DEPARTMENT OF PHYSICS				*CLASS: I M.Sc. Physics*				
Sem	**Course Type**	**Course Code**	**Course Title**	**Credits**	**Contact Hours/week**	**CIA**	**Ext**	**Total**
II	Major Core–4	21P2PMC4	Mathematical Physics - II	4	5	25	75	100

Nature of Course				
Knowledge and skill	✓		Employability oriented	
Skill oriented			Entrepreneurship oriented	

Course Objectives :

- To highlight the relationship of mathematical tools to understanding the dynamics of the physical world we live in.
- To impart knowledge on mathematical tools and techniques that could model real life physical systems.
- To demonstrate the use of Complex analysis and integration, tensor analysis and group theory in areas like Electromagnetic theory, Quantum Mechanical systems and crystallographic systems.

Course Content:

Unit	Description	Hours	K-level	CLO
I	**Complex variables-I :** Analytic function – Cauchy Reiman equations – CR in polar form – Complex line integral – Cauchy integral theorem (simple proof) – cauchy integral formula – Derivative of an analytic function (n^{th} derivative) – Expansion of an analytic function.	15	Up to K3	1
II	**Complex variables-II :** Singular point – Isolated singularity – Removal singularity – Cauchy-Residue theorem – Residue – Calculation of residue at simple poles and poles of higher order – Evaluation of definitive integrals – Integration around unit circle – Jordan lemma – Semicircular contours – Poles on the real axis.	15	Up to K4	2
III	**Tensors :** Scalar, vector and tensors – difference between a tensor and a transformation matrix – second rank tensor – Definition – Examples – Contra variant, covariant and mixed tensors – Tensors – Equality and null tensors- addition, subtraction, outer product and inner product-metric tensor-Tensors in EM theory	15	Up to K2	3
IV	**Crystal symmetry and Abstract Group theory :** Crystal symmetry operators – The crystallographic point groups – stereographic projection of simple point groups – classification of point groups according to crystal systems – Definition of groups – Group multiplication table – Multiplication tables for C_{2v}, C_{3v}, C_3, C_4, C_2 point groups – Rearrangement theorem – Cyclic groups –	15	Up to K4	4

	Subgroups – Cosets – Example groups of finite order – Conjugate elements and class structure – physical interpretation of class structure – Normal divisors and factor groups – isomorphy and homomorphy – class multiplication.			
V	**Theory of Group Representations and construction of character tables :** Definitions – reducible and irreducible representations – Lemma I, II and III with proof – Great orthogonal theorem – Character of a representation – Construction of character tables – Decomposition of regular representations.	15	Up to K3	5

Books for study :

1. Mathematical Physics with Classical Mechanics, Satyaprakash, Sultan Chand & sons, New Delhi, Vth edition, 2009 – Unit I: 6.9, 6.10, 6.12, 6.14, 6.16, 6.17.
2. Mathematical Physics with Classical Mechanics, Satyaprakash, Sultan Chand & sons, New Delhi, Vth edition, 2009 – Unit II: 6.22, 6.23, 6.24, 6.25(a), 6.25(b), 6.25(c), 6.25(d).
3. Vector analysis and Tensor analysis – M.R. Spiegel, Schaum's outline series, MH, 1974
   Unit III – chapter 8.
4. Group theory and quantum mechanics, Michael Tinkam, 2003.
   Unit IV – Chapter 2.1-2.9, 4.1, 4.2; Unit V – Chapter 3.1-3.5.

Books for reference :

1. Chemical Applications of Group theory, Albert F Cotton, Wiley Inc., III Edition, 2008
2. Mathematical Methods for Physicists, Arfken& Weber, VI Edition, Elsevier, 2011
3. Mathematical methods in Physical Sciences, Mary L Boas, Wiley Eastern, III Edition, 2006
4. Mathematical methods for Physicists and Engineers, Riley, Hobson and Bence, Cambridge University Press, III Edition, 2018.

Web Resources :

1. https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Group_Theory/Group_Theory_and_its_Application_to_Chemistry
2. https://ocw.mit.edu/resources/res-3-004-visualizing-materials-science-fall-2017/student-projects-by-year/EPFL2017/crystallographic-point-groups/a-visualisation-of-crystallographic-point-groups/
3. https://www.sjsu.edu/faculty/watkins/tensor1.htm
4. https://nptel.ac.in/courses/111/103/111103070/

Pedagogy :

Chalk and talk, Presentation, Quiz, Seminar, Assignment

Course Designers :

S. Sivaramakrishnan

Dr. K. Neyvasagam

Course Plan :

