Programme Outcomes (POs)					Programme Specific Outcomes (PSOs)								Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO1	4	5	4	4	4	5	2	4	3	4	3	1	4	3.65
CO2	4	4	4	4	3	5	2	4	4	4	4	1	4	3.61
CO3	4	4	4	4	4	3	2	3	4	4	4	3	4	3.61
CO4	4	3	4	4	5	4	2	3	4	3	4	1	4	3.46
CO5	4	4	4	3	4	4	3	3	3	3	3	4	4	3.53
CO6	4	4	4	3	3	3	3	3	3	4	4	1	4	3.30
CO7	4	3	4	4	4	3	3	4	5	3	4	4	4	3.76
CO8	3	4	3	3	3	3	3	3	3	3	3	4	4	3.23
													Overall Mean Score for COs	**3.51**

Result: The Score for this Course is 3.5 (High Relationship)

Note:

Mapping	1-20%	21-40%	41-60%	61-80%	81-100%
Scale	1	2	3	4	5
Relation	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0
Quality	Very poor	Poor	Moderate	High	Very High

Values Scaling:

Mean Score of COs = $\frac{\text{Total of Values}}{\text{Total No.of POs \& PSOs}}$	**Mean Overall Score for COs** = $\frac{\text{Total of Mean Scores}}{\text{Total No. of COs}}$

Semester I **Hours/Week: 6**
18PPH1102 **Credits : 6**

MATHEMATICAL PHYSICS

Course Outcomes:

1. Understand the methods and solutions of special functions and differential equations.
2. Acquire knowledge about Fourier and Laplace transforms
3. Solve physical problems using Fourier series, Fourier and Laplace transforms
4. Understand the concept of Data interpretation and error analysis
5. Acquire knowledge about Binomial, Poisson and Gaussian distributions.
6. Understand the concept of complex analysis and various theorems.
7. Acquire skill to solve physics problems using complex analysis.
8. Acquire skill to solve the problems in Quantum mechanics using Mathematical tools.

Unit-I: SPECIAL FUNCTIONS (15 hr)

Gamma and Beta functions – properties and their basic relations, DE and series solution of Legendre and Hermite – their polynomial, Rodrique's formula, generating function – recurrent – recurrent relation – orthogonality relations.

Unit-II: TRANSFORMS (15 hr)

Fourier series: Dirichlet's condition – determination of coefficient – function having arbitrary period – Fourier series for square wave and half wave.

Fourier Transform: FT of a time dependent function – some important theorems: Paraseval's, linearity, derivatives, shifting of origin and convolution use of FT in solving partial differential equation for heat conduction.

Laplace transform: Theorems – inverse transform – solution to ordinary differential equations – solving equations for LCR circuit.

Unit-III: STATISTICS AND PROBABILITY (15 hr)

Data interpretation and analysis – Precision and accuracy, Error analysis, propagation of errors - Central tendency theorem – chi square fit.

Fundamental laws of probability – discrete probability distribution – continuous distribution- expectations – moments and standard deviations- Binomial distribution- Poisson distribution – Gaussian distribution (normal).

Unit-IV: COMPLEX ANALYSIS (15 hr)

Cauchy – Riemann conditions – Cauchy's integral theorem - applications to multiply connected region – Cauchy's II integral theorem – derivatives of analytic Complex function – Singular points and their classification – Laurent series – Cauchy's residue theorem – calculation of residue at a point – evolution of definite integrals : (i) around the unit circle, (ii) around a semicircular contour, and (iii) integral of the form

Unit-V: MATHEMATICAL TOOLS OF THEORETICAL PHYSICS (15 hr)

The Hilbert space and wave functions – Dirac Notation – Operators: Hermitian, Projection, commutator Algebra, Uncertainty Relation between 2 operators, Functions of operators, Eigenvalues and eigenvectors of an operator, Infinitesimal and finite unitary Transformations.

Representation in Discrete bases: Matrix representation of Kets, Bras and Operators, change of bases and unitary transformations, Matrix representation of the eigenvalues problems.

Representation in Continuous bases: General treatment, position – momentum – connection representations.

Books for Study:

1. Mathematical Physics, H.K Dass and Rama Verma, S.Chand publications (2011 edition).India.
2. Mathematical Physics, Sathya Prakash, Sultan Chand & sons Publications, 2014 edition.
3. Mathematical Methods for Engineers and Physicists, AK Mukhopadhyay, Wheeler Pub, New Delhi,1998.
4. Quantum Mechanics: Concepts and Applications, NouredineZettile, 2/e, John Wiley & Sons, UK, 2009.

Unit	Book	Chapter	SECTIONS
I	1	9,28 &30	9.1, -9.8, 28.1-28.9, 30.1-30.5.
II	1	11,45,46 & 47	11.1-11.4, 11.6, 11.7, 11.10-11.13, 45.6-45.12, 46.1-46.12, 44.14, 47.1-47.6, 47.8, 47.9, 47.12, 47.13
III	2	11	11.25, 11.5, 11.6, 11.10-11.15, 11.19-11.22.
IV	3	14	14.2 – 14.5
V	4	2	2.1 – 2.10

Books for Reference:

1. Special Functions for Engineers and Scientists, Bell W & Van Dale, Nostrand Company Ltd., 1969.
2. Arfken& Weber, Mathematical Methods for Physicists, Academic Press, 6/e, 2009.
3. AK Ghatak, IC Goyal& ST Chua, Mathematical Physics, Macmillan, India, 1985.
4. WWBell, Special Functions for Scientists and Engineers, Dover Pub, 2004.

Relationship Matrix for Course Outcomes, Programme Outcomes and Programme Specific Outcomes

Semester I	Code 18PPH1102					Title of the Paper MATHEMATICAL PHYSICS								Hours 6	Credits 6
Course Outcomes (COs)	Programme Outcomes (POs)					Programme Specific Outcomes (PSOs)								Mean Score of COs	
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8		
CO1	5	4	4	4	4	5	2	4	3	4	3	1	4	3.61	
CO2	4	4	4	4	3	5	2	4	4	4	4	1	4	3.61	
CO3	4	4	4	4	4	3	2	3	4	4	4	3	4	3.61	
CO4	4	3	4	4	5	4	2	3	4	3	4	1	4	3.46	
CO5	4	4	4	4	3	4	3	3	3	3	3	4	4	3.53	
CO6	4	4	4	3	3	3	3	3	3	4	4	1	4	3.30	
CO7	4	3	4	4	4	3	3	4	5	3	4	4	4	3.76	
CO8	3	4	3	3	3	3	3	3	3	3	3	4	4	3.23	
										Overall Mean Score for COs				**3.51**	

Result: The Score for this Course is 3.5 (High Relationship)

Note:

Mapping	**1-20%**	**21-40%**	**41-60%**	**61-80%**	**81-100%**
Scale	**1**	**2**	**3**	**4**	**5**
Relation	**0.0-1.0**	**1.1-2.0**	**2.1-3.0**	**3.1-4.0**	**4.1-5.0**
Quality	**Very poor**	**Poor**	**Moderate**	**High**	**Very High**

Values Scaling:

Mean Score of COs = $\frac{\text{Total of Values}}{\text{Total No.of POs \& PSOs}}$	**Mean Overall Score for COs** = $\frac{\text{Total of Mean Scores}}{\text{Total No. of COs}}$

Semester I **Hours/Week: 6**
18PPH1103 **Credits : 6**

ANALOG AND DIGITAL ELECTRONICS

Course Outcomes:

1. Acquire knowledge about analog and digital electronic devices and circuits.
2. Acquire knowledge about sensors and transducers
3. Apply circuit theory to design analog and digital circuits
4. Design op-amp circuits
5. Understand analog and digital signals and conversion techniques
6. Design timing circuits
7. Analyse and design combinational logic circuits
8. Analyse and design sequential logic circuits

Unit-I: SPECIAL DEVICES, SENSORS AND TRANSDUCERS (15 hr)

Device construction and characteristics: MOSFET, UJT, Gunn diode, IMPATT diode, SCR - Optoelectronic devices: Solar cells, photo-detectors, and OLEDs Sensors and transducers: temperature, pressure, sound, magnetic field, motion, flow– measurement and control.

Unit-II: ELECTRONIC CIRCUITS (15 hr)

Transistor amplifier – Miller's Theorem – Hybrid –pi common emitter transistor model – hybrid II conductance, capacitance –cascaded CE transistor amplifier High frequency analysis –Early Effect - Gummel Plots – Transistor switching circuit – 555 Timer – applications

Unit-III: OP-AMP AND ITS APPLICATIONS (15 hr)

Operational amplifiers –Analog computation – Design of Op-Amp Low pass, High pass and Band pass active filter (first order only) – comparators- sample and hold circuits- logarithmic amplifiers – signal conditioning - instrumentation amplifier– Wave form generators: Phase shift and Wein's Bridge Oscillator – Schmitt trigger –V to I and I to V converter- DAC - design of Binary weighted and R-2R ladder – ADC single, dual slope – SAR method

Unit-IV: COMBINATIONAL CIRCUIT DESIGN (15 hr)

Analysis of Combinational logic circuits–synthesis of Combinational logic circuits – Quine-McCluskey minimization method – Petrick's Algorithm - Encoder and Decoder design – Multiplexer and demultiplexer design - adder and subtracterdesign – digital comparator - PROM –RAM.

Unit-V: SEQUENTIAL CIRCUIT DESIGN (15 hr)

Models for sequential Circuits – synchronous sequential circuit models - sequential circuit Analysis - synchronous sequential circuit synthesis –

state assignment and circuit realization – redundant states – state reduction in completely and incompletely specified circuits - types of Asynchronous circuits – analysis and synthesis of pulse-mode Asynchronous circuits - analysis and synthesis of fundamental-mode Asynchronous circuits

Books for Study:

1. Electronic Devices and Circuit Theory, Robert Boylestad and Louis Nashelsky, Prentice Hall New Jersey, seventh edition
2. Integrated Electronics, Millmanand, Halkies, TATA McGraw Hill, 1972
3. Digital logic circuit analysis and design, Victor P. Nelson, Prentice Hall, 1995

Unit	Book	Chapter	SECTIONS
I	1	5, 20, 21	5.7, 5.8, 21.13, 21.3, 21.4, 20.10
II	2	5, 8, 11 & 12	5.3, 8.11, 11.1, 11.2, 11.3, 12.10,
III	2	15 & 16	15.1, 16.5, 16.6, 16.7, 16.11, 16.12, 16.14, 16.15, 16.16,
IV	3	2, 3, 4 & 5	2.4, 2.5, 3.9, 3.10, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 5.4,
V	3	6, 8, 9 & 10	6.1, 8.1, 8.2, 8.3, 8.4, 9.1, 9.2, 9.3, 10.1, 10.2, 10.3, 10.4, 10.5

Books for Reference:

1. Digital Integrated Circuit Design, Hubert Kaeslin, Cambridge University Press
2. Boylestad," Electronic Devices and Circuit Theory", Pearson
3. Muhammad H. Rashid, "Microelectronics Circuits Analysis and Design", Cengage
4. S. Salivahanan, N. Suresh Kumar,"Electronic Devices and Circuits", Tata McGraw Hill,
5. Adel S. Sedra, Kenneth C. Smith and Arun N Chandorkar," Microelectronic Circuits Theory and Applications", International Version, OXFORD International Students Edition, Fifth Edition.
6. Donald A. Neamen, "Electronic Circuit Analysis and Design", TATA McGraw Hill, 2nd Edition

Web Resources:

1. http://www.analog.com/en/education/education-library/tutorials/analog-electronics.html
2. https://www.tutorialspoint.com/digital_electronics/index.asp

Relationship Matrix for Course Outcomes, Programme Outcomes and Programme Specific Outcomes

Semester I	Code 18PPH1103					Title of the Paper ANALOG AND DIGITAL ELECTRONICS								Hours 6	Credits 6
Course Outcomes (COs)	Programme Outcomes (POs)					Programme Specific Outcomes (PSOs)								Mean Score of COs	
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8		
CO1	5	5	4	5	4	5	5	4	5	4	4	5	5		4.62
CO2	5	4	5	4	4	5	4	4	5	4	4	5	5		4.46
CO3	5	4	4	4	4	5	4	4	4	4	4	4	4		4.15
CO4	5	4	4	5	5	5	5	4	5	5	4	5	4		4.38
CO5	5	4	5	4	4	4	4	4	5	5	5	4	4		4.38
CO6	5	5	4	4	4	5	4	4	4	4	4	5	5		4.38
CO7	5	4	4	5	4	5	4	4	4	5	5	4	5		4.46
CO8	5	4	5	5	4	4	4	4	4	5	5	4	4		4.38
									Overall Mean Score for COs						4.40

Result: The Score for this Course is 4.4 (Very High Relationship)

Note:

Mapping	1-20%	21-40%	41-60%	61-80%	81-100%
Scale	1	2	3	4	5
Relation	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0
Quality	Very poor	Poor	Moderate	High	Very High

Values Scaling:

$$\text{Mean Score of COs} = \frac{\text{Total of Values}}{\text{Total No. of POs \& PSOs}} \qquad \text{Mean Overall Score for COs} = \frac{\text{Total of Mean Scores}}{\text{Total No. of COs}}$$

Semester I **Hours/Week: 8**
18PPH1104 **Credits : 4**

PHYSICS PRACTICAL - I

Any 15 Experiments:

1. Absorption Spectrum of Iodine
2. Susceptibility - Quincke's method and Guoy's method
3. e/m Magnetron and thermionic Work function
4. Dielectric Constant Study and determination of curie temperature - Solid, Liquid (kit)
5. Hall effect in semiconductor
6. Elastic Constants – Elliptic fringes
7. Laser – I: numerical aperture, spot size, absorption coefficient and wave length
8. Planck's constant and Photo sensitive devices
9. Ultrasonic interferometer – velocity and compressibility
10. Electro optic modulation – depth of modulation, frequency range, voltage range
11. Determination of Stefan's constant
12. Characteristics of torque transducer
13. Calibration of thermistor – different range
14. Verification of Norton's, Thevenin's and Max power theorem
15. MOSFET characteristics, amplifier design and switching application
16. UJT – Characteristics and Applications
17. K- map simplification – implementation of logic functions using basic and universal gates by SOP & POS
18. ALU and Scalar
19. Op-amp: I to V, V to I and Square wave
20. Op-amp – design of Instrumentation amplifier
21. 555 – monostable, bistable, Astable and its applications (kit)
22. Temperature coefficient using 555 timer
23. Phase shift and Wien's Bridge Oscillator: Op-amp
24. Computational experiment: Experimental statistics, error analysis – Iodine absorption spectrum
25. Computational experiment: Lagrange interpolation and extrapolation
26. Computational experiment: Binding energy calculation for different mass numbers.

Semester I **Hours/Week: 4**
18PPH1301 **Credits : 4**

PHYSICS FOR COMPETITIVE EXAMINATIONS

Course Outcomes:

1. Understand the principle of mechanics, properties of matter, heat and thermodynamics, light, sound, electricity, magnetism and electronics.
2. Analyze, understand and solve the problems in heat and thermodynamics.
3. Apply the fundamental principles of light and light wave to solve the problems
4. Understand laws and solve the problems in electricity and magnetism and basics of electronics.
5. Explore the problems in physics and apply the laws to solve it.
6. Apply the principles and laws of physics and solve the problems in competitive exams.