Unit	Topics	Hrs	Mode
Unit I	Analytic function	**3**	Chalk and talk, Presentation, Quiz and assignment
	Cauchy Reiman equations – CR in polar form –	**3**	
	Complex line integral – Cauchy integral theorem (simple proof)	**3**	
	cauchy integral formula – Derivative of an analytic function (n^{th} derivative) – Expansion of an analytic function	**3**	
	cauchy integral formula – Derivative of an analytic function (n^{th} derivative) – Expansion of an analytic function	**3**	
Unit II	Singular point – Isolated singularity – Removal singularity	**3**	Chalk and talk, Quiz and assignment
	Cauchy-Residue theorem – Residue – Calculation of residue at simple poles and poles of higher order	**3**	
	Evaluation of definitive integrals – Integration around unit circle	**3**	
	Jordan lemma	**3**	
	Semicircular contours – Poles on the real axis	**3**	
Unit III	Scalar, vector and tensors	**3**	Chalk and talk, Quiz, assignment and seminar
	Difference between a tensor and a transformation matrix – second rank tensor – Definition – Examples	**5**	
	Contra variant, covariant and mixed tensors – Tensors – Equality and null tensors- addition, subtraction, outer product and inner product- metric tensor	**4**	
	Tensors in EM theory	**3**	
Unit IV	Crystal symmetry operators	**3**	Chalk and talk, quiz, Seminar
	The crystallographic point groups – stereographic projection of simple point groups – classification of point groups according to crystal systems	**3**	
	Definition of groups – Group multiplication table – Multiplication tables for C_{2v}, C_{3v}, C_3, C_4, C_2 point groups	**3**	
	Rearrangement theorem – Cyclic groups – Subgroups	**1**	
	Cosets – Example groups of finite order	**1**	
	Conjugate elements and class structure – physical interpretation of class structure – Normal divisors and factor groups	**2**	
	Isomorphy and homomorphy – class multiplication.	**2**	
Unit V	Definitions – reducible and irreducible representations	**2**	Chalk and talk,Quiz, Presentation, Seminar
	Lemma I, II and III with proof – Great orthogonal theorem	**5**	
	Character of a representation	**2**	
	Construction of character tables – Decomposition of regular representations.	**6**	

Course learning Outcomes:

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

CLOs	Course Learning Outcomes	Knowledge Level
CLO–1	Apply Cauchy-Riemann equation and Cauchy's integral theorem to analytic function.	Up to K3
CLO–2	Analyze poles and residues using concepts of contour integration.	Up to K4
CLO–3	Understanding the application of tensors in Physics.	Up to K2
CLO–4	Classify molecules among various crystallographic point groups by applying principles of group theory.	Up to K4
CLO–5	Apply the Great Orthogonality theorem to crystallographic point groups and construct character tables.	Up to K3

Mapping of CLOs with PSOs :

#	PSO1	PSO2	PSO3	PSO4	PSO5
CLO1	3	3		2	1
CLO2	3	3		2	1
CLO3	3	3		2	1
CLO4	3	3		2	1
CLO5	3	3		2	1

Advance application –3, Intermediate level –2 , Basic level–1

Learning Outcome Based Education (LOBE) & Assessment
Summative Examination – Blue Print
Articulation Mapping-K Levels with Courses Learning Outcomes (CLOs)

Units	CLOs	K- Level	Section A		Section B		Section C (Either/or Choice)	Section D (Open Choice)
			MCQs		Short Answers			
			No. of Questions	K-Level	No. of Questions	K-Level		
1	CLO 1	Up to K3	2	K3& K3	1	K3	2 (K3&K3)	1 (K2)
2	CLO 2	Up to K4	2	K2 & K3	1	K4	2 (K1&K1)	1 (K3)
3	CLO 3	Up to K2	2	K1 & K1	1	K1	2 (K4&K4)	1 (K4)
4	CLO 4	Up to K4	2	K4 & K4	1	K4	2 (K4&K4)	1 (K4)
5	CLO 5	Up to K3	2	K2 & K3	1	K2	2 (K2&K2)	1 (K3)
No. of Questions to be asked			10			5	10	5
No. of Questions to be answered			10			5	5	3
Marks for each question			1			2	5	10
Total Marks for each section			10			10	25	30

Distribution of Section-wise Marks with K Levels

K Levels	Section A (No Choice)	Section B (No Choice)	Section C (Either/or)	Section D (Open Choice)	Total Marks	% of Marks without choice
K1	2	4	10	-	**16**	13.33
K2	2	4	10	10	**26**	21.67
K3	4	2	10	20	**36**	30.00
K4	2	-	20	20	**42**	35.00
Total Marks	10	10	50	50	**120**	100.00