Unit-I: GENERAL MECHANICS AND PROPERTIES OF MATTER

Physical quantities - SI system of units, Dimensions, Scalars and Vectors (Concepts), Newton's Equations of Motion, impulse, Principle of conservation of Linear momentum, Projectiles, Kepler's Laws, Newton's Law of Gravitation, acceleration due to gravity, Escape velocity, Angular momentum, banking of roads, simple harmonic motion, Viscosity, Surface Tension

Unit-II: HEAT AND THERMODYNAMICS

Different scales of temperatures, thermal expansions, Calorimetry – specific heat, latent heat, triple point, transmission of heat, heat conductivity, Black bodies, Stefan Boltzmann Law, Wien's Displacement Law, Gas Equation, Boyle's Law, Charle's Law, Law of equipartition of energy

Unit-III: LIGHT AND SOUND

Reflection, Refraction and total internal reflection of light and their applications, propagation of light, Refractive index, Prism, Lenses, mirrors, Aberration in Lenses, Optical instruments – microscopes, telescopes, binoculars, Defects of Human Eye Wave motion, longitudinal and Transverse waves, velocity of sound- Newton's formula, Laplace correction, effects of pressure - beats, laws of vibrating strings, open and closed organ pipes, Resonance

Unit-IV: ELECTRICITY AND MAGNETISM

Electric charge, field, potential, Resistances, Capacitance, cells and their combinations, Kirchoff's laws, Ohm's law, Faraday's laws, Lenz's law, Galvanometer, Voltmeter, Ammeter, Current Electricity. Earth's Magnetism, bar magnet, Magnetic moment, Magnetic field, magnetic substances, torque of a bar magnet placed in a magnetid field, electromagnet.

Unit-V: MODERN PHYSICS AND ELECTRONICS

Bohr's theory, H spectrum, Nuclear Physics, Binding Energy, X – rays, Alpha, Beta and Gamma rays, Einstein's photo electric effect and mass-energy relations Semi-conductors, Diodes, Transistors, Rectifiers, Amplifiers, Oscillators, Boolean Algebra, Logic gates, Electronics in Communication.

BOOK FOR STUDY: Physics for Competitive Exams - Department of Physics, St. Joseph's College, Tiruchirappalli-2

Relationship Matrix for Course Outcomes, Programme Outcomes and Programme Specific Outcomes

Semester I	Code 18PPH1301	Title of the Paper IDC-1 (WS): PHYSICS FOR COMPETITIVE EXAMINATIONS											Hours 4	Credits 4
Course Outcomes (COs)	Programme Outcomes (POs)					Programme Specific Outcomes (PSOs)							Mean Score of COs	
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO1	4	4	4	4	4	4	5	4	3	3	3	3	4	3.77
CO2	4	4	4	4	4	4	3	3	4	4	3	3	4	3.69
CO3	5	4	5	4	4	4	3	4	4	3	4	3	4	3.92
CO4	4	5	4	4	5	4	3	3	3	4	3	4	4	3.85
CO5	4	3	5	4	4	5	4	4	5	3	3	4	4	4.00
CO6	5	5	4	5	5	3	3	4	4	5	5	5	4	4.38
Overall Mean Score for COs														3.92

Result: The Score for this Course is 3.9 (High Relationship)

Note:

Mapping	1-20%	21-40%	41-60%	61-80%	81-100%
Scale	1	2	3	4	5
Relation	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0
Quality	Very poor	Poor	Moderate	High	Very High

Values Scaling:

$$\text{Mean Score of COs} = \frac{\text{Total of Values}}{\text{Total No. of POs \& PSOs}} \qquad \text{Mean Overall Score for COs} = \frac{\text{Total of Mean Scores}}{\text{Total No. of COs}}$$

Semester I **Hours/Week: -**
18PPH1401 **Credits : 2**

Extra Credit Course:
MEDICAL PHYSICS

Course Outcomes:

1. The concept of forces, pressure and the importance of temperature in human body
2. The physics principles involved in respiration and cardiovascular system
3. How the electric signals generate in human body and the working of EMG and ECG.
4. The application of sound and light in medicine and medical imaging.
5. The use of X-rays and radioactivity for diagnosis and treatment.

Unit-I: MECHANICS OF HUMAN BODY (12 hr)

Static, Dynamic and Frictional forces in the Body – Composition, properties and functions of Bone – Heat and Temperature – Temperature scales – Clinical thermometer – thermography – Heat therapy – Cryogenics in medicine – Heat losses from body – Pressure in the Body – Pressure in skull, Eye and Urinary Bladder.

Unit-II: PHYSICS OF RESPIRATORY & CARDIOVASCULAR SYSTEM (12 hr)

Body as a machine – Airways – Blood and Lungs interactions – Measurement of Lung volume – Structure and Physics of Alveoli – Breathing mechanism – Airway resistance – Components and functions of cardiovascular systems – work done by heart – components and flow of Blood – Laminar and Turbulent flow – blood Pressure – direct and indirect method of measuring – Heart sounds.

Unit-III: ELECTRICITY IN THE BODY (12 hr)

Nervous system and Neuron – Electrical potentials of Nerves – Electric signals from Muscles, Eye and Heart – Block diagram and working to record EMG – Normal ECG wave form – Electrodes for ECG – Amplifier and Recording device – Block diagram and working to record ECG – Patient monitoring – Pace maker.

Unit-IV: SOUND AND LIGHT IN MEDICINE (12 hr)

General properties of sound – Stethoscope – Generation,detection and characteristics of Ultrasound – Ultrasound imaging technique – A scan and B scan methods of ultrasound imaging – properties of light – Applications

of visible UV,IR light, and Lasers in medicine – Microscope – Eye as an optical system- Elements of the Eye – Ophthalmology instruments .

Unit-V: DIAGNOSTIC X-RAYS AND NUCLEAR MEDICINE (12 hr)

Production and properties of X- rays – Basic Diagnostic X-ray Machine – X-ray image - Live Xray image –X-ray computed Tomography – Characteristics of Radio activity- Radioisotopes and Radio nuclides – Radioactivity sources for nuclear medicine – Basic instrumentation and clinical applications - Principles of Radiation Theraphy- Nuclear medicine imaging devices – Radiation sources

Book for Study:

1. Medical Physics by Department of Physics, St.Joseph's College, Trichy.

Books for Reference:

1. John R. Cameron and James G. Skofronick, John Wiley &Sons –Medical Physics, Wiley – Interscience Publications, 1978.
2. R.S.Khandpur – Handbook of Biomedical Instrumentation, Tata McGraw Hill Publication Co., Delhi,1987.

Relationship Matrix for Course Outcomes, Programme Outcomes and Programme Specific Outcomes

Semester I	Code 18PPH1401				Title of the Paper Extra Credit Course: MEDICAL PHYSICS								Hours -	Credits 2
Course Outcomes (COs)	Programme Outcomes (POs)					Programme Specific Outcomes (PSOs)								Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO1	4	4	4	4	4	2	5	4	3	3	3	2	4	3.54
CO2	4	3	4	3	3	5	2	4	4	2	4	3	4	3.46
CO3	4	4	4	4	3	2	3	3	2	4	3	3	4	3.30
CO4	3	4	4	4	4	4	3	3	4	3	4	1	4	3.46
CO5	4	3	4	4	3	4	3	3	3	3	3	4	4	3.46
CO6	4	4	4	3	5	3	3	3	3	4	4	1	4	3.46
Overall Mean Score for COs														3.44

Result: The Score for this Course is 3.44 (High Relationship)

Note:

Mapping	1-20%	21-40%	41-60%	61-80%	81-100%
Scale	1	2	3	4	5
Relation	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0
Quality	Very poor	Poor	Moderate	High	Very High

***Values Scaling*:**

Mean Score of COs = $\frac{\text{Total of Values}}{\text{Total No.of POs \& PSOs}}$	**Mean Overall Score for COs** = $\frac{\text{Total of Mean Scores}}{\text{Total No. of COs}}$

Semester II **Hours/Week: 6**
18PPH2105 **Credits : 6**

QUANTUM MECHANICS

Course Outcomes:

1. Acquire conceptual knowledge in learning QM through Dirac's Matrix Formalism an alternate approach of Schrodinger's Differential Equation Formalism
2. Understand the techniques of Operators; Eigen values & Eigen Functions; Degenerate & Non-degenerate Systems; the Theorems & Postulates used in QM
3. Analyze the differences, implications and descriptions of micro physical world from macro physical world under different potentials and scaling
4. Apply the same formalism to understand the time independent, time dependent conservative hard core physical problem which includes the orbital, spin, total angular momenta and iso-spin
5. Apply integral / residual approach to simple problems using Variational Principle, JWKB Approximations for degenerate and degenerate cases
6. Apply the theory of perturbation for the transition probability between states under different situations and the interaction with field
7. Compute to systems of similar nature through solving them with appropriate techniques
8. Acquire the required skill with necessary intricacies to attempt and compete in the Competitive Examinations

Unit-I: POSTULATES OF QUANTUM MECHANICS (15 hr)

The Basic postulates of Quantum Mechanics (QM) – The state of a system – observables and operators – Measurement in QM : how measurements disturb systems – Expectation values – CSCO – measurement and the uncertainty relation; Time Evolution of the system's state: time evolution operator – stationary states – Schrodinger equation and wave pockets – conservation of probability – time evaluation of expectation values; Symmetries and conservation laws; Connecting Quantum Mechanics to Classical Mechanics.

Unit-II: ONE AND THREE DIMENSIONAL PROBLEMS (15 hr)

Properties of 1D motions: Bound, unbound states, mixed spectrum – symmetric potential and parity; the free particle continuous states – the potential step; the potential barrier & well : E>Vo, E < Vo : Tunneling, tunneling effect; the infinite square well potential : Asymmetric square – symmetric ;

the finite square well potential : Scatting solutions (E > Vo), Bound state solution (0 < E < Vo).

Harmonic oscillator: Energy eigenvalues – Energy eigenstates – Matrix representation of various operators – Expectation values of various operators.

3D problems in spherical coordinates: central potential – general treatment, the free particle, spherical square well potential, isotropic harmonic oscillator, the hydrogen atom.

Unit-III: ANGULAR MOMENTUM (15 hr)

General formalism – Matrix and Geometrical representation – Spin Angular momentum: Experimental Evidence of spin, general theory of spin, spin ½ and Pauli Matrices – eigenfunctions of orbital angular momentum: eigenfunctions and eigenvalues of Lz, eigenfunctions of L^2, properties of the spherical harmonics – Rotations in QM: Infinitesimal, finite, properties, Euler rotations; Representation of the Rotation operator, Rotation matrices and spherical harmonics. Addition of Angular Momenta: General formalism, calculation of CG Coefficient, coupling of orbital and spin angular momenta, Addition of more than 2 Angular momenta, Iso-spin.

Unit-IV: APPROXIMATION METHODS FOR STATIONARY STATES (15 hr)

Time independent Perturbation Theory: Non-degenerate, Degenerate, Fine structure and the Anomalous Zeeman effect; The variational method; JWKB method: General formalism, bound states for potential wells with NO and ONE Rigid walls, tunneling through potential barrier.

Unit-V: TIME DEPENDENT PERTURBATION THEORY (15 hr)

The different picture: The Schrodinger – The Heisenberg – The Interaction. Transition probability – Constant and Harmonic perturbation; Adiabatic and sudden approximation; Interaction of 3 atoms with radiations: Quantization of Electro Magnetic field – Transition rates for: Absorption and Emission radiation – within the dipole approximate – Electric dipole selection rules – Spontaneous emission.

Books for Study:

1. Nouredine Zettile, Quantum Mechanics: Concepts and Applications, 2/e, John Wiley & Sons, UK, 2009
2. G. L. Squires, Problems in Quantum mechanics with solutions, Cambridge University Press, 2002. (Only for Tutorial and Self-Study)

Unit	Book	Chapter	SECTIONS
I	1	3	3.1 – 3.10
II	1	4, 6	4.1 – 4.8, 4.10, 4.11; 6.1 – 6.6
III	1	5, 7	5.1 – 5.8; 7.1 – 7.3
IV	1	9	9.1 – 9.7
V	1	10	10.1 – 10.7

Books for Reference

1. AjoyGhatak and S.Lokanathan, Quantum Mechanics :Theory and Applications, Macmillan India Ltd., New Delhi,2007.
2. Quantum Mechanics, Alastair IM Rae, Jim Napolitano, 4thEdn., CRC Press, 2016
3. Richard L Liboff, Introduction to Quantum Mechanics, Pearson Education Ltd., 4/e, 2006.
4. AFJ Levi, Applications of Quantum Mechanics, Cambridge University Press, Delhi, 2009.
5. Thankappan, V.K. –Quantum Mechanics, Wiley Eastern Ltd., New Delhi, 2ndEdn, 1995
6. G. Aruldhas, Quantum Mechanics, Prentice Hall of India, New Delhi, 2003.

Web Resources

1. http://bookboon.com/Introduction to Quantum Mechanics, Intermediate Quantum Mechanics, Chemistry: Quantum Mechanics and Spectroscopy I, Chemistry: Quantum Mechanics and Spectroscopy II
2. https://swayam.gov.in/courses/3485-quantum-chemistry
3. http://freevideolectures.com/Course/2876/Fundamentals-of-Physics-III/19

Relationship Matrix for Course Outcomes, Programme Outcomes and Programme Specific Outcomes

Semester II	Code 18PPH2105				Title of the Paper QUANTUM MECHANICS									Hours 6	Credits 6
Course Outcomes (COs)	Programme Outcomes (POs)					Programme Specific Outcomes (PSOs)								Mean Score of COs	
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8		
CO1	4	5	3	2	2	4	4	4	2	2	2	1	3	2.92	
CO2	4	5	3	2	2	4	5	4	2	4	2	1	3	3.15	
CO3	4	5	3	3	2	3	4	4	4	4	3	1	2	3.23	
CO4	4	5	4	3	2	4	5	4	4	4	2	1	3	3.46	
CO5	4	5	3	3	2	4	4	4	3	4	3	1	3	3.30	
CO6	4	5	3	4	2	4	4	3	3	4	4	1	3	3.38	
CO7	5	5	5	5	5	4	4	4	3	4	3	1	3	3.92	
CO8	5	5	5	5	5	4	4	4	3	5	3	1	3	4.00	
Overall Mean Score for COs														3.42	

Result: The Score for this Course is 3.4 (High Relationship)

Note:

Mapping	1-20%	21-40%	41-60%	61-80%	81-100%
Scale	1	2	3	4	5
Relation	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0
Quality	Very poor	Poor	Moderate	High	Very High

Values Scaling:

Mean Score of COs = $\frac{\text{Total of Values}}{\text{Total No. of POs \& PSOs}}$	**Mean Overall Score for COs** = $\frac{\text{Total of Mean Scores}}{\text{Total No. of COs}}$

Semester II **Hours/Week: 6**
18PPH2106 **Credits : 6**

ELECTROMAGNETIC THEORY

Course Outcomes:

1. Understand the basics of Electrostatics
2. Solve boundary value problems in electrostatics
3. Understand the basics of Magnetostatics
4. Solve problems on magnetic vector potential
5. Acquire knowledge on field equations and conservation laws
6. Analyse the behaviour of EM waves in conducting surface through absorption, dispersion and reflection
7. Acquire the knowledge of the various modes of propagation of EM waves in waveguides
8. Understand the basis of radiation and radiation reaction

UNIT-I: ELECTROSTATICS (15 hr)

Coulomb's law – The electric field – Continuous charge distributions- Field lines, Flux and Gauss's law – The Divergence of E – Applications of Gauss's Law – The curl of E – Electric potential - Poisson's and Laplace Equation - Potential of a localized charge distribution – Electrostatic Boundary conditions –Uniqueness theorems – Method of images – boundary value problems on spherical symmetry, cylindrical symmetry and plane symmetry.

UNIT-II: MAGNETOSTATICS (15 hr)

The Lorentz Force Law – The Biot- Savart Law – The magnetic field of steady current - The Divergence and Curl of B – Applications of Ampere's Law – magnetic potential– from uniform surface current - of a long solenoid - torroidal coil – large parallel plate capacitor – magnetic field inside and outside a cylindrical wire - magnetic field inside and outside the slab - Magnetic vector potential – magnetostatic boundary conditions.

UNIT-III: FIELD EQUATIONS AND CONSERVATION LAWS (15 hr)

Ohm's law -Faraday's law – induced electric field - Inductance – Energy in magnetic fields – Maxwell's equations in free space and linear isotropic media - Boundary conditions on fields at interface- continuity equations – Poynting's theorem - Potential formulation – Lorentz and Coulomb Gauge transformations – retarded potentials

UNIT-IV: ELECTROMAGNETIC WAVES (15 hr)

Waves in one dimension – Reflection, transmission and polarization - The wave equation for E and B – monochromatic plane waves - Energy and

momentum in EM waves – Propagation in linear media – Reflection and transmission at normal and oblique incidence EM waves in conductors – Absorption, dispersion and reflection at a conducting surface

UNIT-V: GUIDED WAVES, RADIATIONAND HIGH FREQUENCY DEVICES (15 hr)

Wave guides -TE and TM waves in a rectangular wave guide – The coaxial transmission line – Electric dipole radiation – Magnetic dipole radiation – power radiated by a point charge – Radiation reaction - radiation damping of a charged particle – Physical basis of the radiation reaction- High frequency devices: Klystron – Gunn diode oscillator

Books for study:

1. David J. Griffiths, Introduction to Electrodynamics, (Pearson, 2018) 4th edition

Electrostatics	1.2 -1.4, 2.1 – 2.4, 3.1, 3.3 -3.5
Potentials	1.5, 1.6, 2.1 -2.4
Magnetostatics	1.1 – 1.3, 2.1, 2.2, 3.1-3.3, 4.1, 4.2
Electrodynamics	1.1, 2.1 - 2.4, 3.3 – 3.6
Conservation Laws	1.1, 1.2
Potentials and Fields	1.1 -1.3, 2.1
Electromagnetic Waves	1.1 – 1.4, 2.1 – 2.3, 3.1 – 3.3, 4.1, 4.2
Electromagnetic Waves	5.1 -5.3
Radiation	1.2,1.3, 2.1-2.3

Books for reference:

1. J.D. Jackson, Classical Electrodynamics, (John Wiley, New York, 1999), 3rd Edition
2. Edward C. Jordan & Keith G. Balmain, Electromagnetic waves and Radiating systems – Second Edition, Prentice Hall of India, New Delhi, 2015
3. DR. SurekaTomar, CSIR – UGC / NET / JRF/SET Physical Sciences, Upkar Prakashan, Agra, 2016.

Relationship Matrix for Course Outcomes, Programme Outcomes and Programme Specific Outcomes

Semester II	Code 18PPH2106					Title of the Paper ELECTROMAGNETIC THEORY								Hours 6	Credits 6
Course Outcomes (COs)	Programme Outcomes (POs)					Programme Specific Outcomes (PSOs)								Mean Score of COs	
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8		
CO1	4	2	5	3	3	4	5	5	2	2	3	1	3		3.23
CO2	4	4	5	3	2	3	4	5	4	4	3	1	2		3.31
CO3	4	5	4	2	2	4	5	5	3	3	4	1	3		3.46
CO4	4	5	3	3	4	4	4	5	2	5	2	1	3		3.62
CO5	5	5	4	5	4	3	4	5	3	4	3	1	2		3.69
CO6	4	5	5	3	3	4	4	5	4	2	3	1	2		3.46
CO7	4	3	5	4	4	3	4	5	3	3	2	1	3		3.31
CO8	5	4	3	4	4	4	4	5	4	3	3	1	3		3.61
													Overall Mean Score for COs		3.46

Result: The Score for this Course is 3.4 (High Relationship)

Note:

Mapping	1-20%	21-40%	41-60%	61-80%	81-100%
Scale	1	2	3	4	5
Relation	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0
Quality	Very poor	Poor	Moderate	High	Very High

Values Scaling:

$$\text{Mean Score of COs} = \frac{\text{Total of Values}}{\text{Total No. of POs \& PSOs}} \qquad \text{Mean Overall Score for COs} = \frac{\text{Total of Mean Scores}}{\text{Total No. of COs}}$$

Semester II **Hours/Week: 6**
18PPH2107 **Credits : 6**

CONDENSED MATTER PHYSICS

Course Outcomes:

1. Acquire knowledge on crystal structure
2. Apply XRD to analyze crystal structure
3. Acquire knowledge about lattice vibrations
4. Understand thermal properties of solids
5. Apply free electron theory for conductivity studies in metals
6. Acquire knowledge about different phenomena of superconductors
7. Understand the properties of semiconductors and dielectrics
8. Acquire knowledge about properties and phase change phenomena in Magnetic materials.

Unit-I: FUNDAMENTALS OF CRYSTAL STRUCTURE AND X-RAY DIFFRACTION (15 hr)

Crystalline and amorphous solids-periodicity in crystal -unit cell -Space lattice-rational features and miller indices–inter planar spacing -packing efficiency of lattices (sc,bcc,fcc)- X-ray diffraction-Laue equations-interpretation of Bragg's equation- Ewald construction-reciprocal lattice-properties of reciprocal lattice- Concept of Brillouin zones - atomic form factor-structure factor -X-ray diffraction experiment-powder method -defects in crystal(zero, one and two dimensional)

Unit-II: LATTICE VIBRATIONS, DIFFUSION AND THERMAL PROPERTIES OF SOLIDS (15 hr)

Dynamics of chain of identical atoms-dynamics of diatomic linear chain-Fick's first and second law of diffusion-diffusion mechanisms-Kirkendall effect-Einstein and Debye density of states - model for specific heat capacity-thermal conductivity of solids-thermal conductivity due to electrons and phonons-thermal resistance of solids- anharmonicity and thermal expansion.

Unit-III: CONDUCTORS AND SUPERCONDUCTORS (15 hr)

Electrical conductivity and ohms law-Wiedemann-Franz –Lorentz law-electrical resistivity of metals-Bloch theorem-nearly free electron model-Fermi surface and Brillouin zones-Characteristics of Fermi surfaces-effect of electric field and magnetic field on Fermi surface-experimental study of Fermi surfaces(anomalous skin effect, cyclotron resonance, de Hass-van Alphen effect)- Meissner effect-thermodynamics of superconducting transitions-

London equations-London penetration depth-coherence length-BCS theory-Josephson effect.

UNIT-IV: SEMICONDUCTORS AND DIELECTRICS (15 hr)

Effective mass – intrinsic carrier concentration - intrinsic mobility - impurity conductivity - thermal ionization of donors and acceptors - thermoelectric effect – polarization - macroscopic electric field - local electric field at an atom - electronic polarizability - classical theory of electronic polarizability - ferroelectric crystal – classification - Piezo electricity.

UNIT-V: MAGNETISM (15 hr)

Langevin diamagnetism equation - quantum theory of diamagnetism - Para magnetism - quantum theory of Para magnetism - Hund rules - crystal field splitting, paramagnetic susceptibility of conduction electrons - ferromagnetic order - temperature dependence of the saturation magnetization - neutron magnetic scattering - ferrimagnetic order - curie temperature and susceptibility of ferrimagnets - antiferro magnetic order - susceptibility below the Neel temperature - ferromagnetic domains - origin of domains - coercivity and hysteresis.

Book for study:

1. Wahab. M.A, Solid State Physics, second edition, Narosa, 2010.
2. Charles Kittel "Introduction to Solid State Physics", 7th edition John Wiley & sons.(2006)
3. SurekhaTomar, CSIR-UGC /JRF/SET Physical Sciences, 3rd Edition (for problems)

Unit	Book	Sections
I	1	1.1-1.3, 1.9-1.11, 3.2, 8.6, 8.7, 8.9-8.16, 5.2, 5.4, 5.12
II	1	7.2, 7.3, 6.2, 6.3, 6.6, 6.8, 9.4 -9.7-9.10, 7.6
III	1	10.11-10.13, 11.1, 11.7, 12.1, 12.2, 12.5-12.9, 17.4, 17.5, 17.8-17.11, 17.13
IV	2	Relevant topics in Chapters 8 and 13
V	2	Relevant topics in Chapters 14 and 15

Relationship Matrix for Course Outcomes, Programme Outcomes and Programme Specific Outcomes

Semester II	Code 18PPH2107				Title of the Paper CONDENSED MATTER PHYSICS									Hours 6	Credits 6
Course Outcomes (COs)	Programme Outcomes (POs)					Programme Specific Outcomes (PSOs)								Mean Score of COs	
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8		
CO1	4	4	4	4	4	5	2	4	3	4	3	1	4	3.58	
CO2	4	4	4	4	3	4	2	4	4	4	4	1	4	3.58	
CO3	4	4	4	4	4	3	2	3	4	4	4	3	4	3.61	
CO4	4	3	4	4	5	4	2	3	4	3	4	1	4	3.46	
CO5	4	4	4	4	3	4	3	3	3	3	3	4	4	3.53	
CO6	4	4	4	3	3	3	3	3	3	4	4	1	4	3.30	
CO7	4	3	4	4	4	3	3	4	5	3	4	4	4	3.76	
CO8	3	4	3	3	3	3	3	3	3	3	3	4	4	3.23	
Overall Mean Score for COs														3.50	

Result: The Score for this Course is 3.5 (High Relationship)

Note:

Mapping	1-20%	21-40%	41-60%	61-80%	81-100%
Scale	**1**	**2**	**3**	**4**	**5**
Relation	**0.0-1.0**	**1.1-2.0**	**2.1-3.0**	**3.1-4.0**	**4.1-5.0**
Quality	**Very poor**	**Poor**	**Moderate**	**High**	**Very High**

Values Scaling:

Mean Score of COs = $\frac{\text{Total of Values}}{\text{Total No. of POs \& PSOs}}$	**Mean Overall Score for COs** = $\frac{\text{Total of Mean Scores}}{\text{Total No. of COs}}$

Semester II | **Hours/Week: 8**

18PPH2108 | **Credits : 4**

PHYSICS PRACTICAL - II

Any 15 Experiments:

1. Michelson Interferometer
2. Biprism – Optic bench
3. Energy Gap study of a semiconductor
4. Elastic Constants – Hyperbolic fringes
5. Laser – II: Magneto-striction, Faraday effect and Verdert constant of a given material
6. e – Millikan's oil drop method
7. Ultrasonic diffraction
8. Determination of e/k using Ge and Si transistors
9. Permittivity of a liquid using RFO
10. Determination of phase transition temperatures of a binary liquid mixture at different concentrations
11. Polarizability of liquids
12. Fermi-Curie plot of the â-ray spectrum and determination of end-point energy
13. Determination of transition temperature in liquid crystalline materials
14. Characteristics of laser and tunnel diode
15. Characteristics of LVDT
16. Characteristics of load cell
17. SCR – Characteristics and Applications
18. Study of regulated power supply – there terminal IC
19. Transmission Line Characteristics
20. Shift Registers using Flip-Flop & ICs
21. Design of ROM and RAM using diode / OR gate and flip flop
22. Design of Encoder and Decoder
23. Op-amp: Low, High and band pass Filters
24. Computational experiment: Curve fitting – Least square fitting
25. Computational experiment: Solving Schrodinger equation for hydrogen / LHO
26. Computational experiment: Op-Amp parameter study – Circuit simulation using Proteus

Semester II **Hours/Week: -**
18PPH2109A **Credits : 2**

Self-paced Learning:
PHYSICS OF THIN FILM AND CRYSTAL GROWTH

Course Outcomes:

1. Know various methods to prepare thin films.
2. Know the measurement of thickness, other properties of thin films.
3. Understand the nucleation and growth of thin films.
4. Know the theories of nucleation of crystals, understand their mechanisms and differentiate different types of nucleation.
5. Know the growth of single crystals by various techniques.
6. Analyze the properties and characteristics of crystals by different techniques.

Unit-I: Preparative techniques of thin film - physical methods-Vacuum evaporation, sputtering chemical methods-chemical vapour deposition, Electro and electroless coating hybrid methods-dip coating, spin coating

Unit-II: Thickness measurement and Nucleation growth- gravimetric - microbalance– electrical –resistance ,capacitance method–optical –Fieazu fringes method- Four stages of film growth - Incorporation of defects during growth.

Unit-III: Theory of nucleation in crystal growth Theories of nucleation - classical theory of nucleation - Gibbs Thomson equation for vapour - Modified Thomson equation for melt - Gibbs-Thomson equation for solution - Energy of formation of a nucleus – Spherical nucleus - Cylindrical nucleus - Heterogeneous nucleation

Unit-IV: Preparative techniques of Crystal Crystal growth from melt: Czocharlski technique-Bridgmann-stockbarger technique - Crystal growth from Solution: Low temperature solution growth - Slow cooling technique - Slow evaporation technique - High temperature solution growth - Gel growth.

Unit-V: Characterization Techniques-Structural –XRD, Micro hardness electrical-DC and AC conduction-Four Probe technique ,impedance analysis, LCR bridge measurement, optical FTIR –functional analysis-UV-Visible - transmittance,reflectance, and Absorbance

Books for study

Study material prepared by the department.

Relationship Matrix for Course Outcomes, Programme Outcomes and Programme Specific Outcomes

Semester II	Code 18PPH2109A					Title of the Paper Self-paced Course: PHYSICS OF THIN FILM AND CRYSTAL GROWTH								Hours -	Credits 2
Course Outcomes (COs)	Programme Outcomes (POs)					Programme Specific Outcomes (PSOs)								Mean Score of COs	
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8		
CO1	4	4	2	3	3	4	3	4	3	3	2	3	3		3.2
CO2	4	4	3	4	3	4	3	4	3	4	3	3	3		3.5
CO3	3	3	2	3	4	3	2	3	2	4	2	3	3		2.8
CO4	4	4	4	3	4	4	3	4	4	4	2	1	3		3.4
CO5	3	4	3	4	3	4	3	4	3	3	3	2	4		3.3
CO6	3	3	2	4	3	3	4	4	3	4	3	1	3		3.1
										Overall Mean Score for COs					3.2

Result: The Score for this Course is 3.2 (High Relationship)

Note:

Mapping	1-20%	21-40%	41-60%	61-80%	81-100%
Scale	1	2	3	4	5
Relation	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0
Quality	Very poor	Poor	Moderate	High	Very High

Values Scaling:

$$\text{Mean Score of COs} = \frac{\text{Total of Values}}{\text{Total No. of POs \& PSOs}} \qquad \text{Mean Overall Score for COs} = \frac{\text{Total of Mean Scores}}{\text{Total No. of COs}}$$

Semester II **Hours/Week: -**
18PPH2109B **Credits : 2**

Self-paced Learning:
ULTRASONICS - FUNDAMENTALS, SOURCES, MEASUREMENT & APPLICATIONS

Course Outcomes:

1. Know and understand the fundamental properties and behavior of ultrasonic waves.
2. Understand the relationship between Piezoelectric effect and ultrasonic waves.
3. Differentiate, classify and analyze different piezoelectric materials
4. Understand the various methods of detecting and measuring ultrasonic waves.
5. Know and Classify the applications of ultrasonics.
6. Understand the application of ultrasonics in nondestructive testing.

Unit-I: Fundamentals of Ultrasound

Introduction – Classification of sound waves – Ultrasonic waves – Different modes of Ultrasonic waves –Characteristics Properties of Ultrasonic waves – Velocity – Specific acoustic impedance – Acoustic intensity and pressure – Behaviour of Ultrasonic waves – Reflection and transmission at normal incidence –Diffraction.

Unit-II: Ultrasonic Transducers

Piezoelectric Effect – Piezoelectric crystals — Advantages and limitations of quartz – Transducer Materials – Piezoelectric ceramic materials – Polymer materials – Materials for transmission and reception – Thickness selection of a Piezoelectric Element.

Unit-III: Measurement Techniques of Ultrasound

Detection of Ultrasonic Waves –Optical Method – Electrical Method –Pulse echo overlap method –Resonance ultrasound spectroscopy – Laser Interferometry.

Unit-IV: Applications of Ultrasound - General and Advanced

Classification of Ultrasonic Applications –Welding – Cleaning – Flow meters – Food industry – Concrete testing — Echo sounder – Length meters - Applications – Level meters – Thickness measurements – Ultrasonic microscopy

Unit-V: Ultrasonic Non-destructive Testing

Classification of Non-Destructive Testing – Ultrasonic Testing – Classification of Ultrasonic Testing – Pulse echo –Resonance – Surface wave – Different Types of Techniques in Pulse Echo Method – Flaw Detectors – Functions of a flaw detector – Different types of scans – Applications of Flaw Detectors **Book for Study:** Baldev Raj, V Rajendran and P Palanichamy, Science and Technology of Ultrasonics, 2nd edition, Narosa Publishing House, New Delhi, 2009

Book for Study:

1. Baldev Raj, V. Rajendran and P. Palanichamy, 'Science and Technology of Ultrasonics', 2nd edition, Narosa Publishing House, New Delhi, 2009

Relationship Matrix for Course Outcomes, Programme Outcomes and Programme Specific Outcomes

Semester II	Code 18PPH2109B				Title of the Paper: **Self-paced Course: ULTRASONICS - FUNDAMENTALS, SOURCES, MEASUREMENT & APPLICATIONS**								Hours -	Credits 2
Course Outcomes (COs)	Programme Outcomes (POs)					Programme Specific Outcomes (PSOs)								Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO1	4	4	4	3	3	4	4	4	4	5	4	3	4	3.8
CO2	3	4	4	3	3	4	4	4	4	4	3	4	4	3.6
CO3	4	3	3	3	3	4	4	3	4	3	4	3	4	3.5
CO4	4	4	4	4	4	4	3	4	3	4	4	3	4	3.7
CO5	3	3	3	4	3	4	4	5	4	3	3	4	4	3.5
CO6	4	3	4	4	4	4	3	4	4	4	4	3	4	3.7
													Overall Mean Score for COs	**3.7**

Result: The Score for this Course is 3.7 (High Relationship)

Note:

Mapping	**1-20%**	**21-40%**	**41-60%**	**61-80%**	**81-100%**
Scale	**1**	**2**	**3**	**4**	**5**
Relation	**0.0-1.0**	**1.1-2.0**	**2.1-3.0**	**3.1-4.0**	**4.1-5.0**
Quality	**Very poor**	**Poor**	**Moderate**	**High**	**Very High**

Values Scaling:

Mean Score of COs = $\frac{\text{Total of Values}}{\text{Total No. of POs \& PSOs}}$	**Mean Overall Score for COs** = $\frac{\text{Total of Mean Scores}}{\text{Total No. of COs}}$

Semester II **Hours/Week: 4**
18PSS2301 **Credits : 4**

IDC: SOFT SKILLS

Course Outcomes:

1. Students are taught the various nuances of grooming such as, good manners and etiquettes and they are trained to practice them in the class rooms.
2. Students are empowered with public speaking skills via extempore speeches and prepared speeches, presented before the class and assessed by the trainer as well as the companions which eventually helps build self confidence of the students.
3. Students learn the different types of resumes and different types of interview skills and write and print their own resumes and present before the interview panel for their mock interview.
4. Students actively learn the ten parameters of group discussion, perform on the stage with their colleagues, which is videotaped, reviewed and evaluated.
5. As students go through their teenage, self discovery becomes a tool to develop their personality facilitated with scientific psychological personality tests.
6. Students are guided to knowing their SWOT (Strengths, Weaknesses, Opportunities and Threats)and setting their short term and long term goals for their lives.

Module 1: Basics of Communication: Definition of communication, Process of Communication, Barriers of Communication, Non-verbal Communication,

Effective Communication: The Art of Listening, Exercises in Kinesthetics, Production of Speech, Organization of Speech, Modes of delivery, Conversation Techniques, Dialogue, Good manners and Etiquettes, Politeness markers & Listening links.

Module II: Resume Writing: What is Resume? Types of Resume? Chronological, Functional and Mixed Resume, Steps in preparation of Resume, structure and framework for writing resume, Intensive training / personalized training on resume writing. **Interview Skills**: Common interview questions, Attitude, Body Language, The mock interviews, Phone interviews, Behavioral interviews.

Module III: Group Discussion: Group Discussion Basics, GD Topics for Practice, Points for GD Topics, Case-Based and Article based Group Discussions, Points for Case Studies, and Notes on Current Issues for GDS & Practicum with video coverage. **Team Building:** Team Vs Group – Synergy,

Stages of Team Formation, Broken Square-Exercise, Win as much as you win- Exercise, Leadership – Styles, Work ethics.

Module IV: Personal Effectiveness: Self Discovery, Self Esteem, Goal setting, Problem-solving, Conflict and Stress Management

Module V: Numerical Ability: Average, Percentage, Profit and Loss, Problems on ages, Simple Interest, Compound Interest, Area, Volume and Surface Area,Time and Work, Pipes and Cisterns, Time and Distance, Problems on Trains, Boats and Streams, Calendar, Clocks, Permutations and Combinations, Probability.

Module VI: Test of Reasoning: Series Completion, Analogy, Data Sufficiency, Blood Relations, Assertion and Reasoning, Logical Deduction, Direction. **Non-Verbal Reasoning**: Series, Classification

Text Book

1. Melchias, G., Balaiah John., John Love Joy (Eds) 2015. *Winners in the making*. St.Joseph's College, Trichy-2

References

1. Aggarwal, R. S. *Quantitative Aptitude, S.Chand & Sons*
2. Aggarwal, R.S. (2010). *A Modern Approach to Verbal and Non Verbal Reasoning*. S. Chand & Co, Revised Edition.
3. Covey, Stephen. (2004). *7 Habits of Highly effective people,* Free Press.
4. Egan Gerard (1994). *The Skilled Helper* (5th Ed). Pacific Grove, Brooks/ Cole.
5. Khera, Shiv (2003). *You Can Win.* Macmillan Books, Revised Edition.
6. Murphy, Raymond. (1998). *Essential English Grammar*. 2nd ed., Cambridge University Press.
7. Prasad, L. M. (2000). *Organizational Behaviour, S.Chand & Sons.*
8. Schuller, Robert. (2010). *Positive Attitudes*. Jaico Books.
9. Trishna's (2006). *How to do well in GDs & Interviews*, Trishna Knowledge Systems.
10. Yate, Martin. (2005). H*iring the Best: A Manager's Guide to Effective Interviewing and Recruiting*.

Modules	Topics	Examination Pattern	
		CIA	Online
I	Basics of Communication	15	5
II	Resume Writing & Interview Skills	15	5
III	Group Discussion & Team Building	10	5
IV	Personal Effectiveness	10	5
V	Numerical Ability (Common Session)	5	10
VI	Test of Reasoning (Common Session)	5	10
Total		**60**	**40**

Semester III **Hours/Week: 4**
18PPH3110 **Credits : 4**

STATISTICAL MECHANICS AND THERMODYNAMICS

Course Outcomes:

1. Acquire knowledge about different laws of thermodynamics
2. Understand about different thermodynamic Potentials and their importance to deduce reciprocity relations.
3. Knowledge about Liouville's theorem and its importance
4. Applications of MB distribution law.
5. Applications of BE and FD distribution laws.
6. Application of statistical laws to study transport phenomena
7. Acquire knowledge about phase transitions of first and second type
8. Understand Bragg-Williams Approximation and its importance.

Unit-I: FUNDAMENTALS OF STATISTICAL MECHANICS (12 hr)

Objectives of statistical Mechanics- Concept of Entropy and disorder-Thermodynamic potentials and reciprocity relations - chemical potential - description of systemsof particles system-phase space-volume in phase space-concept of ensembles-micro canonical- canonical-grand canonical - Liouville's theorem– priori Probability-Statistical, thermal, mechanical and particle equilibrium- Gibb's paradox.

Unit-II: CLASSICAL STATISTICAL MECHANICS (12 hr)

Micro and Macro states- classical Maxwell-Boltzmann distribution law-distribution of velocities- principle of equipartition of energy-connection between the partition function and thermodynamic quantities- mean values obtained from distribution law- Boltzmann's entropy relation-perfect gas in micro canonical ensemble.

Unit-III: QUANTUM STATISTICAL MECHANICS (12hr)

Statistical weight-density matrix-Bose-Einstein -Fermi-Dirac - Maxwell-Boltzmann statistics - black body radiation and Planck's radiation law-Thermodynamic behavior of ideal Bose and Fermi gas -Bose-Einstein condensation- Liquid Helium– Super fluidity -Tisza's two Fluid model-second sound- electron gas of metals.

Unit-IV: TRANSPORT PROPERTIES AND FLUCTUATION (12 hr)

Boltzmann transport equations-Boltzmann transport equations for electrons and Lorentz solution-chambers equation-thermal conductivity of metals-

mean square deviation- fluctuations in energy, Probability of one dimensional random walk- Brownian movement- Nyquist's theorem.

Unit-V: PHASE TRANSITIONS AND ITS MODELS (12 hr)

Phase transitions-first and second kind – critical exponent -YANG and LEE theory - phase transition of second kind- Ising model – Bragg-Williams approximation- one dimensional Ising model.

Books for Study:

1. Gupta S.L & Kumar V., Statistical Mechanics, PragatiPrakashan, Meerut, 2006.
2. Surekha Tomar, CSIR-UGC NET/JRF/SET Physical Sciences, 3rd Edition (for problems)

Unit	Book	Sections
I	1	A-3, 7, 1.1, 1.1-1, 1.3, 1.7, 1.9, 1.10-1.13, 3.0-3
II	1	2.1, 2.7, 2.10, 2.12, 2.14, 2.15, 2.16, 3.0-2
III	1	5.8, 5.10, 6.2-6.4, 6.108.0, 8.2, 9.0, 8.4, 8.4-1, 9.3
IV	1	10.1, 10.2, 10.3, 10.5, 12.1, 12.5, 12.6, 12.10
V	1	13.1-13.7

Books for reference:

1. Statistical Mechanics by SatyaPrakash and JP Agarwal (Pragati Prakahan-2002)
2. K. Huang, Introduction to Statistical Mechanics

Relationship Matrix for Course Outcomes, Programme Outcomes and Programme Specific Outcomes

Semester III	Code 18PPH3110	Title of the Paper STATISTICAL MECHANICS & THERMODYNAMICS												Hours 4	Credits 4
Course Outcomes (COs)	Programme Outcomes (POs)					Programme Specific Outcomes (PSOs)								Mean Score of COs	
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8		
CO1	4	4	4	4	5	5	2	4	3	4	3	1	4		3.61
CO2	4	4	4	4	3	5	2	4	4	4	4	1	4		3.61
CO3	4	4	4	4	4	3	2	4	3	4	4	3	4		3.61
CO4	4	3	4	4	5	4	2	3	4	3	4	1	4		3.46
CO5	3	4	4	4	4	4	3	3	3	3	3	4	4		3.53
CO6	4	4	4	3	3	3	3	3	3	4	4	1	4		3.30
CO7	4	3	4	4	4	3	3	4	5	3	4	4	4		3.76
CO8	3	4	3	3	3	3	3	3	3	3	3	4	4		3.23
											Overall Mean Score for COs				3.51

Result: The Score for this Course is 3.5 (High Relationship)

Note:

Mapping	1-20%	21-40%	41-60%	61-80%	81-100%
Scale	1	2	3	4	5
Relation	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0
Quality	Very poor	Poor	Moderate	High	Very High

Values Scaling:

$$\text{Mean Score of COs} = \frac{\text{Total of Values}}{\text{Total No. of POs \& PSOs}} \qquad \text{Mean Overall Score for COs} = \frac{\text{Total of Mean Scores}}{\text{Total No. of COs}}$$

Semester III **Hours/Week: 8**
18PPH3111 **Credits : 4**

PHYSICS PRACTICAL - III

Any 15 Experiments:

1. e/m Zeeman effect
2. Microwave – Klystron /Gunn diode
3. Design of Multiplexer and De-multiplexer
4. Digital to Analog Converters design
5. Design of Asynchronous Counter
6. Study of Power Amplifier: IC
7. Mod & De-mod: PAM,PPM,PWM
8. Laser III: Brewster angle and related parameters
9. Geiger Muller Counter
10. Analysis of XRD spectrum - Determination of lattice parameters of a crystal
11. Analysis of FTIR spectrum - Determination of vibration levels in a compound
12. Solar cell characteristics
13. Charge of an electron by spectrometer
14. Monte Carlo simulation of electronic distribution of hydrogen atom
15. Characteristics of tri colour LED and production of different colours
16. Measurement and analyses of Raman Spectra of liquids and solids.
17. Magneto resistance of a semiconductor
18. Thin film preparation and measurement of its thickness
19. Determination of Rydberg constant
20. Study of porosity and grain size of thin film by SEM
21. Brass arc spectrum
22. UV Vis spectrometer - Analysis of UV Vis spectrum - Determination of absorption coefficient and band gap
23. Analysis of rotation and vibration spectrum
24. Computational experiment: Solution of Poison's equation
25. Computational experiment: 2-D Electrostatic Calculation
26. Computational experiment: Chaotic and Nonchaotic dynamics

Semester III **Hours/Week: 4**
18PPH3201(A) **Credits : 4**

MATERIALS SCIENCE - I

Course Outcomes:

1. Acquire knowledge about phase diagrams
2. Understand different synthesis techniques of Nano materials
3. Understand the phenomenon of second and third harmonic generation in nonlinear materials
4. Acquire knowledge on different types of nonlinear materials
5. Acquire knowledge about different applications of ceramics
6. Understand the properties of polymers

Unit-I: PHASE TRANSITION IN MATERIALS

Definition and basic concepts – solubility limit – phases – microstructure – phase equilibria – unary phase diagrams – Binary phase diagrams – Binary isomorphous systems – Interpretation of phase diagrams – Development of microstructure in isomorphous alloys – mechanical properties of isomorphous alloys – Binary eutectic systems – Development of microstructure in eutectic alloys – Equilibrium diagrams having intermediate phases or components – Eutectoid and peritectic reactions – Concurrent phase transformations – ceramics and ternary phase diagrams – The Gibbs phase rule – The iron – iron carbide phase diagrams.

Unit-II: SYNTHESIS OF NANOMATERIALS

Vapour – phase synthesis: Gas-Vapour deposition - Plasma - based synthesis - Molecular beam epitaxy - Inert gas condensation - Flame pyrolysis

Liquid phase - synthesis: Colloidal methods - Solution precipitation - Electro deposition - Sol-gel technique

Solid – state phase synthesis: Mechanical milling-attriction and alloying.

Unit-III: NONLINEAR OPTICAL MATERIALS

Introduction-Harmonic Generation-Second Harmonic Generation-Phase Matching-Third Harmonic Generation-Optical Mixing-Parametric Generation of Light-Selffocusing of Light– nonlinear optical materials.

Unit-IV: CERAMICS

Introduction – Glasses – Glass Ceramics – clay products – refractory's - abrasives – cements – advanced ceramics – ceramic phase diagrams – brittle fracture of ceramics – stress – strain behavior – mechanism of plastic deformation – miscellaneous mechanical consideration

Unit-V: POLYMERS

Introduction – Hydrocarbon molecules – polymer molecules – chemistry of polymer molecules – molecular weight – molecular shape – molecular structure – molecular configuration – thermo plastic and thermosetting polymers – copolymers – mechanical behavior of polymers – polymer types – miscellaneous applications – advanced polymer materials – polymerization – polymer additives.

Books for Study:

1. Balasubramanian. R., Callister's material Science and Engineering, Wiley, India, 2010.
2. V. Pokropivny, R. Lohmus, I. Hussainova, A. Pokropivny, S. Vlassov. Introduction in nanomaterials and nanotechnology. University of Tartu. 2007
3. B. B. Laud, Lasers and Non-Linear Optics, New Age International Publishers, 2007.

Unit	Book	Sections
I	1	7.1-7.18
II	2	5.1.1-5.4.1
III	3	13.1-13.7
IV	1	12.1-12.16
V	1	13.1-13.10, 14.1-14.6, 14.15-14.21

Relationship Matrix for Course Outcomes, Programme Outcomes and Programme Specific Outcomes

Semester III	Code 18PPH3201A					Title of the Paper MATERIAL SCIENCE-I								Hours 4	Credits 4
Course Outcomes (COs)	Programme Outcomes (POs)					Programme Specific Outcomes (PSOs)								Mean Score of COs	
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8		
CO1	4	4	4	3	3	4	4	4	2	2	3	1	3		3.15
CO2	4	4	4	3	3	4	4	4	3	5	3	1	3		3.52
CO3	5	4	3	2	2	4	3	4	4	4	3	2	3		3.25
CO4	4	4	3	2	2	4	4	4	3	4	1	3	3		3.23
CO5	4	5	4	4	3	4	4	4	3	5	3	2	3		3.69
CO6	4	4	4	3	4	4	4	4	4	4	3	1	3		3.58
											Overall Mean Score for COs				3.40

Result: The Score for this Course is 3.4 (High Relationship)

Note:

Mapping	1-20%	21-40%	41-60%	61-80%	81-100%
Scale	1	2	3	4	5
Relation	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0
Quality	Very poor	Poor	Moderate	High	Very High

Values Scaling:

$$\text{Mean Score of COs} = \frac{\text{Total of Values}}{\text{Total No. of POs \& PSOs}} \qquad \text{Mean Overall Score for COs} = \frac{\text{Total of Mean Scores}}{\text{Total No. of COs}}$$

Semester III **Hours/Week: 4**
18PPH3201(B) **Credits : 4**

MATHEMATICAL METHODS OF COMPUTATIONAL PHYSICS

Course Outcomes:

1. Solve mathematical problems involving vectors and tensors
2. Competently use vector and tensor algebra as a tool in the field of applied sciences and related fields
3. Determine the types of elements and symmetry operations and constructing the character tables based on the principles of the group theory
4. Apply symmetry considerations to solve problem within molecular physics, solid state physics and particle physics
5. Solve a differential equation using an appropriate numerical method and root finding methods
6. Constructing a polynomial, like Newton Gregory method for equally spaced points and Lagrange Methods for unequally spaced points.

Unit-I: TENSORS (10hr)

Introductory ideas on Scalars, Vectors and Tensors – Co-ordinate transformation: Rotation of the axes and vectors – Fundamental ideas and representations – Algebra of tensors – Curvature of space–time manifold: Metric tensor of the space, Einstein's field equations, Geodesics, Curvature of space, Schwarzschild metric – Christoffel's 3-index symbols.

Unit-II: BASIC GROUP THEORY (10hr)

Definition and nomenclature – Rearrangement theorem – cyclic groups – subgroups – conjugate elements and class structure – identification of symmetry element and operations – molecular point groups – matrix representation of symmetry operations – The Great Orthogonality Theorem – (Qualitative treatments) – character of representation.

Unit-III: APPLIED GROUP THEORY (10hr)

Character table – generating symmetry operators – construction of character tables – irreducible representation for C2v and C3v groups – symmetry species specifications – Rotation Group: SO(2) & SO(3) and Special Unitary groups : SU(2) & SU(3).

Unit-IV:

NUMERICAL METHODS APPLIED TO PHYSICS PROBLEMS-I (10hr)

Numerical integration: trapezoidal, Simpson's 1/3 rules – Truncation error –

composite trapezoidal and Simpson's 1/3 rules. ODE: Euler and fourth-order Runge-Kutta methods for first order ODE. (no theory and derivation of formulae)

Unit-V:

NUMERICAL METHODS APPLIED TO PHYSICS PROBLEMS-II (10 hr)

Interpolation: Newton's interpolation – Linear interpolation – Higher – order polynomials – Divided differences – Gregory – Newton forward and backward interpolation formulae – error in interpolation – Lagrange interpolation (no theory and derivation of formulae).

Books for Study

1. A.W. Joshi, Matrix and Tensors in Physics, London, New Age, 2010.
2. Tinkham M - Group Theory and Quantum Mechanics - McGraw Hill - New Delhi. 1974.
3. M.K. Venkataraman, Numerical Methods in Science & Engineering National Pub. Co. Madras, 2013.

Unit	Book	Chapter	Sections
I	1	1 & 2	1, 16
II	2	1	1.1, 1.2, 2.1,2.3,2.4, 3.2, 3.3
III	2	2	3.4, 5.2, 5.3, 5.4, 5.5, 5.6
IV	3	3	All sections
V	3	1 & 7	All sections

Books for Reference

1. Pipes, L.A. & Harvil, L.R., Applied Mathematics for Engineers and Physicists. McGraw Hill Company, New Delhi.
2. A.K Mukhopadhyay, Mathematical Methods for Engineers and Physicists. Wheeler Publications, New Delhi. 1998.

Relationship Matrix for Course Outcomes, Programme Outcomes and Programme Specific Outcomes

Semester III	Code 18PPH3201B	Title of the Paper MATHEMATICAL METHODS OF COMPUTATIONAL PHYSICS											Hours 4	Credits 4
Course Outcomes (COs)	Programme Outcomes (POs)					Programme Specific Outcomes (PSOs)								Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO1	4	3	3	3	2	4	4	4	4	3	3	3	4	3.38
CO2	4	3	4	4	3	4	3	4	3	4	3	3	4	3.53
CO3	4	3	4	5	5	4	4	4	4	4	3	3	4	3.92
CO4	5	4	4	3	4	4	4.5	4.5	4	4..5	3	3	4.5	3.65
CO5	4	4	4	3	3	4	4	4	4	3	3	3	4	3.61
CO6	4	3	4	5	4	4	4.5	4	4.5	4	3	3	4	3.92
													Overall Mean Score for COs	3.66

Result: The Score for this Course is 3.6 (High Relationship)

Note:

Mapping	1-20%	21-40%	41-60%	61-80%	81-100%
Scale	1	2	3	4	5
Relation	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0
Quality	Very poor	Poor	Moderate	High	Very High

Values Scaling:

Mean Score of COs = $\frac{\text{Total of Values}}{\text{Total No. of POs \& PSOs}}$	**Mean Overall Score for COs** = $\frac{\text{Total of Mean Scores}}{\text{Total No. of COs}}$

Semester III **Hours/Week: 6**
18SPS3101A **Credits : 5**

Interdisciplinary Core:

SPECTROSCOPY AND STATISTICAL THERMODYNAMICS

Course Outcomes:

1. Students learn and understand the concept of Molecular spectroscopy
2. The concept of FT-IR is well understood
3. The concepts of Raman Spectroscopy is well understood
4. Students learn and understand the concepts of NMR spectroscopy
5. The concepts of probability distribution is understood
6. The concept of statistical thermodynamics is understood
7. Students learn and understand the concept of partial molar properties
8. The application of statistical thermodynamics is understood

Unit-I: Rotational and Vibrational Spectroscopy (18 hr)

Basic aspects of Spectroscopy - Characterisation of electromagnetic radiation - Quantization of energy. Microwave Spectroscopy - Rotation of molecules and selection rules, Diatomic molecules - Rigid and non-rigid rotator, Rotational constant and centrifugal distortion - Techniques and instrumentation. Vibrational spectroscopy - diatomic molecules, Harmonic and anharmonic oscillators - zero point energy - force constant - fundamental absorption and overtones (hot bands, fermi resonance) - Polyatomic molecules - Techniques and instrumentation of FT-IR.

Unit-II: Raman and NMR and Mossbauer Spectroscopy (18 hr)

Raman spectroscopy - Raman and Rayleigh scattering - Quantum and Classical theories of Raman effect - Stokes and anti-stokes lines - Pure rotational Raman spectra - Vibrational Raman spectra - Mutual exclusion rule - Polarized and depolarized Raman lines - Techniques and instrumentation. NMR - Hydrogen nuclei - Chemical shift and spin-spin splitting - Coupling constant (*J*). Splitting with and without chemical exchange - Interaction between spin and magnetic field - Gyromagnetic ratio – Instrumentationof NMR - FT NMR- Applications of 2D NMR techniques like COSY, NOESY. Applications of C^{13} NMR spectroscopy - Mossbauer spectroscopy - principles of Mossbauer spectroscopy, Doppler shift, Recoil energy, Isomer shift, Quadrupole splitting - Applications to various compounds.

Unit-III: ESR spectroscopy & Electronic Spectroscopy (18 hr)

ESR – Principle - Position of ESR absorptions - *g* value - Hyperfine splitting - Zero field splitting - ESR spectrum of free radicals and copper salicyaldehyde complexes.

Electronic spectra - Electronic spectra of diatomic molecules – Born Oppenheimer approximation - Vibrational coarse structure - Franck - Condon Principle - Dissociation energy and dissociation products - rotational fine structure of electronic vibration - vibration transition - Fortrate Diagram. Electronic angular momentum in diatomic molecules - Spectrum of molecular hydrogen - Molecular photoelectron spectroscopy - UV photo electron spectroscopy and X-ray photo electron spectroscopy.

Unit-IV: Fundamentals of Statistical Thermodynamics (Online) (18 hr)

Statistical method - Microstates, macro states - Permutations and combinations - Combinatory rule - Probability theorems – Ensembles - Phase space - Thermodynamic probability - Statistical equilibrium - Maxwell-Boltzmann statistics - Derivation of M.B. statistics - Relationship between entropy and probability - Heat capacity of solids - Einstein and Debye models - Statistical meaning of third law of thermodynamics.

Unit-V: Applications of Statistical Thermodynamics (18 hr)

Partition functions - Molar, translational, rotational and vibrational partition functions of diatomic and polyatomic molecules - Separation of partition function according to forms of energy-Partition function and vibrational energy - Total partition function - Electronic partition function-Derivation of thermodynamic quantities E, S, A, H, G, K and *Cp*, *Cv* using partition function-Sackur-Tetrode equation – Bose Einstein statistics - Fermi Dirac statistics - Electronic heat capacity of gases - Equipartition of energy - Classical and quantum statistical theory of heat capacities - Heat capacities for diatomic molecule - Rotational heat capacity of hydrogen molecule - Nuclear spin statistics - Nuclear spin entropy- Quantum statistics.

Textbooks

1. Banwell C N, *Molecular spectroscopy,* 2nd Ed., New Delhi, TATA McGraw Hill Co., 2010.
2. Kuriakose J. C and Rajaram J.C, *Thermodynamics,* Jalandar Shoban Lal Co., 1999.

References

1. Drago R S, *Physical Methods in Inorganic Chemistry,* New Delhi, East West Press Ltd, 1971.
2. Chang R, *Basic Principles of Spectroscopy,* New Jersey, Englewood Cliffs, 1978.
3. Straughan B P and Walker S, *Spectroscopy Volume 1,2,3,* New York, London Chapman and Hall, A Halstet Press Book, John Wiley & Sons Ins. 1975.

4. Barrow G M, *Introduction to Molecular Spectroscopy,* Tata McGraw - Hill Ed., 1993.
5. Gurdeep R Chatwal and Sham K Anand, *Spectroscopy*, Himalaya Publishing House, 2009.
6. Gupta, M. C., *Statistical Thermodynamics, 2nd* Edition, New Age International Publishers, Chennai, 1998.
7. Donald McQuarrie, *Statistical Thermodynamics,* Indian Edition, Viva Books Private Ltd., New Delhi, 2003.

Relationship Matrix for Course Outcomes, Programme Outcomes and Programme Specific Outcomes

Semester III	Code 18SPS3101A	Title of the Paper SPECTROSCOPY AND STATISTICAL THERMODYNAMICS											Hours 6	Credits 5
Course Outcomes (COs)	Programme Outcomes (POs)					Programme Specific Outcomes (PSOs)								Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO1	3	4	4	4	3	3	4	3	3	4	3	4	3	3.5
CO2	4	3	3	3	3	4	3	2	3	4	3	4	4	3.3
CO3	3	4	3	3	4	3	2	3	4	3	4	3	3	3.5
CO4	3	4	3	3	3	3	3	3	3	3	3	4	3	3.6
CO5	4	3	3	4	3	2	4	2	3	4	3	3	4	3.1
CO6	3	4	4	3	4	3	3	3	4	3	3	4	3	3.4
CO7	3	4	2	3	4	3	4	3	3	4	3	4	3	3.4
CO8	3	4	5	4	3	4	3	4	5	3	4	3	3	3.7
													Overall Mean Score for COs	3.43

Result: The Score for this Course is 3.43 (High Relationship)

Note:

Mapping	1-20%	21-40%	41-60%	61-80%	81-100%
Scale	**1**	**2**	**3**	**4**	**5**
Relation	**0.0-1.0**	**1.1-2.0**	**2.1-3.0**	**3.1-4.0**	**4.1-5.0**
Quality	**Very poor**	**Poor**	**Moderate**	**High**	**Very High**

Values Scaling:

Mean Score of COs = $\frac{\text{Total of Values}}{\text{Total No. of POs \& PSOs}}$	**Mean Overall Score for COs** = $\frac{\text{Total of Mean Scores}}{\text{Total No. of COs}}$

Semester III **Hours/Week: 6**
18SPS3101B **Credits : 5**

IDC: SPECTROSCOPY

Course Outcomes:

1. Understand the aspects of rotational spectroscopy and its techniques.
2. Understand the theory and principles of vibrational spectroscopy and its techniques.
3. Comprehend the basics of Raman and their instrumentation techniques.
4. Understand the physics behind NMR and ESR spectroscopy and its instrumentation.
5. Perceive the theory and principles of electronic and X-ray spectroscopy.
6. Understand Mossbauer spectroscopic techniques and hyperfine spectral lines.
7. Understand phosphorescence and fluorescence.
8. Analyze the structure of compounds by various spectroscopic techniques.

Unit-I: ROTATIONAL SPECTROSCOPY

Basic aspects of spectroscopy-characterization of EM radiation, quantization of energy Microwave spectroscopy-rotation of molecules and selection rules, diatomic molecules; Rigid diatomic molecule - intensities of spectral lines-effect of isotppe substitution - Non-rigid rotator (rotational constant-centrifugal distortion constant) - polyatomic molecules -techniques and instrumentation - Chemical analysis.

Unit-II: INFRA-RED SPECTROSCOPY

Vibration Spectroscopy - diatomic molecules; Harmonic and anharmonic oscillators, Zero point energy - force constant - The diatomic vibrating rotator - fundamental vibrations and overtones (hot bands, Fermi resonance) - Influence of rotation on polyatomic molecules - Analysis by IR techniques - Techniques and instrumentation.

Unit-III: RAMAN SPECTROSCOPY

Raman spectroscopy: Raman Rayleigh scattering- Quantum and Classical theory of Raman effect- Pure rotational Raman spectra - Stokes and anti-Stokes lines – Raman activity of vibrations - mutual exclusion principle-overtones and combinations vibrations- vibrational Raman spectra-rotational fine structure-Polarized and depolarized Raman lines- Structure determination-Techniques and instrumentation.

Unit-IV: SPIN RESONANCE SPECTROSCOPY

Nature of spinning particles - Interaction between spin and magnetic field - Gyromagnetic ratio-The Larmor Presession - NMR: Hydrogen nuclei - chemical shift - spin-spin splitting - coupling constant - Chemical analysis by NMR - CNMR Spectroscopy – Instrumentation - FT-NMR - ESR- Principle - position of ESR absorptions - g value - hyperfine splitting - zero field splitting - ESR spectrum of free radicals and complex

Unit-V: ELECTRONIC AND MOSSBAUER SPECTROSCOPY

Born-Oppenheimer approximation - vibrational coarse structure - Frank-Condon Principle - dissociation energy and dissociation product- vibration transitions - Fortratdiagram-electronic structure of diatomic molecules - electronic angular momentum in diatomic molecules -spectrum of Molecular hydrogen - Photo electron spectroscopy - UV photo electron spectroscopy - X-ray photo electron spectroscopy. Mossbauer Spectroscopy - Principle - Doppler shift - recoil energy - isomer shift - quadrupole splitting - hyperfine splitting - Applications.

Books for Study:

1. Colin N. Banwell and E. M. McCash, Fundamentals of Molecular Spectroscopy, TMH Edition, 4th Edition (1994).

Unit	Book	Sections
I	1	1.1, 1.2, 1.3, 2.1, 2.2, 2.3.1, 2.3.2, 2.3.3, 2.3.4, 2.3.5, 2.4.1, 2.4.2, 2.5, 2.6
II	1	3.1.1, 3.1.2, 3.1.3, 3.2, 3.3, 3.5.1, 3.5.2, 3.6.1, 3.6.3, 3.7.1, 3.7.2, 3.8.1, 3.8.3
III	1	4.1, 4.1.1, 4.1.2, 4.2.1, 4.2.2, 4.2.3, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 4.3.5, 4.4.1, 4.4.2, 4.4.3, 4.5, 4.6,
IV	1	7.1.1, 7.1.2, 7.1.3, 7.1.4, 7.1.5, 7.1.6, 7.2.1, 7.2.2, 7.2.3, 7.2.4, 7.2.5, 7.3.1, 7.3.2, 7.4, 7.4.1, 7.4.2, 7.5.1, 7.5.2, 7.5.3, 7.5.4, 7.5.5,
V	1	6.1.1, 6.1.2, 6.1.3, 6.1.4, 6.1.5, 6.1.6, 6.1.7, 6.2.1, 6.2.2 6.2.3, 6.2.4, 6.4, 5.5, 6.5, 6.5.1, 6.5.2, 9.1, 9.2.1, 9.2.2, 9.2.3

Books for Reference:

1. Straughan, B.P and Walker.S, Spectroscopy Vol. 1,2,3, Chapman and hall, London (1996).
2. Gurdeep R. Chatwal and Sham K. Anand, Spectroscopy, Himalaya Publishing House (2009).

Relationship Matrix for Course Outcomes, Programme Outcomes and Programme Specific Outcomes

Semester III	Code 18SPS3101B					Title of the Paper SPECTROSCOPY								Hours 6	Credits 5
Course Outcomes (COs)	Programme Outcomes (POs)					Programme Specific Outcomes (PSOs)								Mean Score of COs	
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8		
CO1	4	4	4	4	4	4	2	4	3	4	3	1	4		3.59
CO2	4	4	4	4	3	5	2	4	5	4	4	1	4		3.63
CO3	4	4	4	4	4	3	2	4	3	4	4	3	4		3.61
CO4	4	3	4	4	5	4	2	3	4	3	4	1	4		3.46
CO5	5	4	4	4	4	4	3	3	3	3	3	4	4		3.55
CO6	4	4	4	3	3	3	3	3	3	4	4	1	4		3.30
CO7	4	3	4	4	4	3	3	4	5	3	4	4	4		3.76
CO8	3	4	3	4	3	3	3	3	3	3	3	4	3		3.23
														Overall Mean Score for COs	3.51

Result: The Score for this Course is 3.5 (High Relationship)

Note:

Mapping	1-20%	21-40%	41-60%	61-80%	81-100%
Scale	1	2	3	4	5
Relation	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0
Quality	Very poor	Poor	Moderate	High	Very High

Values Scaling:

$$\text{Mean Score of COs} = \frac{\text{Totalof Values}}{\text{TotalNo.of POs\& PSOs}} \qquad \text{Mean Overall Score for COs} = \frac{\text{Total of Mean Scores}}{\text{Total No. of COs}}$$

Semester IV **Hours/Week: 6**
18SPS3101C **Credits : 5**

SENSORS AND TRANSDUCERS

Course Outcomes

1. Understand the working principles of various transducers.
2. Characterize and measure the non - electrical quantities
3. Acquire knowledge of measurement techniques of thermal conductivity
4. Enhance the knowledge on integrated sensors.
5. Able to understand the usage of electrolytic sensors
6. Learn about biosensors and MEMS based sensors
7. Design the signal conditioning circuits used in bio- instrumentation
8. To analyze the operations of various sensors used in industries and commercial applications.

Unit-I: TRANSDUCERS (15 hr)

Introduction to measurement - Direct and indirect measuring methods - Accuracy - Errors - Transducers - Resistive transducers - Potentiometers - Non-linear potentiometers function generators - Strain gauges - Types of strain gauges - Resistance thermometers – Variable inductance transducers - Linear variable differential transformer - Capacitive transducers - Piezo electric transducers - Hall Effect transducers - Magneto resistors

Unit-II: MEASUREMENT OF NON-ELECTRICAL QUANTITY (14 hr)

Measurement of vibrations - Seismic transducers - Measurement of flow rate - Measurement of thickness - Measurement of humidity - Measurement of sound using microphones - Measurement of pH value - Measurement of thermal conductivity - Measurement of pressure.

Unit-III: INTEGRATED SENSORS (14 hr)

LM 35 temperature sensor - DS18s20 1-wire digital thermometer - TSOP 17 photo modules for PCM remote control system - MOC3041 zero cross optoisolators - TL173L linear hall effect sensor - KMZ51 magnetic field sensor - MPXV5004G pressure sensor - A1425 analog speed sensor - LM1830 water level sensor - HC610 humidity sensor - ICM105A VGA CMOS sensor

Unit-IV: BIOSENSORS AND MEMS BASED SENSORS (15 hr)

Introduction - FET & MOSFET chemical sensor - Bio sensors - Ion exchange membrane electrodes - Oxygen electrodes - CO2 electrodes enzyme electrode - Construction - ISFET for glucose, urea - Electrolytic sensors - Optical

sensor - Fiber optic sensors - ADXL 335 accelerometer - MPU 6050 IMU Sensor.

Unit-V: SIGNAL CONDITIONING CIRCUITS (14 hr)

Signal conditioning basics – type of signal conditioning: analog and digital – analog signal conditioning amplification - attenuation – level shifting - Clippers – clampers - data sampling and optimization - Filters: RC filter - active filter - Wheatstone bridge - AC bridges- noise reduction techniques. Comparators – Schmitt trigger for noise removal – Current amplification – isolation.

Books for study

1. A.K. Sawhney, “A course in Electrical and Electronic Measurements and Instrumentation”, Dhanpat Rai & Co. publishers,2011.
2. N.Mathivanan, “PC Based Instrumentation: Concepts and Practice”, PHI, 2007.

Books for Reference

1. H. S. Kalsi, “Electronic Instrumentation”, Tata McGraw-Hill publishers
2. Albert D. Helfrick and William D.Cooper, “Modern Electronic Instrumentation and Measurement techniques”, New Delhi: Prentice Hall of India, 1995.

Unit	Book	Sections
I	1	25.2 – 25.9
II	1	25.11 – 25.13,25.16,25.17,25.19,25.22-25.24,25.28-25.31
III		Lecture notes
IV		Lecture notes
V	2	2.1 – 2.5, 2.7, lecture notes

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Relationship Matrix for Course Outcomes, Programme Outcomes and Programme Specific Outcomes

Semester III	Code 18SPS3101C					Title of the Paper SENSORS AND TRANSDUCERS								Hours 6	Credits 5
Course Outcomes (COs)	Programme Outcomes (POs)					Programme Specific Outcomes (PSOs)								Mean Score of COs	
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8		
CO1	4	4	3	4	4	4	4	2	3	4	4	4	4	3.7	
CO2	4	4	3	4	4	3	4	2	3	2	4	3	5	3.5	
CO3	4	4	3	4	4	4	4	2	4	4	4	3	5	3.8	
CO4	5	4	3	4	4	3	4	2	4	4	4	3	4	3.7	
CO5	5	4	3	4	4	4	4	2	4	3	4	3	4	3.7	
CO6	5	4	3	4	4	4	4	2	3	3	4	3	4	3.6	
CO7	5	4	3	4	4	4	4	2	3	3	4	3	4	3.6	
CO8	5	4	3	4	4	4	4	2	3	3	4	3	4	3.6	
Overall Mean Score for COs														3.6	

Result: The Score for this Course is 3.6 (High Relationship)

Note:

Mapping	1-20%	21-40%	41-60%	61-80%	81-100%
Scale	1	2	3	4	5
Relation	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0
Quality	Very poor	Poor	Moderate	High	Very High

Values Scaling:

Mean Score of COs = $\frac{\text{Total of Values}}{\text{Total No. of POs \& PSOs}}$	**Mean Overall Score for COs** = $\frac{\text{Total of Mean Scores}}{\text{Total No. of COs}}$

Semester III **Hours/Week: 4**
18PPH3202(A) **Credits : 4**

ADVANCED INSTRUMENTATION TECHNIQUES

Course Outcomes:

1. Understand the various types of errors in experiments
2. Analyse the errors in statistical approach
3. Acquire knowledge and skill to study the acoustical parameters of the liquids
4. Ability to analyze the structure of the elements by powder, single crystal XRD, G-XRD data.
5. Determine the elements present in the sample
6. Analyse the mechanical parameters of the sample by Hardness tests

Unit-I: ERRORS AND STATISTICAL ANALYSIS

Limiting errors – Relative limiting error – combination of quantities with limiting errors – known errors – types of errors – Gross errors – systematic errors: Instrumental errors –Environmental errors – Observational errors - Random errors – central value – statistical treatment of data: Histogram – Gaussian Curve of errors – Precision Index – Probable error – Rejection of data – Uncertainty analysis and treatment of single sample data.

Unit-II: ACOUSTICAL ANALYSIS

Musical Acoustics Instrumentation - Transducers- The Oscilloscope - The Spectrum Analyzer- Frequency Counter - Generator - Virtual Instrumentation - Noise pollution –Different types of noise pollution and methods for reduction - Building acoustics- Underwater acoustics - SODAR-LIDAR - Measurements in the Atmospheric Boundary Layer at Sea-Detection of Ultrasonic Waves Phase slope method – Direct method – Computer Based Automated Method – Continuous wave method – sing around method - Pulse echo overlap method - Cross correlation method – Zero crossing method – Resonance ultrasound spectroscopy – Laser Interferometry.

Unit-III: STRUCTRAL AND ELEMENTAL ANALYSIS

Structural analysis: Powder XRD: determination of crystal structure, phase and size of particles- Single crystal XRD: finding the point group, space group and crystal system of mono crystals – G-XRD-analysis of crystalline structure of thin films – H-NMR: Chemical structure identification of solids and liquids containing Hydrogen - C-NMR: Chemical structure identification of compounds and mixtures in solids and liquids containing Carbon– Case study

Elemental analysis: CHN-identification of composition of C, H and N in an organic compound – EDAX: elemental composition of materials-XPS: Measurement of composition, chemical and electronic states of materials – Case study

Unit-IV: MECHANICAL, THERMALAND SURFACE ANALYSIS

Mechanical analysis: Determination of hardness of materials based on Rockwell, Brinell, Vickers, and Knoop hardness tests.

Thermal Analysis: Identification in stages of thermal decomposition of materials by TG and DTG methods - Examination of phase changes and melting point of materials by DTA and DSC methods– Case study

Surface Analysis: Analysis of surface defects in single crystal and morphology and size of micro particles by SEM - Identification of morphology of nano materials by TEM - Determination of crystalline structure of nano materials HR-TEM - Examine the surface of single crystals by Etching using optical microscopy - Morphology - case study.

Unit-V: OPTICAL ANALYSIS AND MICROSCOPIC ANALYSIS

Optical analysis: Determination of absorption properties of materials by UV – Visible spectral analysis – Determination of luminescence characteristics of materials by Photo luminescence – NLO: Identification of SHG and Phase matching characteristics of powder crystalline materials by Kurtz – Perry powder technique – Determination of third order NLO properties by Z-scan technique – Determination of laser damage threshold by LDT measurements– Case study

Microscopic analysis: Determination of surface roughness and other surface quality parameters by AFM – Examination of 3D profile of a surface by STM– Case study

Books for study:

1. Book under preparation

Relationship Matrix for Course Outcomes, Programme Outcomes and Programme Specific Outcomes

Semester III	Code 18PPH3202A					Title of the Paper ADVANCED INSTRUMENTATION TECHNIQUES								Hours 4	Credits 4
Course Outcomes (COs)	Programme Outcomes (POs)					Programme Specific Outcomes (PSOs)								Mean Score of COs	
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8		
CO1	2	2	4	5	4	1	2	3	4	5	3	4	5		3.4
CO2	5	4	3	4	3	5	3	2	3	5	3	3	5		3.7
CO3	3	4	5	4	3	5	2	3	4	5	4	3	4		3.8
CO4	4	4	3	4	4	3	2	5	4	4	4	4	4		3.8
CO5	4	5	4	4	5	4	3	3	4	3	4	3	4		3.8
CO6	4	4	4	4	3	4	3	5	3	5	3	4	4		3.8
													Overall Mean Score for COs		3.7

Result: The Score for this Course is 3.7 (High Relationship)

Note:

Mapping	1-20%	21-40%	41-60%	61-80%	81-100%
Scale	1	2	3	4	5
Relation	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0
Quality	Very poor	Poor	Moderate	High	Very High

Values Scaling:

$$\text{Mean Score of COs} = \frac{\text{Total of Values}}{\text{Total No. of POs \& PSOs}} \qquad \text{Mean Overall Score for COs} = \frac{\text{Total of Mean Scores}}{\text{Total No. of COs}}$$

Semester III **Hours/Week: 4**
18PPH3202(B) **Credits : 4**

PROGRAMMING USING PYTHON

Course Outcomes:

1. Understand the basics, structure and functions of PYTHON
2. Understand the structured types
3. Understand and Apply object oriented programing for physics problems
4. Understand and apply Tkinter API for physics application GUI program
5. Learn and apply NumPy
6. Learn and apply SciPy

Unit-I: BASICS OF PYTHON

The basic elements of python (Software, Development Tools, Programming with Python, writing a Python Program, Python Interactive Shell,Values and Variables, Expressions) - Branching Programs - Control Structures - Strings and Input – Iteration - Functions and scoping – Specifications – Recursion - Global variables – Modules – Files - System - Functions and Parameters – simple programs.

Unit-II: STRUCTURED TYPES, MUTABILITY AND HIGHER-ORDER FUNCTIONS

Strings, Tuples, Lists and Dictionaries - Lists and Mutability - Functions as Objects – extrapolation, de'slanders table, – Classes and Object-Oriented Programming – programs

Unit-III: TKINTER

TKinter modules – Tkinter classes - Tkinter widgets: button, canvas, frame, listbox, messagebox – widget configuration – widget styles – events and bindings - standard dialogs – GUI programs

Unit-IV: NumPy

SciPy organization – Interaction with NumPy – NumPy matrix - Special functions (scipy.special) – Integration (scipy.integrate) – optimization (scipy.optimize) – Least-squares minimization (least_squares) – root finding – Programs

Unit-V: SciPy

Interpolation (scipy.interpolate) – Fast Fourier Transforms – Signal Processing (scipy.signal) – Eigenvalue Problems – curve fittings - Programs

Books for Study:

1. John V Guttag. "Introduction to Computation and Programming Using Python", Prentice Hall of India 2013
2. Tkinter manual
3. SciPy Reference Guide Release 1.0.0, Written by the SciPy community, October 25, 2017

Unit	Book	Chapter	Sections
I	1	1, 2 & 3	1, 16
II	1	5 & 8	1.1, 1.2, 2.1,2.3,2.4, 3.2, 3.3
III	2		Relevant Sections
IV	3	2, 3	3.12, 3.13, 3.14, 3.15
V	3	3	3.1.6, 3.1.7, 3.1.8

Books for Reference:

1. R. Nageswara Rao, "Core Python Programming", dreamtech
2. Wesley J. Chun. "Core Python Programming - Second Edition", Prentice Hall
3. Michael T. Goodrich, Roberto Tamassia, Michael H. Goldwasser, "Data Structures and Algorithms in Pyhon", Wiley
4. Kenneth A. Lambert, "Fundamentals of Python – First Programs", CENGAGE Publication
5. NumPy Reference Guide Release 1.14.0, Written by the NumPy community, January 08,2018

Web Resources

1. https://www.python.org/
2. https://www.programiz.com/python-programming
3. https://python programming.net/beginner-python-programming-tutorials/
4. https://www.tutorialspoint.com/python/
5. https://www.scipy.org/

Relationship Matrix for Course Outcomes, Programme Outcomes and Programme Specific Outcomes

Semester III	Code 18PPH3202B					Title of the Paper PROGRAMMING USING PYTHON								Hours 4	Credits 4
Course Outcomes (COs)	Programme Outcomes (POs)					Programme Specific Outcomes (PSOs)								Mean Score of COs	
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8		
CO1	5	4	4	3	4	4	4	4	4	4	4	4	5	4.07	
CO2	5	4	4	4	4	3	4	4	4	4	4	4	4	4.07	
CO3	5	3	4	5	5	5	3	4	5	3	4	5	4	4.23	
CO4	5	4	3	4	4	4	4	4	3	5	3	4	4	3.92	
CO5	5	3	4	4	4	5	4	4	4	4	4	5	5	4.23	
CO6	5	4	4	5	4	3	3	4	5	5	4	4	5	4.23	
											Overall Mean Score for COs			4.13	

Result: The Score for this Course is 4.1 (Very High Relationship)

Note:

Mapping	1-20%	21-40%	41-60%	61-80%	81-100%
Scale	1	2	3	4	5
Relation	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0
Quality	Very poor	Poor	Moderate	High	Very High

Values Scaling:

Mean Score of COs = $\frac{\text{Total of Values}}{\text{Total No. of POs \& PSOs}}$	Mean Overall Score for COs = $\frac{\text{Total of Mean Scores}}{\text{Total No. of COs}}$

Semester III **Hours/Week: 4**
18PPH3302 **Credits : 4**

IDC-3 (BS): MODERN PHOTOGRAPHY

Course Outcomes:

1. Acquire knowledge on parts of cameras, types of cameras and interchangeable lenses.
2. Understands the importance of exposure and pictorial composition
3. Create, select, and apply appropriate techniques and editing tools for editing and printing
4. Learn to produce a good quality photo using adobe photo software
5. Acquire the knowledge of different parts of video cameras and its accessories
6. Learn to operate the video cameras and use the video editing software

Unit-I: Camera, Lenses, Developing and Printing: SLR Camera – Mechanical and Auto – Interchangeable lenses – Telephoto, Wide angle, Zoom and macro lenses – Developing of the film – Tank Development –Printing – Enlarger. (10 hr)

Unit-II: Colour and Digital Photography: Colour Photography – Light and colour – Filters for colour – The colourquality – Processing of colour films – Digital photography – Digital still camera and their parts – Types of digital camera. (10 hr)

Unit-III: Digital Photography - Image, Storing & Exposure techniques: The CCD chips – storing images – The view finder – Optical and LCD display– Optical / Digital zooms – Composing the picture – focus – Depth of field – exposure– white balance. (10 hr)

Unit-IV: Basic Digital Techniques - Photoshop: Introduction to Photoshop – starting to use Editing Software – saving thephotos – Cropping - Straightening – Resizing – Brightening and Darkening Photos –Removing Red eye. (10 hr)

Unit-V: Video Photography: Video camera – Principle of camera tube – Types of camera tubes – Blockdiagram of a video camera and their parts – Handling operations and precautions forthe use of a video camera – Video and Audio mixing using software – PC digitalvideo and its applications. (10 hr)

Books for Study:

1. O. P. Sharma, 'Practical Photography', Hind Pocket Books(P) Ltd., 1997
2. Alex May, 'Digital Photography', A Dorling Knidersley Book, London, 2002
3. Doug Harman, The Digital Photography, Hand Book, Quercus Publishing Ltd., USA. 2010.

Relationship Matrix for Course Outcomes, Programme Outcomes and Programme Specific Outcomes

Semester III	Code 18PPH3302					Title of the Paper MODERN PHOTOGRAPHY								Hours 4	Credits 4
Course Outcomes (COs)	Programme Outcomes (POs)					Programme Specific Outcomes (PSOs)								Mean Score of COs	
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8		
CO1	4	5	4	4	4	2	5	4	3	4	3	1	4	3.6	
CO2	4	4	4	4	3	5	2	4	4	4	4	1	4	3.6	
CO3	4	4	4	4	4	2	3	3	4	4	4	3	4	3.6	
CO4	3	4	4	4	5	4	2	3	4	3	4	1	4	3.5	
CO5	4	4	4	4	3	4	3	3	3	3	3	4	4	3.5	
CO6	4	4	4	3	3	3	3	3	3	4	4	1	4	3.3	
						Overall Mean Score for COs								**3.5**	

Result: The Score for this Course is 3.5 (High Relationship)

Note:

Mapping	**1-20%**	**21-40%**	**41-60%**	**61-80%**	**81-100%**
Scale	**1**	**2**	**3**	**4**	**5**
Relation	**0.0-1.0**	**1.1-2.0**	**2.1-3.0**	**3.1-4.0**	**4.1-5.0**
Quality	**Very poor**	**Poor**	**Moderate**	**High**	**Very High**

Values Scaling:

Mean Score of COs = $\frac{\text{Total of Values}}{\text{Total No. of POs \& PSOs}}$	**Mean Overall Score for COs** = $\frac{\text{Total of Mean Scores}}{\text{Total No. of COs}}$

Semester III **Hours/Week: -**
18PPH3402 **Credits : 2**

Extra Credit Course-II: (MOOC)
FIBER OPTIC COMMUNICATION

Course Outcomes:

1. Understand the principle and structure of optical fibers.
2. Understand the working principle of fiber optical sources and couplers and apply it in the optical communication systems.
3. Apply the fundamental principles of optics and light wave to design optical fiber communication systems.
4. Understand different analog and digital transmission systems.
5. Understand and apply the concepts of coherent optical modulation and detection techniques.
6. Explore concepts of designing and operating principles of modern optical communication systems and networks.

Unit-I: INTRODUCTION TO OPTICAL FIBERS

Evolution of fiber optic system - elements of an optical fiber transmission link- fiber types- rays and modes – step indexed fiber structure – graded index fiber structure – graded index numerical aperture – fiber losses.

Unit-II: FIBER OPTICAL SOURCES AND COUPLERS LED

LED materials – fiber LED coupling – LASER – spatial emission pattern of LASER – modulation response of LASER – single frequency LASER – light emitting transistor. Optical Couplers: Types of optical couplers – star couplers – T couplers – source to fiber coupling efficiency – opto-couplers and applications.

Unit-III: ANALOG AND DIGITAL TRANSMISSION SYSTEM

Overview of analog links – multichannel transmission techniques – multichannel amplitude modulation – multichannel frequency modulation – digital transmission - line coding – NRZ codes RZ codes – Block codes.

Unit-IV: COHERENT OPTICAL FIBER COMMUNICATION SYSTEM

Fundamental concepts – homodyne detection – heterodyne detection – modulation techniques – direct detection OOK – OOK homodyne detection – PSK homodyne detection – heterodyne detection schemes – polarization control requirements.

Unit-V: NETWORK SYSTEMS AND TECHNIQUES

Wavelength Division Multiplexing – Local Area Networks – optical fiber bus – ring topology – star architectures – advanced multiplexing strategies - optical TDM, sub carrier multiplexing, WDM network architectures.

Book for Study:

1. Optical Fiber Communication – Gerd Keiser – McGraw-Hill – 2nd Edition
2. Optical Communication System – John Gowar – Prentice Hall of India – 2nd Edition
3. Optical fiber and fiber optic communication system – Subirkumarsarkar-S.Chand – 4th Edition (2010).

Unit	Book	Sections
I	1, 3	1.2, 1.3, 2.3.1, 2.3.2, 2.3.3, 2.6 & Chapter 7 respectively
II	3	Chapter 9 & 12
III	1	9.1, 9.3, 9.3.1, 9.3.2, 8.2, 8.2.1-8.2.3
IV	1	10.1, 10.3.1-10.3.4, 10.4
V	1	11.1, 11.2.1-11.2.3

Book forReference:

1. Govind P. Agarwal - Fiber Optic Communication System John Wiley & Sons (2002)

Relationship Matrix for Course Outcomes, Programme Outcomes and Programme Specific Outcomes

Semester III	Code 18PPH3402					Title of the Paper FIBER OPTIC COMMUNICATION								Hours -	Credits 2
Course Outcomes (COs)	Programme Outcomes (POs)					Programme Specific Outcomes (PSOs)								Mean Score of COs	
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8		
CO1	4	4	4	4	4	2	5	4	3	3	3	2	4		3.54
CO2	4	3	4	3	3	5	2	4	4	2	4	3	4		3.46
CO3	4	4	4	4	3	2	3	3	2	4	3	3	4		3.30
CO4	3	4	4	4	4	4	3	3	4	3	4	1	4		3.46
CO5	4	3	4	4	3	4	3	3	3	3	3	4	4		3.46
CO6	4	4	4	3	5	3	3	3	3	4	4	1	4		3.46
													Overall Mean Score for COs		3.45

Result: The Score for this Course is 3.4 (High Relationship)

Note:

Mapping	1-20%	21-40%	41-60%	61-80%	81-100%
Scale	1	2	3	4	5
Relation	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0
Quality	Very poor	Poor	Moderate	High	Very High

Values Scaling:

$$\text{Mean Score of COs} = \frac{\text{Total of Values}}{\text{Total No. of POs \& PSOs}} \qquad \text{Mean Overall Score for COs} = \frac{\text{Total of Mean Scores}}{\text{Total No. of COs}}$$

Semester IV **Hours/Week: 6**
18PPH4112 **Credits : 6**

NUCLEAR, PARTICLE AND RADIO ASTRONOMY

Course Outcomes:

1. Understand the basic structure, properties of nucleus and deuteron.
2. Acquire the knowledge of various nuclear decays and radioactivity.
3. Know the different type of nuclear reactions.
4. Apply the knowledge of nuclear reactions for producing fission and fusion energy.
5. Analyze the properties of various fundamental particles, their decay modes and the interactions.
6. Understand symmetry properties & Quark model of elementary particles.
7. Understand Cosmic rays.
8. Understand concepts of Radio astronomy.

Unit-I: BASIC PROPERTIES OF NUCLEUS (15 hr)

Nuclear mass and binding energy - atomic masses - systematics of nuclear binding energy - nuclear size - charge radius - potential radius - spin and parity - statistics of nucleus - magnetic dipole moment - electric moments - electric quadrupole moments - isospin - nuclear forces - ground state of the deuteron - wave equation for the deuteron and solution - excited state of deuteron - low energy proton neutron scattering - spin dependence of n-p interaction.

Unit-II: NUCLEAR DECAY AND RADIOACTIVITY (15 hr)

Theory of alpha disintegration - hindrance and formation factors – fine structure of alpha decay - energetics of beta decay - neutrino hypothesis - Fermi theory of beta decay - selection rules - Sargent diagram - orbital electron capture - parity non conservation - double beta decay - gamma ray spectra and nuclear energy level - radio active transition in nuclei - nuclear isomerism-internal conversion - resonance fluorescence - angular correlation.

Unit-III: NUCLEAR REACTIONS (15 hr)

Types of nuclear reactions - conservation laws - reaction energetics – Q value - threshold energy - nuclear reaction cross section - level width - compound nuclear theory - Briet Wigner dispersion formula and interpretation - direct reaction - striping and pick up reactions -nuclear fission -energy released in fission - nuclear chain reaction - four factor formula - nuclear reactor - nuclear fusion - Stellar energy.

Unit-IV: PARTICLE PHYSICS (15 hr)

Production of new particles in high energy reaction - classification of elementary particle - fundamental interaction - quantum numbers - anti particles - resonances - law in production and decay process - symmetry and conservation laws -special symmetric groups – Gelman-Neeman theory - Quark model – SU(3) symmetry - unification of fundamental interactions - CPT invariance and applications of symmetry arguments to particle reaction, parity non conservation in week interaction.

Unit-V: COSMIC RAYS AND RADIO ASTRONOMY (15 hr)

Nature of Cosmic rays –soft and hard components-Instruments and apparatus used in research of cosmic rays – absorption of cosmic ray-discovery of positron-cosmic ray shower discovery of muons – properties of ì- meson- discovery of Pi meson - Radio astronomy - radio telescopes - Synchrotron radiation - spectral lines in radio astronomy - a few major discoveries in radio astronomy - Radio astronomy in India - Hot big bang cosmology.

Books for Study:

1. S.N. Ghoshal, Nuclear Physics, S. Chand and company Ltd. 2003.
2. Satya Prakash, Nuclear Physics and Particle Physics, Sultan Chand and sons, First edition 2014
3. S.L.Kaakani,Shubhrakakani, Nuclear Particle and Physics, Vivo books(private) Ltd, second edition 2013
4. Joshi A.W, Horizons of Physics, Willey Eastern Ltd.

Unit	Book	Sections
I	1	2.1, 2.13, 17.2, 17.3, 17.4, 17.6, 17.8
II	1	4.9-4.12, 5.5-5.7, 5.9, 5.10, 5.12, 5.16, 5.18, 6.8–6.11, 6.16, 6.19
III	2	8.1, 8.2, 8.4, 8.5, 8.7, 8.10, 8.12, 8.13, 8.15, 8.16, 9.2, 9.4, 9.11, 9.12, 9.13, 9.17, 9.21
IV	2	11.4 –11.14, 11.15, 11.16.
V	3 4	10.3, 10.4, 10.7-10.12, 10.14 Chapter 15

Books for Reference:

1. Kenneth S. Krane -Introductory Nuclear Physics, John Wiley and Sons, New York, 1988
2. Joshi A.W-Nuclear Physics, Gujarat UmeshPrahasham.
3. Pandya and Yadav-Nuclear and Particle Physics world, Cambridge University Press.
4. Bernard L. Cohen -Concepts of Nuclear Physics, Tata McGraw Hill Publishing Co., New Delhi.
5. Irwing Kaplan, Nuclear Physics, Addison-Wesley Pub. Co., 2nd edition

Relationship Matrix for Course Outcomes, Programme Outcomes and Programme Specific Outcomes

Semester IV	Code 18PPH4112	Title of the Paper NUCLEAR, PARTICLE AND RADIO ASTRONOMY											Hours 6	Credits 6
Course Outcomes (COs)	Programme Outcomes (POs)					Programme Specific Outcomes (PSOs)								Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO1	5	5	4	5	4	5	5	4	5	4	4	5	5	4.62
CO2	4	5	5	4	4	5	4	4	5	4	5	5	5	4.60
CO3	5	5	4	5	4	5	4	5	4	4	4	4	4	4.38
CO4	4	4	4	5	5	5	5	4	5	5	5	5	4	4.76
CO5	5	4	5	4	4	4	4	5	5	5	5	4	4	4.44
CO6	4	5	4	5	4	5	4	4	4	4	4	5	5	4.54
CO7	5	4	4	5	4	5	4	5	5	5	4	4	5	4.42
CO8	4	4	5	5	4	4	4	4	4	5	5	4	5	4.46
													Overall Mean Score for COs	4.52

Result: The Score for this Course is 4.5 (Very High Relationship)

Note:

Mapping	1-20%	21-40%	41-60%	61-80%	81-100%
Scale	1	2	3	4	5
Relation	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0
Quality	Very poor	Poor	Moderate	High	Very High

Values Scaling:

Mean Score of COs = $\frac{\text{Total of Values}}{\text{Total No. of POs \& PSOs}}$	Mean Overall Score for COs = $\frac{\text{Total of Mean Scores}}{\text{Total No. of COs}}$

Semester IV **Hours/Week: 6**
18PPH4113 **Credits : 6**

DESIGN OF MICROCONTROLLER AND ARDUINO PHYSICS INSTRUMENTS

Course Outcomes:

1. Understand the architecture of Microcontroller
2. Learn the architecture of Arduino and its features
3. Understand the structure and features of Arduino IDE and apply it to programs
4. Acquire the knowledge about the signal communication protocols
5. Acquire required skill to Develop the program
6. Design Arduino instruments for physical parameters
7. Understand Internet of Things
8. Design IOT devices with Arduino

Unit-I: MICROCONTROLLER AND ARCHITECTURE OF ARDUINO

Microprocessor and Microcontroller - ATmega328/P: Introduction – Feature – Description - Block Diagram - Pin Configurations - Pin Descriptions.

Arduino: Block diagram – Architecture - Pin functions – features - I/O Ports – Timers - interrupts - serial port– variants.

Unit-II: ARDUINO IDE AND PROGRAMMING WITH DIGITAL I/O

Introduction to Arduino IDE - writing, saving, compiling and uploading sketches – libraries and library management – board management – digital I/O: blinking LED, Switch -Interfacing LCD – simple programs.

Unit-III: PROGRAMING WITH ANALOG I/O FOR PHYSICAL PARAMETERS

ADC - AnalogRead – AnalogReference –Pulse Width Modulation (PWM) – control of DC motor - Serial Communication – Inter Integrated Circuit (I2C) – Serial Peripheral Interface (SPI) - Ethernet shield.

Unit-IV: ARDUINO INSTRUMENT DESIGN

Pressure meter – thermometer – lux meter – Ultrasonic range finder –humidity meter – density meter – viscometer – dielectric meter – LCR meter.

Unit-V: IOT

Introduction – Block diagram – Protocols (HTTP, MQTT) – IOT service platform – REST API - internet weather display – Email alert system – REST application programs.

Books for Study:

1. Atmega328/P Data sheet
2. Beginning Arduino Programing,Brain Evans, Apress, 2011
3. Learning Internet of Things by Peter Waher – Packt Publishing, 2015

Unit	Book	Chapter	Sections
I	1 2	1, 2, 4, 5, 11 & 12 1	All All
II	2	2, 3, 4 & 5	All
III	2	6, 7 & 10	All
IV	2	Projects	All
V	3	1, 2, 5 & 7	All

Books for Reference:

1. Arduino Manual
2. Arduino Programming Language, Allison M. Okamura, Stanford University
3. Arduino Programming notebook, Brain W. Evans, 2007
4. Arduino Microcontroller Guide, W. Durfee, University of Minnesota, 2011

Web Resources:

1. https://www.arduino.cc/
2. https://www.microsoft.com/en-in/internet-of-things/

Relationship Matrix for Course Outcomes, Programme Outcomes and Programme Specific Outcomes

Semester IV	Code 18PPH4113					Title of the Paper DESIGN OF MICROCONTROLLER AND ARDUINO PHYSICS INSTRUMENTS								Hours 6	Credits 6
Course Outcomes (COs)	Programme Outcomes (POs)					Programme Specific Outcomes (PSOs)								Mean Score of COs	
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8		
CO1	5	5	4	5	4	5	5	4	5	4	4	5	5	4.62	
CO2	5	5	5	4	4	5	4	4	5	4	5	5	5	4.62	
CO3	5	5	4	5	4	5	4	5	4	4	4	4	4	4.38	
CO4	5	4	4	5	5	5	5	4	5	5	5	5	5	4.76	
CO5	5	4	5	4	4	4	4	5	5	5	5	4	4	4.46	
CO6	5	5	4	5	4	5	4	4	4	4	4	5	5	4.54	
CO7	5	4	4	5	4	5	4	5	5	5	4	4	5	4.46	
CO8	5	4	5	5	4	4	4	4	4	5	5	4	5	4.46	
													Overall Mean Score for COs		4.53

Result: The Score for this Course is 4.5 (Very High Relationship)

Note:

Mapping	1-20%	21-40%	41-60%	61-80%	81-100%
Scale	1	2	3	4	5
Relation	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0
Quality	Very poor	Poor	Moderate	High	Very High

Values Scaling:

$$\text{Mean Score of COs} = \frac{\text{Total of Values}}{\text{Total No. of POs \& PSOs}} \qquad \text{Mean Overall Score for COs} = \frac{\text{Total of Mean Scores}}{\text{Total No. of COs}}$$

Semester IV **Hours/Week: 8**
18PPH4114 **Credits : 4**

PHYSICS PRACTICAL - IV

Any 15 Experiments:

1. AlO Band
2. Laser IV: Fiber Optics cable parameters
3. Op-amp: Solving I order Simultaneous Equation
4. Analog to Digital Converter design
5. Design of Synchronous Counter
6. Digital Modulation: PAM, ASK, FSK
7. Four Probe and two probe Method
8. Optical constants of dielectric and metal films
9. Electron Spin Resonance Spectrometer
10. Determination of Fermi energy of copper
11. Measurement of radiant flux density and luminous intensity of emission source
12. Surface morphological characterization of nanomaterial by TEM
13. Jamin's interferometer - refractive index of air
14. Measurement of thermoelectric power
15. Computational experiment: Origin - Mathematics
16. Computational experiment: Origin - Fitting
17. Computational experiment: Origin - Signal processing
18. Basic programs - Arduino
19. Frequency and humidity measurement - Arduino
20. Light intensity and distance measurement - Arduino
21. Pressure and density measurement - Arduino
22. Density and viscosity measurement - Arduino
23. Design of LCR meter - Arduino
24. Measurement and control of temperature - Arduino
25. Weather and astronomy related image processing - Python
26. FFT - Python

Semester IV **Hours/Week: 4**
18PPH4203(A) **Credits : 4**

Core Elective:
MATERIAL SCIENCE - II

Course Outcomes:

1. Acquire knowledge about the development of high Temperature superconductors
2. Understand the applications of high Tc super conductors
3. Acquire knowledge on solar cell fabrication and characterization
4. Apply fuel cells and carbon nano tubes for energy storage
5. Understand different phenomena in luminescence materials
6. Understand the properties of alloys and composites used in our day to day life.

Unit-I: SUPERCONDUCTING MATERIALS

Discovery of the phenomenon of High Temperature Superconductivity: Discovery of various types of HTSC materials, viz; - Y-, Bi-, Tl and Hg based materials. Preparation of HTSC materials by the solid state reaction method and their fundamental physical properties (Elementary treatment only) – properties-possible mechanisms-examples-squid-superstibes-superconducting wire-applications.

Unit-II: ENERGY CONVERSION AND STORAGE MATERIALS

Solar cells: Organic solar cells - Polymer composites for solar cells - p-n junction - Device fabrication and characterization – Nanomaterials for solar cells - Dye-sensitized solar cells - Organic - inorganic hybrid solar cells - Current status and future prospects.

Fuel Cells: Polymer membranes for fuel cells - Acid/ alkaline fuel cells - design of fuel cells - Carbon Nanotubes for energy storage - Hydrogen Storage in Carbon Nanotubes - Use of nanoscale catalysts to save energy and increase the industrial productivity.

Unit-III: LUMINESCENCE MATERIALS

Introduction- General Discussion of Emission from a Luminescent center, Stimulated emission - Non-radioactive transition in an Isolated Luminescent center - Efficiency – Maximum Efficiency for high energy excitation, Photo ionization and Electron –Transfer Quenching-Early phosphors-Hallo-phosphates-phosphors for tricolour lamp—Red emitting phosphors

Unit-IV: ALLOYS AND COMPOSITES

Introduction – Ferrous alloys: Steels – Heat treatment – Formation of pear tile – Formation of lamite – Formation of manterisite – Terryzering of mechanical steels. Non-ferrous alloys: copper and its alloys – aluminum and its alloys – Titanium and its alloys – Nickel and its alloys.

Large particle composite – dispersion strengthened composites – influence of fiber length – influence of fiber orientation and concentration – The fiber phase – The matrix phase – polymer – matrix composites – Metal – Matrix composites – ceramic – matrix composites – carbon – carbon composites – hybrid composites – Laminar composites – sandwich panels.

Unit-V: NANOSENSORS

Introduction –classification of sensors-optical sensors-chemical sensors-electrochemical sensors-mass sensitive sensors-parameters for characterizing sensors-electronic nose-metal nano particle for chemi resistive sensors-sensing mechanism-effect of nanoparticle size, cross links-quantum dot based temperature, chemical, biosensors-nanowire based sensors for electrical, optical, thermoelectric-semiconducting nano wire sensors for gas sensing applications-sensors based on polymeric nanostructures.

Books for study:

1. Balasubramanian. R., Callister's Material Science and Engineering, Wiley, India, 2010.
2. Luminescent Materials, G. Blasse and B.C Grabmaier, Springer Verleg (1994). Introduction in nanomaterials and nanotechnology. University of Tartu. 2007
3. Study material by Department of Physics, St. Josephs College (Autonomous), Trichy-2.

Unit	Book	Sections
I	3	Study materials
II	3	Study materials
III	2	3.1, 3.2, 3.6, 4.1-4.5, 6.4.1.1-6.4.1.4
IV	2 3	For Alloys: 15.1-15.14, 5.1.1-5.4.1 For Composites: Study Materials
V	3	Study materials

Relationship Matrix for Course Outcomes, Programme Outcomes and Programme Specific Outcomes

Semester IV	Code 18PPH4203A					Title of the Paper MATERIAL SCIENCE-II								Hours 4	Credits 4
Course Outcomes (COs)	Programme Outcomes (POs)					Programme Specific Outcomes (PSOs)								Mean Score of COs	
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8		
CO1	5	4	4	3	3	4	4	4	2	2	2	1	3		3.15
CO2	5	4	4	3	3	4	4	4	3	5	3	1	3		3.53
CO3	4	4	3	2	2	4	3	4	4	4	3	2	3		3.23
CO4	4	4	3	2	2	4	4	4	3	4	1	3	3		3.23
CO5	5	4	4	3	3	4	4	4	5	3	3	2	4		3.69
CO6	4	5	4	4	3	4	4	4	3	5	3	2	3		3.69
														Overall Mean Score for COs	3.42

Result: The Score for this Course is 3.4 (High Relationship)

Note:

Mapping	1-20%	21-40%	41-60%	61-80%	81-100%
Scale	1	2	3	4	5
Relation	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0
Quality	Very poor	Poor	Moderate	High	Very High

Values Scaling:

$$\text{Mean Score of COs} = \frac{\text{Total of Values}}{\text{Total No. of POs \& PSOs}} \qquad \text{Mean Overall Score for COs} = \frac{\text{Total of Mean Scores}}{\text{Total No. of COs}}$$

Semester IV **Hours/Week: 4**
18PPH4203(B) **Credits : 4**

Core Elective: ADVANCED QUANTUM MECHANICS

Course Outcomes:

1. Acquire conceptual knowledge in the phenomena of scattering, interactions of different types of single and many particle systems, their behavior under relativistic phenomenon
2. Understand the techniques followed in choosing the appropriate wave functions, type of interactions, energy association, spin responses
3. Analyse the differences, implications and descriptions of the different methodologies applied in the study of scattering, relativistic behavior of particles
4. Apply the same formalism to understand hard core physical problem which includes the interaction of orbital, spin, total angular momenta with different fields, creation of resonance effect, experimental outcome
5. Apply integral / residual approach to simple problems using Born's Approximation, Partial Wave Approximation, Green's Function
6. Apply the theory of Matrices / Tensors to the behavior of elementary particles due to relativistic corrections under different situations

Unit-I: SCATTERING THEORY (10 hr)

Definition and interpretation of scattering cross section – quantum theory of scattering – The green's function – The Born approximation – applied to shielded Coulomb potential.

Unit-II: PARTIAL WAVE ANALYSIS AND ITS APPLICATIONS (10 hr)

Method of Partial Waves: expansion formula for a plane wave, scattering by a hard sphere, a square well & the Ramsauer effect, neutron by proton – Coulomb scattering.

Unit-III: RELATIVISTIC QUANTUM MECHANICS (10 hr)

The Klein – Gordan equation – the Dirac Equation – Dirac's matrices – probability and current density – plane wave solution – the electron in an electromagnetic field – the spin orbit interaction – central potential – energy levels of the hydrogen – the hole theory and positrons.

Unit-IV: IDENTICAL PARTICLES (10 hr)

Many particle system: Schrodinger equation, interchange of symmetry, systems of distinguishable non-interacting particles., System of identical particles: Identical particles in classical & Quantum Mechanics, Exchange degeneracy, symmetrization postulates, constructing symmetric and anti-symmetric function, system of identical non-interacting particles. The Pauli Exclusion Principle - Periodic Table.

Unit-V: EXPERIMENTS WITH SPIN-HALF PARTICLE (10 hr)

Orbital angular momentum and Magnetic Moment – Spin angular momentum and Magnetic Moment – Stern-Gerlach Experiment – Larmour Precession – Principle of Magnetic Resonance experiment – the EPR Paradox – A toy model for spin.

Books for Study:

1. Nouredine Zettile, Quantum Mechanics: Concepts and Applications, 2/e, John Wiley & Sons, UK, 2009
2. AjoyGhatak and S.Lokanathan, Quantum Mechanics :Theory and Applications, Macmillan India Ltd., New Delhi,2007.
3. G. L. Squires, Problems in Quantum mechanics with solutions, Cambridge University Press, 2002. (Only for Tutorial and Self-Study)

Unit	Book	Chapter	Sections
I	2	24	24.1 - 24.5
II	2	24	24.6, 24.7
III	2	28	28.1 - 28.9
IV	1	8	8.1 - 8.6
V	2	14	14.1 - 14.7

Books for Reference:

1. Quantum Mechanics, Alastair IM Rae, Jim Napolitano, 4th Edn., CRC Press, 2016
2. Richard L Liboff, Introduction to Quantum Mechanics, Pearson Education Ltd., 4/e, 2006.
3. AFJ Levi, Applications of Quantum Mechanics, Cambridge University Press, Delhi, 2009.
4. Thankappan, V. K., Quantum Mechanics, Wiley Eastern Ltd., New Delhi, 2nd Edn,1995
5. G. Aruldhas, Quantum Mechanics, Prentice Hall of India, New Delhi, 2003.

Web Resources:

1. http://bookboon.com/Introduction to Quantum Mechanics, Intermediate Quantum Mechanics, Chemistry: Quantum Mechanics and Spectroscopy I, Chemistry: Quantum Mechanics and Spectroscopy II
2. https://swayam.gov.in/courses/3485-quantum-chemistry
3. http://freevideolectures.com/Course/2876/Fundamentals-of-Physics-III/19

Relationship Matrix for Course Outcomes, Programme Outcomes and Programme Specific Outcomes

Semester IV	Code 18PPH4203B			Title of the Paper ADVANCED QUANTUM MECHANICS									Hours 4	Credits 4
Course Outcomes (COs)	Programme Outcomes (POs)					Programme Specific Outcomes (PSOs)								Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
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CO6	4	5	4	4	3	4	4	4	3	5	4	1	3	3.69
Overall Mean Score for COs														**3.42**

Result: The Score for this Course is 3.4 (High Relationship)

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Mean Score of COs = $\frac{\text{Total of Values}}{\text{Total No.of POs \& PSOs}}$	**Mean Overall Score for COs** = $\frac{\text{Total of Mean Scores}}{\text{Total No. of COs}}$